National Park Service
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Natural Resource Stewardship and Science

Allegheny Portage Railroad National Historic Site Natural Resource Condition Assessment

Natural Resource Report NPS/ALPO/NRR—2013/727

ON THIS PAGE
West Portal of the Staple Bend Tunnel
Photograph by: NPS Park Staff

ON THE COVER
View of the Lemon House located near the top of Plane 6 at the Summit level
Photograph by: NPS Park Staff

Allegheny Portage Railroad National Historic Site Natural Resource Condition Assessment

Natural Resource Report NPS/ALPO/NRR—2013/727

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Executive Summary

Background and Context

Allegheny Portage Railroad National Historic Site (ALPO) is in southwestern Pennsylvania in Blair and Cambria counties. The park protects the cultural resources that comprise the Allegheny Portage Railroad and tells the story of its influence on the nation.

Prior to the 18th century, the region of what is now ALPO was occupied primarily by Native American groups and scattered European settlers who often fought each other for land. Consequently, the area was extremely dangerous to settle with much of the area existing as dense forest. During a relatively peaceful period, land was cleared for settlement. Settlers to the area were initially searching for agriculture. As more settlers came to the region, gristmills, sawmills, and distilleries were constructed along the steep, mountain streams flowing from the high plateau down the front to the valleys below. Timber became valuable for building and heating homes and for making charcoal to fuel the iron furnaces. During this period, much of the land was cleared. As coke replaced charcoal in the iron-making process, the coal industry grew rapidly in Cambria and Blair Counties. In the early nineteenth century, Pennsylvania began the State Works project to utilize the waterways of the commonwealth for transportation. The first section of the Pennsylvania Canal's Main Line extended from Philadelphia to Hollidaysburg; the second section began in Pittsburgh and extended east toward Johnstown. In between lay the vast expanse of the rugged Allegheny Mountains. A team of engineers designed the Allegheny Portage Railroad, a system of horse-drawn (later replaced by locomotives) rail lines and tiered incline planes which carried the canal boats across the Alleghenies. The Allegheny Portage Railroad opened in March of 1834 and, although only in operation for two decades, is still regarded as an engineering marvel and symbol of America's ingenuity and perseverance during the first steps toward western expansion.

Allegheny Portage Railroad was designated as a National Historic Site on August 31, 1964 in order to preserve the history and remnants of the Allegheny Portage Railroad and interpret the Pennsylvania Mainline Canal's system of canals, railroads, and inclined planes and its impact on the early development of the nation. The park extends across 40 miles and encompasses two main areas: 1) the Main Unit, which begins at the summit of the original portage, roughly 3 miles east of the town of Cresson, and includes the Summit Area and Level 6, the Eastern Slope (Allegheny Front) area (includes Inclines 6, 8, 9 and 10), Levels 8 through 10, and the Foot of Ten area; and 2) the Staple Bend Tunnel Unit (SBTU), which includes Incline 1 and a portion of Level 2 and is located southwest of the Main Unit. The total park acreage for 2010 was 1284 acres (520 ha).

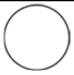
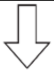
Although this small park was established for the preservation of cultural resources, these resources are embedded within the natural resources of the park, including forested mountains, streams and other natural areas supporting a variety of wildlife, including rare or regionally important plant and animal species. Understanding the structure and function of these ecosystems, as well as the lasting impacts to them from past land use as humans began to reshape the land and extract its resources through agriculture, logging, mining, damming, and other activities, is essential to maintaining both the cultural and natural resources of the park for future generations (Marshall and Piekielek 2007).

Several factors are important to remember when conducting natural resource condition assessments of small cultural parks. First are the major objectives for park management, which are cultural in nature and may conflict with natural resource management. Second, their small size makes these parks extremely vulnerable to surrounding landscape change. Thus, it is important to understand the history of the region and how this has affected natural resource condition.

Approach

ALPO is one of nine parks belonging to the National Park Service's (NPS) Eastern Rivers and Mountains Network (ERMN) selected for a Natural Resource Condition Assessment (NRCA). The following NRCA for ALPO begins with an extensive review of the land-use history of the region. Our approach utilizes a combination of historical land use and documentation to understand both the potential and limitations of the natural resources within and around the park, followed by a review of the current condition of those resources using the ERMN vital signs framework as a guide.

Both units of the park (Main Unit and SBTU) were assessed separately and the results were scaled up to park-wide condition, if data was available for each unit. In many cases, data was limited, however, and only a park-wide assessment was possible. We assigned reference conditions and threshold values based on one or more of the following: 1) established NPS ERMN Vital Signs or NPS Air Resources Division (ARD) condition categories for natural resources; 2) federal or state agency regulations and criteria; 3) peer-reviewed research; or 4) best professional judgment and expert guidance. In the case of federal or state agency regulations and criteria, we evaluated metrics based on the percentage of measures attaining or exceeding the threshold values. All metrics were assigned a rating of natural resource condition. In the case of multiple metrics or parameters, the condition results were then combined (quantitatively, qualitatively, or heuristically) to provide an overall condition rating for the natural resource. Trends in condition were determined, if consistent and standardized long-term datasets were available. An estimate of the confidence in the assessment was also provided. In most cases, trend analysis was not possible and confidence in the assessment was often low to medium due to limited data.

CONDITION STATUS		TREND IN CONDITION		CONFIDENCE IN ASSESSMENT	
	Resource is in Good Condition		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Warrants Significant Concern		Condition is Deteriorating		Low

ALPO Management Objectives and Cultural Resources

Park-wide management objectives are "to use, enhance, and preserve extant cultural resources and natural resources within the National Park Service units and interpret associated stories that will enable visitors to understand why the Pennsylvania Canal and Allegheny Portage Railroad were constructed, the technical challenge….and the human experience…" (NPS 1992). Parkwide management objectives also specify "to protect and maintain natural diversity of plants and animals outside of areas managed for primarily cultural resources or developed areas. In areas managed for primarily cultural resources, to protect natural resources through the management of cultural landscapes" (NPS 1992). Important cultural resources at ALPO include the following:

- Lemon House, a stone tavern located in the Historical Core of the Summit Area
- Engine House No. 6, an exhibit shelter reflecting the original building and housing exhibits, as well as full-scale models of the internal workings and a section of track located near the Lemon House
- Skew Arch Bridge, which was designed to cross over the Old Portage at the lower end of Plane 6
- Allegheny Portage Railroad Trace/Inclined Planes 8, 9, 10 and Corridor
- Staple Bend Tunnel, which was the first railroad tunnel constructed in the nation and declared a National Historic Landmark in 1994.

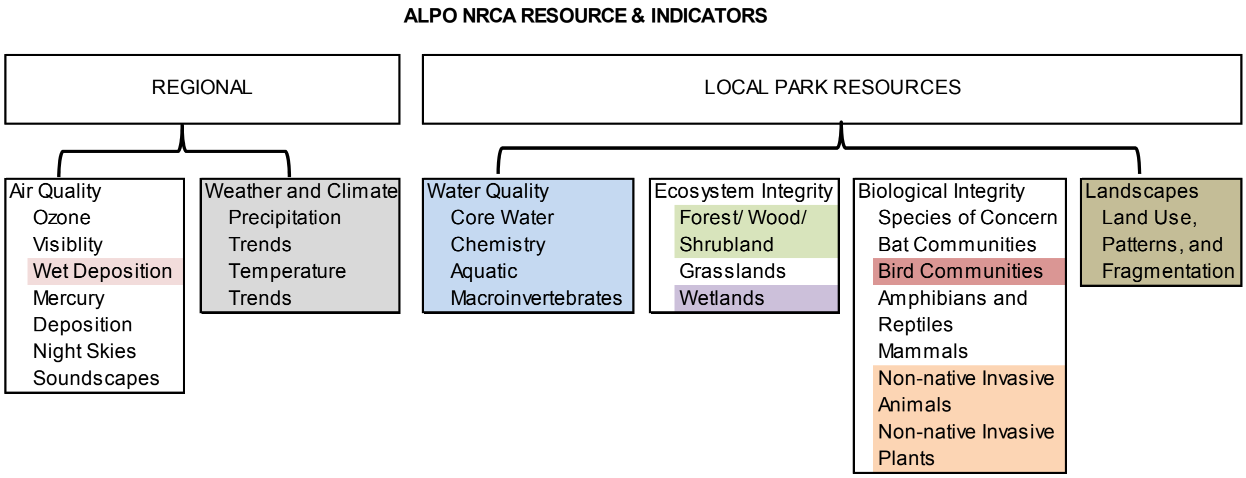
Threats to ALPO

The boundaries of ALPO are largely determined by the cultural resources of the park, resulting in a narrow, linear park that is essentially bisected by the remnants of the Old Portage Railroad. As a result, the park's natural resources are under threat from fragmentation and invasive plant and animal species. Past land use activities, including extensive logging, burning, and mining followed by a long period of no physical disturbance to the landscape, have resulted in major shifts in forest community composition, some of which include dominance of undesirable species. In addition, ALPO's location downwind of suspected regional sources of mercury, sulfur, and nitrogen emissions, as well as the large proportion of high-elevation forests within the park, makes ALPO highly susceptible to enhanced atmospheric deposition. Additional regional threats to the park include suburban development, Marcellus shale gas extraction and infrastructure, and wind turbines.

Current Condition of ALPO Natural Resources

NRCA Framework

Our approach utilizes the ERMN's 'vital signs' framework for reporting natural resource condition (Marshall and Piekielek 2007). This allows NPS to utilize these NRCA results in conjunction with ERMN's long-term monitoring, especially since the latter is intended to evaluate trends in condition. This report also allows one to identify gaps in existing data for the park. Several of the ERMN vital signs not included in this assessment were lacking data for ALPO or had very limited data where only heuristic or qualitative assessments were possible. The natural resources and indicators chosen for the ALPO NRCA are shown below. Indicators that correspond directly to the ERMN vital signs are shown in color. Those in white were included primarily because of their importance and relevance to ALPO.



Air Quality

Air pollution can be a serious threat to both natural and cultural resources, causing injury to sensitive plant species, acidifying waterways, eroding buildings and monuments, leaching nutrients from the soil, and reducing visibility. The NPS Air Monitoring Program focuses primarily on visibility, ozone, and atmospheric deposition and includes air monitoring stations throughout the nation. For the ALPO NRCA, we included ozone, visibility, wet deposition of nitrogen and sulfur, and mercury deposition. We also evaluated night skies and soundscapes. We used information from the NPS ARD guidance to report current condition, if on-site monitoring data was not available (e.g., ozone, visibility). We did include regional trends reported by NPS ARD for parks with on-site monitoring (NPS ARD 2010). For air quality parameters monitored within the park (wet deposition of nitrogen, sulfur, and mercury), we supplemented the interpolated estimates with these park-specific results and used the latter to estimate trends.

ALPO's air quality for ozone warrants *moderate concern* with an *improving* trend. Visibility at the park warrants *significant concern* with an *unchanging* trend. Wet deposition of nitrogen, sulfur, and mercury also warrant *significant concern* but conditions are *improving* for nitrogen and sulfur whereas trends in wet mercury deposition are *unchanging*. Night skies are considered to be of *moderate concern*. Soundscapes were not assigned a condition for ALPO due to the lack of data for the park.

Weather and Climate

We did not conduct a condition assessment on weather and climate, primarily because these indicators represent drivers of change in the condition of natural resources. Rather, we reported the trends in precipitation and temperature data collected from the nearest monitoring location with the longest period of record of data collection that was most representative of park conditions. The trend arrows also differ from the standard terminology used in this NRCA, because an increase or decrease in precipitation or temperature does not necessarily coincide with improving or deteriorating condition. These indicators serve a very important purpose in understanding the effects of climate change on both terrestrial and aquatic ecosystems at multiple scales from communities to populations of species and even individual organisms. Precipitation and temperature trends indicate that ALPO has been experiencing milder winters with less snow cover. The lowest recorded temperature during the calendar year increased throughout the entire period of record, while the number of sub-zero days decreased. Thus, the coldest days of the year are becoming warmer. In accord with these milder temperatures, the growing season length has increased. Although the cumulative annual precipitation has remained roughly the same, all precipitation in the form of snow is decreasing. These changes can have substantial impacts to aquatic and terrestrial plant and wildlife communities, affecting multiple factors related to overall population success, including life cycles, adaptive strategies, reproductive health, range expansion and contraction, competition with invasive species, etc. We recommend continued monitoring to provide important context for interpreting results from other natural resources condition assessments.

Water Quality

Past land use has substantially impacted water quality at both the Main Unit and SBTU. Historical land use in and around the headwaters of Blair Gap Run and Bradley Run included surface and subsurface mining activities, resulting in several acidic and net-alkaline seeps throughout this area. The SBTU has been severely impacted by mining activities; with many of its small drainages resulting from acidic abandoned mine drainage and iron mounds. Water chemistry, overall, suggested rankings of *good* condition at the Main Unit and *moderate* to *significant concern* at the SBTU. The aquatic macroinvertebrate community ranked the mainstem of Blair Gap Run as *moderate concern*, while two tributaries were considered to be in *good* condition. Like the water chemistry parameters, biological condition in the headwater reaches of the Summit Area were largely of *significant concern.* Long-term monitoring by the ERMN will provide important water quality information, including trends in condition, for this indicator. As aquatic macroinvertebrates represent a more reliable and robust indicator of water quality than discrete water chemistry measurements, the overall water quality rating for the Main Unit is based primarily on the BMI results, which corresponds to *moderate concern*. Water quality is recognized as an important vital sign with water chemistry and aquatic macroinvertebrates being monitored regularly by the ERMN. We recommend these monitoring activities continue in order to protect these valuable resources. Although the impacts from AMD are of significant concern, steps to correct these impacts are typically beyond the available resources of park managers. Thus, we recommend the park continues to work with local, state, and federal agencies to assist in remediation efforts.

Ecosystem Integrity

Past land use activities have resulted in major shifts in forest community composition, some of which include dominance of undesirable species. While most forest associations within ALPO ranked *good* for floristic quality, all associations contain non-native, invasive species, as well as several other non-target invasive and weedy species that could potentially become problematic. It is likely these areas will decrease in quality if measures to control invaders are not undertaken or continued. For these reasons, the condition of Forest/Wood/Shrubland habitats within the park warrants *moderate concern*. Specific measures of grassland metrics indicated mixed condition ratings indicating an overall rating of *moderate concern.* Although grasslands are an important natural resource that provide habitat for declining bird populations, the steep terrain and dense forests covering much of the park severely limits the ability of park management to establish and maintain sufficient patch sizes to support breeding grassland bird populations. Therefore, we recommend that the focus remain on optimizing the habitat quality of the existing grassland patches around the Lemon House. Minimal information exists regarding wetlands. In order to properly address concerns for this critical resource, multi-year monitoring is necessary. This is especially important considering many of the wetlands throughout the park have been invaded by aggressive plant species. The condition of ALPO wetlands warrants *moderate concern*. Several wetland types supported target invasive species, suggesting condition will most likely decline in the future if control measures are not included in management plans. We recommend control measures be put in place or maintained in forests and wetland communities to prevent the further spread of both undesirable understory species and non-native invasive species.

Biological Integrity

Biological integrity indicators were rated across a variety of condition levels. Four species of concern were inventoried within the park. These species received an overall rating of moderate concern given their low population numbers within the boundary of the surveyed areas, although brook trout and crayfish populations at the Main Unit were considered good. Northern myotis was considered to be of significant concern. Additional surveys to assess the bat community as a whole also found declining populations and diversity of bats using the Staple Bend Tunnel as a winter hibernacula and also warranted significant concern while bat diversity park-wide was rated as moderate concern. The Bird Community Index (BCI) was used to evaluate the avian community, both for streamside birds at the Main Unit and for Breeding Bird Atlas (BBA) surveys regionally. BCI scores rated the Main Unit as good and the surrounding region as moderate concern with and unchanging trend. Reptiles and amphibians and mammal communities warranted moderate concern because only 67% of expected reptile and amphibian species and only 42% of expected mammal species were found to be in the park. Four species were monitored as non-native invasive species indicators, which included hemlock woolly adelgid, gypsy moth, brown trout, and crayfish. Gypsy moths occur at low levels within the park and were considered good. Non-native crayfish were not found within the park and levels of native crayfish populations were also good. Brown trout are known to occur just outside the boundary of the park resulting in a rating of moderate concern. Additionally, hemlock woolly adelgid has now been found within the park and warrants significant concern. Action to remove or maintain their absences within the park is at the utmost importance. Non-native invasive plants are a major threat to biodiversity and natural resource condition at ALPO. In 1999, eight non-native invasive plant species were targeted by the park as high priorities for control. In addition, an invasive plant study found 91 non-native plant species in the park, of which 19 were considered to be moderate or serious threats by DCNR. Target non-native invasive species warrant moderate concern at both the Main Unit and SBTU; % non-native species also warrant moderate concern at the Main Unit but were considered to be in good condition at the SBTU. We recommend that park managers continue to monitor all relevant biological indicators on a regular schedule (i.e., approximately every 2-5 years) to gain or maintain trend information and provide an opportunity to intervene when invasive species issues or urgent changes in protected species arise.

Landscape Use, Patterns and Fragmentation

Land cover condition was compared to detect change between 1992 and 2006. Based on past work we selected Percent Forest, Percent Core Forest, Road Density, and Percent Developed as our primary metrics for evaluation as they help to inform on forest habitat condition and forest fragmentation. To aid land cover interpretation we included photo interpreted land use using historic aerial photography from 1939, 1994 and 2006. Between 1992 and 2006 both percent forest and percent core forest decreased slightly in the Main Unit. The SBTU had a similar trend for forest but remained unchanged for core forest. Road density was unchanged for both the Main Unit and SBTU and within the catchment landscape percent development increased in both park units with the SBTU being the highest at 9.2% but still within the <10 % Good condition threshold. From the land use data we found that percent forest increased from 1939 to 2006 but percent core forest decreased suggesting increased forest fragmentation in or near ALPO's Main Unit. There does not appear to be indications of important landscape change in the region but park conditions are directly influenced by areas close to the park boundary. However, forest fragmentation appears to be increasing in the region and with the potential for still unknown changes brought by energy development, efforts should be made to influence regional development decisions, especially in that 1 km buffer zone, to reduce the impacts of forest fragmentation on the habitats inside the park.

ALPO natural resource condition assessment categories, results, and recommendations

RESOURCE	CONDITION/TREND	RECOMMENDATION
Air Quality		
Ozone	*Moderate Concern with improving trend*	Continued monitoring, especially of wet N, S, and wet & dry Hg within the park
Visibility	*Significant Concern with no trend*	
Wet N & S Deposition	*Significant Concern with improving trend*	
Wet Hg Deposition	*Significant Concern with no trend*	
Night Skies	*Moderate Concern with unknown trend*	
Weather & Climate		
Precipitation Trends	*Declining trend for winter precipitation (snow)*	Continued monitoring to provide context for interpreting results for other park resources
Temperature Trends	*Increasing trend for minimum temperatures*	
Water Quality		
Water Chemistry--Core	*Moderate Concern with unknown trend*	Continuous montioring within the park to detect impacts and trends and work with outside agents to address AMD issues
Aquatic Macroinvertebrates	*Moderate Concern with unknown trend*	
Ecosystem Integrity		
Forests/ Wood/ Shrubland	*Moderate Concern with unknown trend*	Implement control measures to slow the spread of undesirable species
Grasslands	*Moderate Concern with unknown trend*	Optimize habitat quality of existing grassland patches
Wetlands	*Moderate Concern with unknown trend*	Implement control measures to slow the spread of invasive species; increaes
Biological Integrity		
Species of Special Concern		
American Bugbane & American Ginseng	*Not Rated* *Moderate Concern with unknown trend*	Continued inventory and monitoring of existing populations
Northern Myotis	*Significant Concern with deteriorating trend*	
Brook Trout	*Good with unknown trend*	
Bat Communities	*Significant Concern with deteriorating trend*	Continued monitoring of existing populations
Bird Communities	*Good with unknown trend*	
Amphibians & Reptiles	*Moderate Concern with unknown trend*	
Mammals	*Moderate Concern with unknown trend*	
Non-Native Invasive Animals		
Hemlock Woolly Adelgid	*Significant Concern with unkown trend*	Regular monitoring to gain and maintain trend information and interven when invasive species issues arise
Gypsy Moth	*Good with unknown trend*	
Brown Trout	*Moderate Concern with unknown trend*	
Crayfish	*Good with unknown trend*	
Non-Native Invasive Plants	*Moderate Concern with unknown trend*	Control measures to slow the spread of target invasive species
Landscapes	*Good with unchanging trend*	Continued monitoring of trends in external threats to park resources

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*

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, however, the breadth of natural resources and number/type of indicators evaluated will vary by park
- employ hierarchical indicator frameworks that 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
- 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-on response (e.g., ecological thresholds or management "triggers")
- emphasize spatial evaluation of conditions and GIS (map) products. As possible and appropriate, NRCAs describe condition gradients or differences across the park for important natural resources and study indicators through a set of GIS coverages and map products
- summarize key findings by park areas. In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on a area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested
- follow national NRCA guidelines and standards for study design and reporting products

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

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

Important NRCA Success Factors …

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

Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ➪ indicators ➪ broader resource topics and park areas)

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

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

In-depth analysis of climate change effects on park natural resources is outside the project scope. However, existing condition analyses and data sets developed by a NRCA will be useful for subsequent park-level climate change studies and planning efforts.

NRCAs do not establish management targets for study indicators. Decisions about management targets must be made through sanctioned park planning and management processes. NRCAs do provide science-based information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning and help parks report to government accountability measures.

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

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)

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

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

Chapter 2 Introduction and Resource Setting

2.1 Introduction

The mission of NPS is to preserve "unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations" (http://www.nps.gov/aboutus/mission.htm). To aid this mission, the NPS implemented a national strategy to ensure that individual park units possessed the information needed for effective, science-based resource management decision-making. This strategy consisted of three major components: 1) basic resource inventories to provide the basic foundation for monitoring efforts; 2) experimental monitoring programs to evaluate alternative monitoring designs and strategies; and 3) ecological monitoring in all parks with significant natural resources (Marshall and Piekielek 2007). These parks were grouped into 32 monitoring networks, linked by geography and shared natural resource characteristics, to share funding and professional staff in order to plan, design, and implement an integrated long-term monitoring program designed to collect, analyze, and share new data.

Allegheny Portage Railroad National Historic Site (ALPO) is one of nine parks belonging to the Eastern Rivers and Mountains Network selected for a natural resource condition assessment (Figure 1). Although this small park was established for the preservation of cultural resources, these resources are embedded within the natural resources of the park, including forested mountains, streams and other natural areas supporting a variety of wildlife, including rare or regionally important plant and animal species. Understanding the structure and function of these ecosystems, as well as the lasting impacts to them from past land use as humans began to reshape the land and extract its resources through agriculture, logging, mining, damming, and other activities, is essential to maintaining both the cultural and natural resources of the park for future generations (Marshall and Piekielek 2007).

Furthermore, developing practical solutions to aid park managers in balancing the often conflicting needs of both cultural and natural resources, especially when the latter extend beyond the boundaries of the park, requires site-specific information collected at multiple spatial and temporal scales. This cannot be accomplished without long-term ecosystem monitoring of the physical, chemical, and biological elements and processes that represent the overall health or condition of park resources, important human values, or suspected and known stressors that impact a condition or value (Marshall and Piekielek 2007).

The following NRCA for ALPO begins with an extensive review of the land-use history of the region. This is important for several reasons: 1) past land use leaves behind a legacy that shapes both present and future natural resource condition; and 2) the narrow, fragmented nature of ALPO's boundaries make this park extremely vulnerable to surrounding land use change. Thus, interpretation of the natural resource conditions in the park must be made within the context of the region's history.

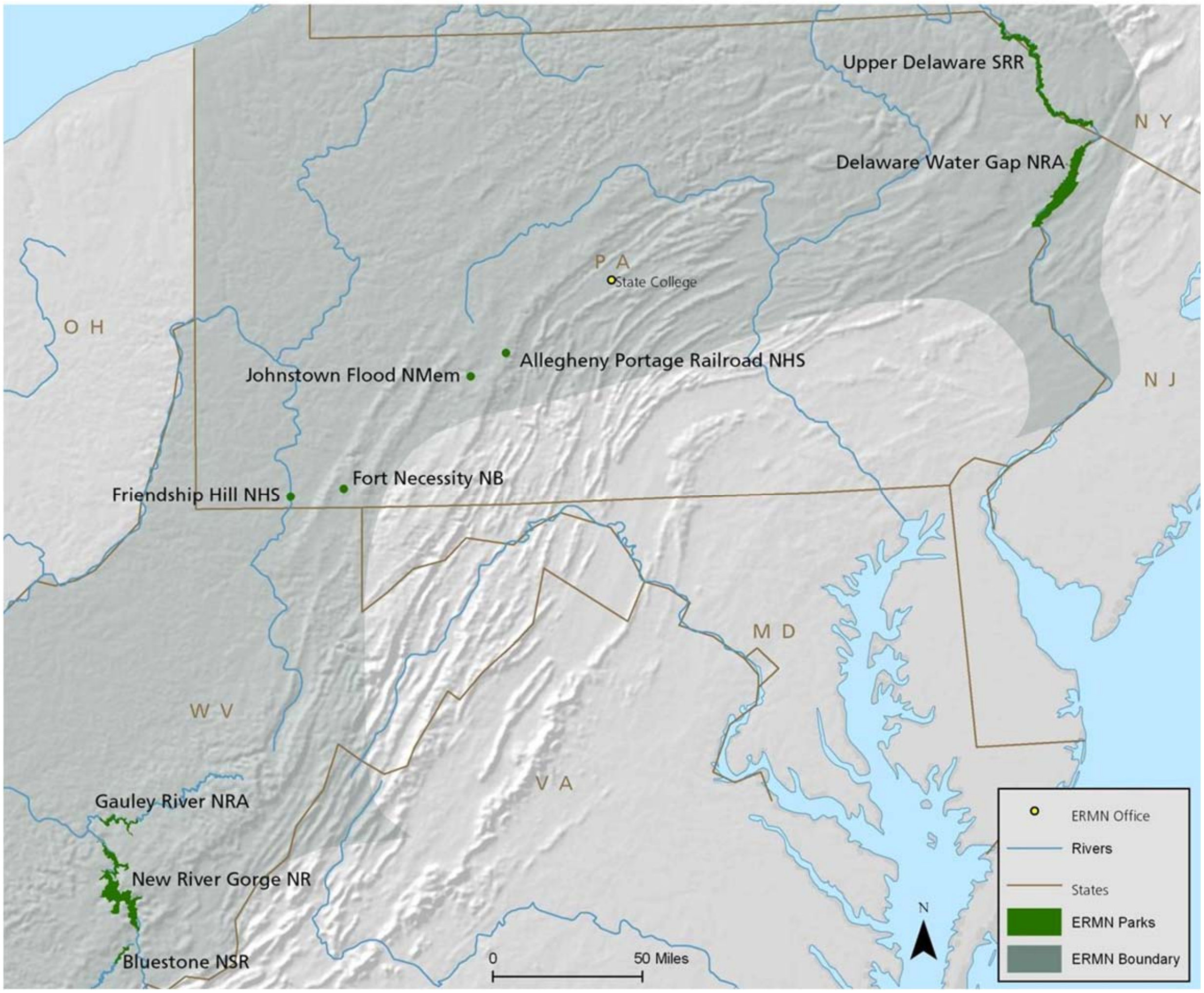


Figure 1. Locations of the Eastern Rivers and Mountains Network parks (from Marshall and Piekielek 2007).

2.1.1 History

Cultural history in Pennsylvania extends thousands of years into the past to the descendants of Paleo-Indians. Although the Delawares or Lenni Lenape became the Native American group most often thought of as living in Pennsylvania, the picture was much more complex. Historically, several distinct groups inhabited the region but inter-Indian conflicts, disease, and other factors produced recombinations of these former entities into mixed groupings of survivors. By the seventeenth century, the three great river valleys of what is now the Commonwealth were occupied largely by the Lenape and Munsee Indians along the Delaware River, the Susquehannocks on the Susquehanna River, and poorly known settlements along the upper and lower Ohio Rivers collectively known as the "Monogahela people" (Richter 2002). Although at that time the Iroquois, or Five Nations, resided to the north in what is now New York, through a series of conflicts they eventually gained control of the wilderness west of the Susquehanna. Europeans came into Pennsylvania during the Late Woodland period and would have likely encountered Native groups that were no longer nomadic but living in towns, engaging in social and religious rituals, making pottery, carving, weaving, singing and dancing. As before, interaction among Native neighbors often led to rivalry and warfare, but the addition of European trade in the area fueled flames as weapons became some of the first objects acquired by trade. Interaction between Native groups and Europeans often escalated as they fought each other for the land (Miller and Pencak 2002, Wallace 1999). Consequently, although land was made legally available to settlers as early as 1755, the area was extremely dangerous to settle, especially along the Kittanning Path as the western section of the Frankstown Path (near the region that is now ALPO) was known. Thus, little area had been cleared at this time and was mostly dense forest (Clark 1896, Emerson 2002).

During a relatively peaceful period between the French and Indian War and the Revolutionary War (~1764 – 1775), many land warrants were issued and land was cleared for settlement starting primarily in the eastern portion of the region (e.g., Morrison's Cove ~1760 and Hollidaysburg area ~1768) and moving westward to what is now Cambria county and the western border of Blair county (corresponding roughly to the Main Unit). After obtaining a warrant, a survey was conducted of the tract of land and trees located at the corners were marked as 'witnesses' to the boundaries. Figure 2 provides an image of the area as shown in W. Scull's map of Pennsylvania (1770-1775) encompassing the region within and surrounding what is now the Main Unit of ALPO. At the time, there were no roads going through the area, only the Kittanning Path from Frankstown. The Kittanning Path was part of a vast system of interconnecting trails that stretched across the Allegheny Mountains and ended at the Native American village of Kittanning along the Allegheny River. Although the old Indian trail was widened to make way for wagons, no towns or villages with shops could be yet be found in the region (Clark 1896, Butts and Kurtz [no date], Emerson 2002).

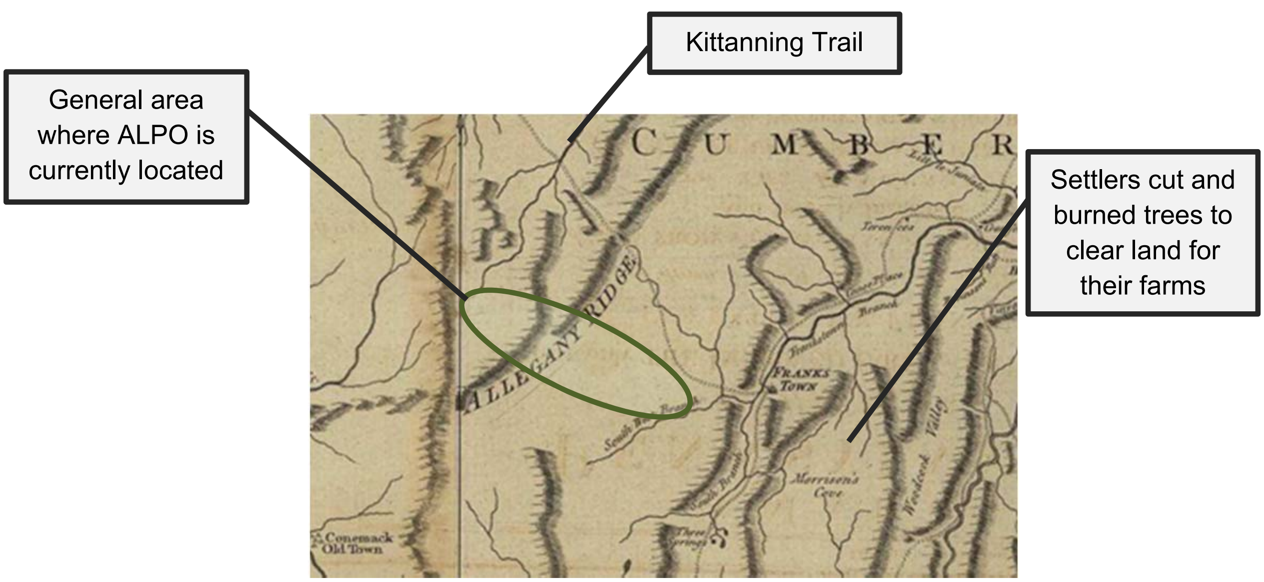


Figure 2. Close-up of the region surrounding ALPO's Main Unit taken from 'A Map of Pennsylvania, 1770-1775' by W. Scull (Pennsylvania Digital Map Library, USGenWeb Archives, United States Digital Map Library; http://usgwarchives.org/maps/pa.

Settlers to the area were searching for farm land and consisted primarily of two main groups. First, the Scotch-Irish, many of whom were squatters prior to 1754, settled primarily along the valleys north of present-day Altoona but were either burned out or moved on after a year or two after their farms failed to produce good crops. The Pennsylvania Germans, on the other hand, were excellent farmers who sought deep, fertile, well-watered soil (usually by looking for black walnut stands) and built up the soil producing richer yields year after year. For many years, agriculture was the primary endeavor; the dense forest of trees was seen as a hindrance, rather than a resource. Millions of board feet were piled together and burned to make way for fields and dwellings (Clark 1896). Iron making was established in Pennsylvania during the colonial period and lead was actively mined during the Revolutionary war.

Early Manufacturing

Following the Revolutionary War, more settlers came to the region, including Captain John Blair. It did not take long before they began to utilize the natural resources above and below ground. The hilly terrain and gorges of the Allegheny Mountains produced numerous fast-flowing streams complete with waterfalls and cascades. The early settlers took advantage of this falling water to power mills for grinding grain, sawing and processing wood. Raceways and flumes were also used to bring water to power mills where no falling water existed. Grist mills constructed of wood and stone ground wheat and corn into grain and flour. Captain Thomas Blair owned and operated one of the first gristmills, as well as two sawmills, near the park at the eastern end of Blair Gap in 1785 (Clark 1896). At that time, whiskey was considered as much a necessity as flour, and many distilleries were also established in the area.

George Washington's grist mill, circa early twentieth century. (Copyright 2005, David E. Illig).

Timber Industry

Trees have always been the state’s most important renewable resource. Although originally viewed as an obstacle, it did not take long before the value of timber for industry became apparent, first as fuel for the charcoal furnaces to make iron (~150 acres of wood/year/furnace), and later as wooden ties for the railroad and props for coal mines. By the 1860s, the pulpwood industry had emerged, followed by the chemical industry and wood was needed for paper, alcohol, and other goods. Between 1760 and 1895, more than four million acres of forests were harvested two to four times to feed Pennsylvania’s charcoal furnaces and railroads consumed more than 15% of the nation’s timber supply (http://www.explorepahistory.com/). The barren landscape that was left prompted Joseph Rothrock, the state’s first forest commissioner, to refer to it as the “Pennsylvania Desert.”

Skidway of more than 3,000 logs above railroad tracks, somewhere in Pennsylvania, circa 1900 (Courtesy Pennsylvania State Archives). (http://www.explorepahistory.com/)

Iron Industry

Iron ore was discovered in the Juniata Region before the Revolutionary War and was well established in Pennsylvania during the colonial period (Nancy Smith, ALPO Cultural Resource Manager, pers. comm.). Water power was used to blow air through blast furnaces containing a mixture of iron ore, charcoal, and limestone to make iron (http://www.explorepahistory.com). Raceways and flumes were also used to bring water to power mills where no falling water existed. At that time, substantial amounts of charcoal were needed, and ironmasters typically owned large tracts of land for supplying wood. Dr. Peter Schoenberger was considered to be the most prominent ironmaster in the state. At one time he owned ~100,000 acres throughout Pennsylvania and West Virginia, including much of the land in and around what is now Allegheny Portage Railroad NHS. Small ‘company’ towns were established near these furnaces. Each was owned and operated by the company, which also provided homes, stores, churches, and schools for the woodcutters, miners, furnace workers, and other skilled and unskilled laborers needed in the iron-making process. Initially, the first iron was marketed to Pittsburgh and transported at great expense across the Alleghenies on horses or mules followed by boats along the Conemaugh River (Clark 1896). Other manufacturing at the time included fulling and wool carding works, one of which was operated by Robert Gardner at the eastern end of Blair’s Gap near Blair’s old grist mill in 1832. In 1855, there were thirty-two iron and steel working establishments in Blair County (Clark 1896). However, by 1870 most of the iron furnaces in the area closed thanks to cheaper ore and improved methods at Pittsburgh and other large iron centers, which reduced the market price to where small operations could no longer compete, most of the iron furnaces in the area closed.

Coal Industry

As coke replaced charcoal in the iron-making process, the coal industry grew rapidly in Cambria and Blair Counties. The earliest commercially operated coal mines in Cambria County began in 1845 and included Samuel Lemon's mine, which was discovered while digging a well for water to operate the engine on Plane 6 located near the Summit area of the park. For over a century coal mining played an important role in the local economy (Clark 1896).

Allegheny Portage Railroad, the Canal, and the Pennsylvania Main Public Works

In the early nineteenth century, the migration west was beginning in earnest, and the need for two-way transportation was essential. Conestoga wagons were the most dependable means of transportation, but they were also slow, expensive and unable to carry enough cargo to meet demand. However, a more efficient system of transporting goods already existed---water. At that time, it was less expensive to transport goods from Philadelphia to Pittsburgh by ships traveling down the east coast, into the Gulf of Mexico, then up the Mississippi and Ohio Rivers by steamboat to Pittsburgh (Hegemann 2010). Unfortunately, this wasn't any faster than the wagons. Pennsylvania and New York each possessed a major seaport (Philadelphia and New York City) and industrial manufacturing bases for raw materials farther inland (Pittsburgh and Buffalo), making them the top rivals for western trade. The winner: the first to connect their coastal port with their inland ports and the trading places of the Ohio Valley and Great Lakes. Railroads were not yet an option; the best alternative was to build a waterway or series of canals to shorten the distance ships needed to travel west.

After New York completed the Erie Canal, Pennsylvania countered with the State Works project in 1826, a massive endeavor to utilize the waterways of the commonwealth for transportation by creating divisions of canals across the state. The first section of the Pennsylvania Canal's Main Line extended from Philadelphia to Hollidaysburg; the second section began in Pittsburgh and extended east toward Johnstown. In between lay the vast expanse of the rugged Allegheny Mountains, which rose to an elevation of 1,398 feet above Hollidaysburg on the eastern side and 1,171 feet above Johnstown to the west, with its highest point found along Blue Knob Ridge (~3,000 feet) (Hegemann 2010). A member of the board of commissioners charged with establishing the canal system referred to the mountains as being "thrown together as if to defy human ingenuity, and baffle the skill of the engineer" (Hansen 2008). Undeterred, a team of resourceful engineers designed the Allegheny Portage Railroad, which wasn't exactly a railroad, but rather a system of horse-drawn rail lines and tiered incline planes (five on each side of the Allegheny Mountains) which carried the canal boats across the Alleghenies (Figure 3). Horses were replaced by locomotives in the start of the second year. This 36-mile route completed the line between Hollidaysburg in Huntingdon (now Blair) County and Johnstown in Cambria County and also included the construction of the nation's first railroad tunnel, the Staple Bend Tunnel located near Johnstown. The Allegheny Portage Railroad opened in March of 1834 and was considered to be one of the greatest engineering accomplishments of the day and shortened the journey from Philadelphia to Pittsburgh from 23 days to four. The Portage Railroad itself reduced the trip through the mountains from three days to six hours.

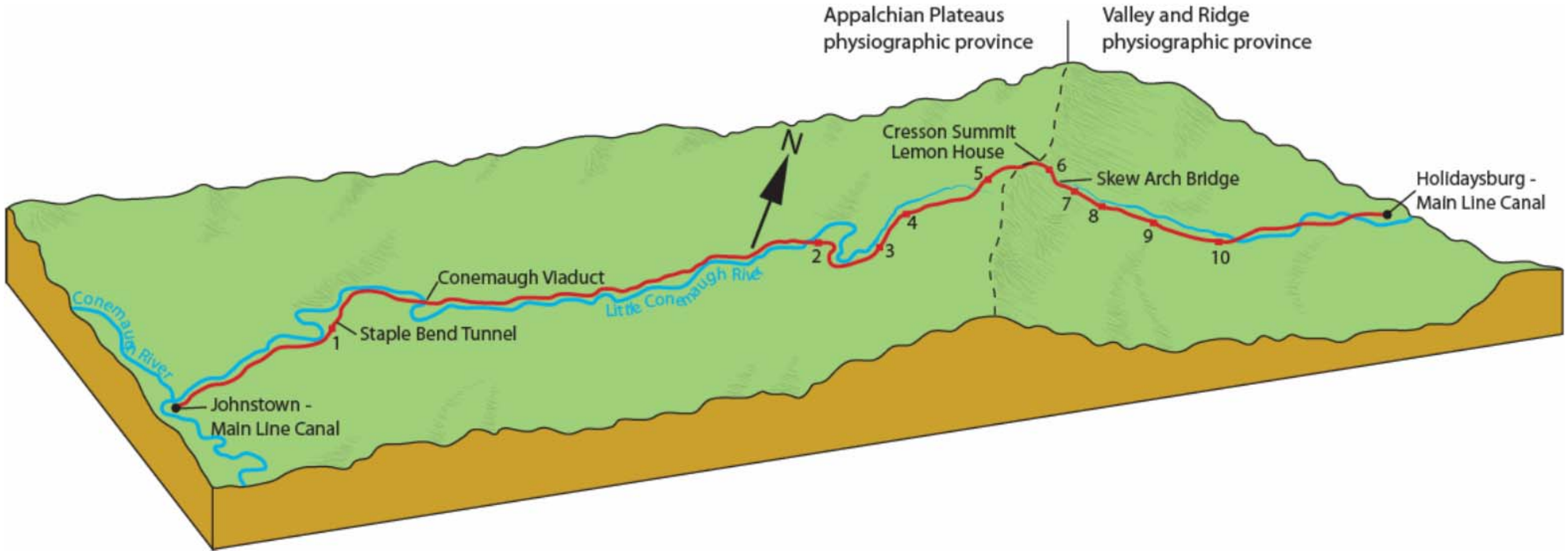


Figure 3. Relief map of the portage route showing the ten incline planes connecting the Main Line Canal between Johnstown and Hollidaysburg, as well as the locations of the Conemaugh Viaduct and Staple Bend Tunnel (From Thornberry-Ehrlich 2008).

Advances in railroad construction (e.g., steam locomotives capable of hauling loads up steep grades, switchbacks, improved tunnel construction, etc.) soon rendered the canal and Portage Railroad obsolete. Although a New Portage Railroad was constructed to replace the inclines, it could not compete with the more modern Pennsylvania Railroad, which eventually purchased the public works and dismantled the Portage Railroad in 1858. The thirteen-mile section of canal between Hollidaysburg and Williamsburg closed in 1872. The Western Division closed in approximately 1864, the Williamsburg to Huntingdon line closed in 1876, and the line east of Huntingdon remained open until the 1880's or 90's. Although only in operation for two decades, the portage railroad is still regarded as an engineering marvel and symbol of America's ingenuity and perseverance during the first steps toward western expansion. An excerpt from an historical map from the Pennsylvania Railroad showing the location of the Portage Railroad, the Pennsylvania Railroad and other important landmarks, as well as locations of iron furnaces and coal fields in or near the park, is shown below (Figure 4).

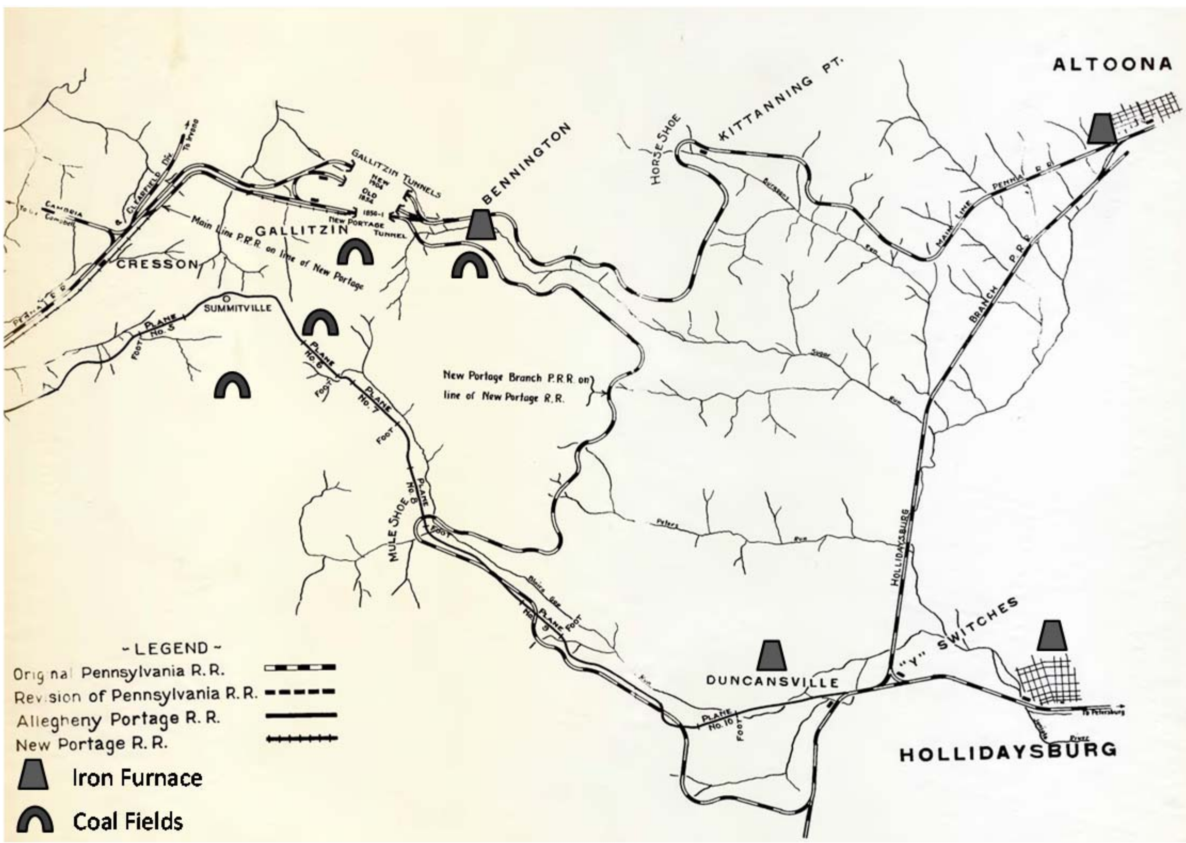


Figure 4. Historical map of region surrounding the Main Unit of ALPO showing portions of the old Portage Railroad (1834), the new Portage Railroad (1856), and the Pennsylvania Railroad (1854) including modern revisions (from a 1948 PRR Board of Directors Inspection of Physical Property—Copyright expired/Public Domain) Symbols showing general locations of iron furnaces and coal fields are also included.

2.1.2 Enabling Legislation

The Organic Act of 1916 directs the NPS "[T]o conserve the scenery and the natural and historic objects and wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (http://www.nature.nps.gov/air/Regs/npsorganic.cfm). The specifics of what constitutes impairment of park resources and values depend on the unique natural or cultural resources defined in the establishing legislation of a particular park and identified in the park's general management plan (http://www.nps.gov/protect/policy_section.htm).

ALPO was established as a unit within the National Park system on August 31, 1964 (Public Law 88-546) with the purpose of illustrating "the significant role in the nation's history of the Allegheny Portage Railroad and the Pennsylvania Canal." (NPS 1980). The significance of Allegheny Portage Railroad NHS is clearly specified in the Long Range Interpretive Plan (LRIP):

> *--The railroad was "one of the great engineering wonders of its day" (U.S. House of Representatives, Committee on Interior and Insular Affairs, 1963). The railroad was the first to apply emerging technologies (including steam and locomotive power, containerized cargoes, wire rope, business practices, and tunnel construction) to the problem of surmounting the Allegheny Mountains.*
>
> *--The Pennsylvania Mainline Canal, including the Allegheny Portage Railroad, was an early (and perhaps the first) intermodal transportation system.*
>
> *--The Allegheny Portage Railroad and Pennsylvania Mainline Canal shaped patterns of regional economic and social development, and helped sustain Pennsylvania's economic well-being for over 20 years.*
>
> *--Construction of the railroad, combined with the Pennsylvania Mainline Canal, exemplified the competitive spirit among several eastern cities (New York, Philadelphia, and Baltimore) and states (New York, Pennsylvania, and Maryland) for commercial access to the Ohio River Valley.*

The law specified that the site could include 950 acres of land and portions of the "Pennsylvania Canal, the Lemon House, the Summit of the Allegheny Portage Railroad, the Skew Arch Bridge, incline planes numbered 6, 7, 8, 9 and 10 and the levels between them, the Portage Railroad tunnel, and such other land and historic features as may be necessary to illustrate the significant role of the Allegheny Portage Railroad and Pennsylvania Canal in the Nation's history" (from the LRIP available at www.nps.gov/alpo/parkmgmt/index.htm).

Cultural Resources

Park-wide management objectives are "to use, enhance, and preserve extant cultural resources and natural resources within the National Park Service units and interpret associated stories that will enable visitors to understand why the Pennsylvania Canal and Allegheny Portage Railroad were constructed, the technical challenge….and the human experience…" (NPS 1992). Although the purpose of this assessment is to synthesize information on the park's natural resources, they must be managed in concert with the park's cultural resources. In fact, parkwide management objectives also specify “to protect and maintain natural diversity of plants and animals outside of areas managed for primarily cultural resources or developed areas. In areas managed for primarily cultural resources, to protect natural resources through the management of cultural landscapes” (NPS 1992). Thus, we are including a brief description of the important cultural resources managed within the park.

Lemon House

Samuel Lemon and his wife Jean built this impressive stone tavern in anticipation of the multitude of potential customers travelling the Allegheny Portage Railroad. He also owned a quarry and coal mine nearby, the latter of which was discovered when drilling for water to supply Engine House No. 6. The Lemon House is located at the Summit Level where management objectives are to “create a representation of the character of the landscape at about 1840…” (NPS 1992). It has been documented that Samuel Lemon had cleared fields at the Summit area (Kathy Penrod, ALPO Natural Resource Manager, pers. comm.).

Lemon House and field located in the Historical Core of the Summit Area. Photo by NPS staff.

Engine House No. 6 (exhibit shelter) near Incline 6, and the Lemon House. Photo courtesy NPS staff.

Engine House No. 6

Engine House No. 6 was located near the Lemon House and straddled the track at the head of plane no. 6. The original building blew up in 1852 and was replaced but eventually demolished. NPS constructed an exhibit shelter to reflect the original building, protect the archeological ruins of the foundation and house the exhibits. Full-scale models of the internal workings and a section of track leading to and from the shelter were also constructed to create a historic scene reminiscent of the time period.

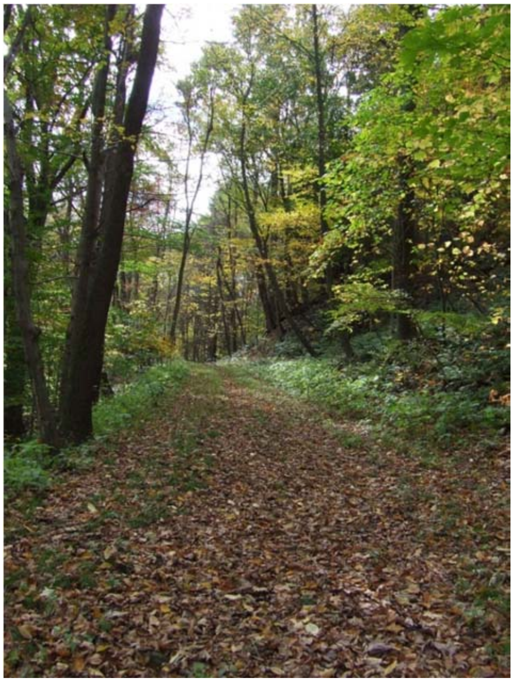
Skew Arch Bridge

The Skew Arch Bridge was designed to cross over the Old Portage at the lower end of Plane 6. Built in 1833 by the Fenlon, Darlin and Kininmouth Company, it was “skewed” during construction to accommodate the oblique angle of the crossing of the Indiana, Huntingdon and Cambria Turnpike and the portage railroad.

Skew Arch Bridge. Photo courtesy of NPS staff.

Allegheny Portage Railroad Trace/Inclined Planes 8, 9, and 10 and Corridor

On the levels, the cars were hauled by teams of horses or steam locomotives. To get over the steeper areas, stationary steam engines in each of the ten engine houses pulled railroad cars and small boats on flatbed cars up five incline planes on one side of the mountain and lowered them down five incline planes on the other side. The cars were hoisted up each plane by continuous hemp ropes, which were later replaced by iron wire ropes. The remains of the five inclines on the eastern side (Inclines 6 through 10) have been mostly preserved as grassy trailways or restored to include a section of reconstructed track (Incline 6); those on the western side, with the exception of Incline 1 at Staple Bend Tunnel, are mostly outside of the park and have been built over. Management objectives for this area are "to provide visitors….a sense of travel conditions at the time of the railroad…enhance appreciation of the stories of the railroad, the significance of geography, and the relationship of natural resources without impairing resource values…encourage maintenance of the corridor surrounding the portage railroad trace…." (NPS 1992).



Railroad trace at Incline 8 (facing east) near the Muleshoe bridge.(Photo by S. Yetter)

Staple Bend Tunnel

The Staple Bend Tunnel was the first railroad tunnel constructed in the nation. Constructed mostly by Irish and Welsh immigrants at a pace of 18" cut per day, this 900-foot tunnel took approximately two to three years (mid-1831 to late 1833) to complete. It was declared a National Historic Landmark in 1994. In 2001, a hiking and biking trail opened at the Staple Bend Tunnel Unit (SBTU). This 2-mile section of trail is maintained by NPS and is an important part of a larger, regional trail, Path of Flood. Path of Flood connects Johnstown to Ehrenfeld, a small community near South Fork and the Johnstown Flood National Memorial.

Staple Bend Tunnel (west portal). Photo courtesy NPS staff.

2.1.3 Geographic Setting

ALPO is located in the Appalachian Mountain section of southwestern Pennsylvania. The Main Unit lies approximately twelve miles west of Altoona; the SBTU is located approximately four miles east of Johnstown (Figure 5). The Summit area of the Main Unit and SBTU are located in Cambria County, which is 688.35 square miles and has a population of 141, 584 (2012 census), which has decreased by 1.5% since the 2010 census. Population density of the county is approximately 209 persons per square mile, with highest densities found in the Johnstown, PA Metro Area. The remainder of the Main Unit is located in Blair County, which is 525.8 square miles and contains the Altoona, PA Metro Area. In 2012 the population of Blair County was 127,121 and has remained relatively unchanged since 2010; over 46,000 people are located within the city of Altoona. Population density of Blair County is approximately 242 persons per square mile (http://quickfacts.census.gov/qfd/states/).

2.1.4 Visitation Statistics

Since 1968 ALPO has had 4,387,705 visitors to the park. Yearly visitation has ranged from 5,500 (in 1968) to 189,009 (1993) with the past decade averaging 123, 642 visitors per year. Based on the last full year of data, visitation occurs primarily during the summer months (50,200 visitors June through August 2012). Although visitation drops dramatically during the winter months with few people visiting the park facilities, many cross country skiers enjoy the trails in snowy conditions (http://irma.nps.gov/Stats/Reports/ReportList).

2.2 Natural Resources

2.2.1 Physical Setting of ALPO

Climate

ALPO is located in the South Central Mountain region of Pennsylvania (Pennsylvania Climate Division 8). This region is generally considered to have a humid continental type of climate; however, high elevations in the mountains and deep, narrow, shaded valleys keep temperatures lower than the surrounding areas. Historically, the climate was more equitable than present, due to deep forest (Hoenstine et al. 1945). Prevailing westerly winds determine weather conditions at the park during the majority of the year, although Atlantic coastal storms may affect day-to-day weather occasionally throughout the year. Temperatures are moderately continental, tempered by cloud production from the Great Lakes and local mountain-valleys. During the summer months, hot, humid air from the Gulf region is pushed into the Laurel Highlands. Precipitation is fairly evenly distributed throughout the year with annual amounts generally ranging between 40 - 46 inches per year. The growing season typically lasts from May through late September or October (Knight et al. 2010).

Geology and Topography

ALPO’s cultural and natural resources are largely a product of the surrounding geology. The park follows the original railroad whose purpose was to traverse the large expanse of the Allegheny Mountains. As a result, the park’s Main unit is located at the junction of two physiographic provinces, beginning at the Foot of Ten area, nestled in the Valley and Ridge province, and ascending across the Allegheny Front to the Summit area within the Allegheny Plateau province

(Figure 5). The Allegheny Front is a sharp escarpment that rises abruptly from 300 to 900 m (1,000 to 3,000 ft) dividing the two provinces and was the primary reason for the construction of the Allegheny Portage Railroad (Thornberry-Ehrlich 2008).

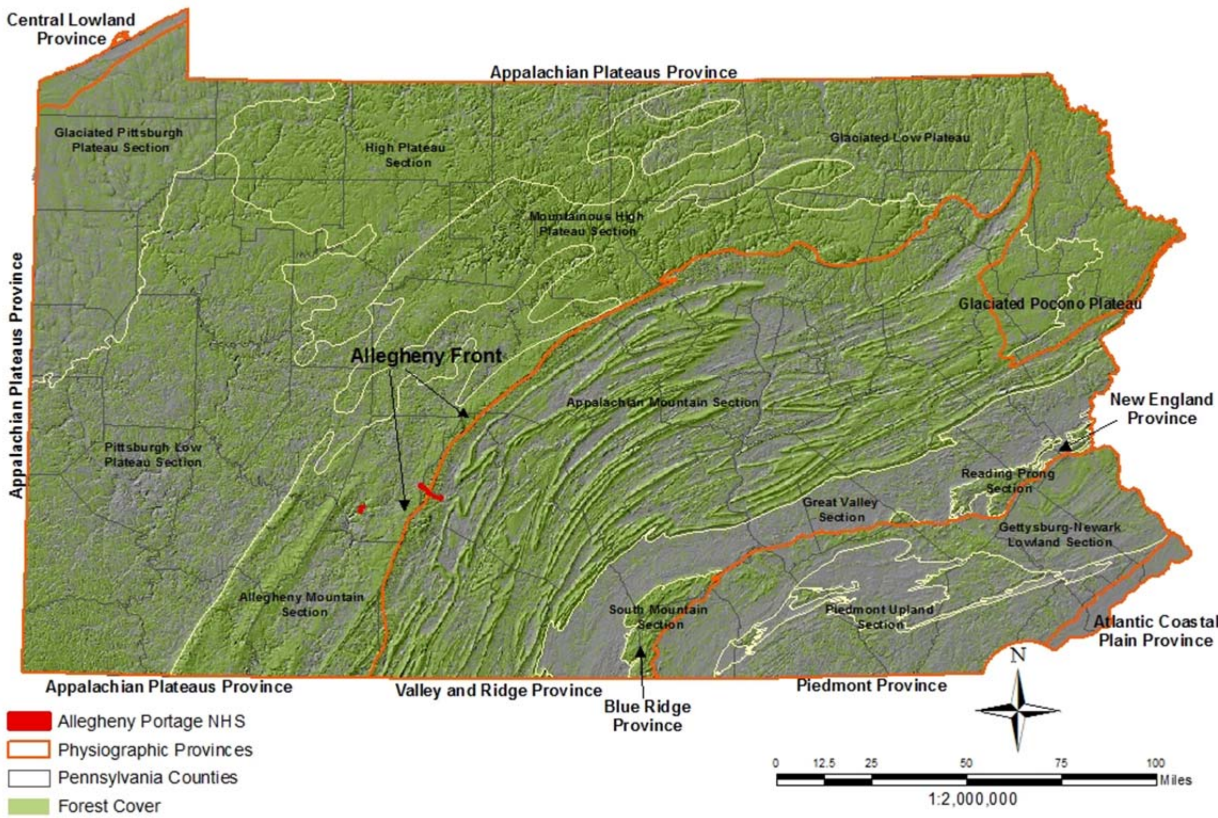


Figure 5. Map of Pennsylvania showing the physiographic provinces and the location of ALPO. The Main Unit of the park traverses the Allegheny Front with the eastern part at "Foot of Ten" starting in the Valley and Ridge province then, as you proceed west, the park climbs the Allegheny Front ending with the "Summit" area in the Appalachian Plateau province. The shaded relief used for the map helps to illustrate Pennsylvania's diverse topography. As you move from southeast to northwest across Pennsylvania the topography changed dramatically, starting with the relatively flat Atlantic Coastal Plain, in Philadelphia, and Piedmont, to the folding of the Appalachian Mountains as they pass through the state then on to the Appalachian Plateaus found in the northern and western regions. Green shading represents areas dominated by forest cover. Spatial data source: Pennsylvania Spatial Data (PASDA)

The folded and faulted sedimentary rocks of the Valley and Ridge province on the eastern edge of the park are quite different from the eroded, horizontal beds of the Allegheny plateau to the west (Thornberry-Ehrlich 2007). Alternating layers of erosion-resistant Paleozoic sandstone and less-resistant shale and carbonate rock produced high ridgetops and low-lying stream valleys. Geologic units of the Allegheny plateau are typically repetitious sequences of shale, coal, limestone, and sandstone with deep ravines characterizing much of the plateau's rugged topography (Thornberry-Ehrlich 2007). Surface geology at the SBTU is composed of a geological formation known as the Allegheny Group, which includes beds of limestone. These limestone derived soils have a high availability of nutrients and often support diverse fauna and flora. Figures 6 and 7 provide a close-up of the geologic formations underlying both the Main and Staple Bend Tunnel Units of the park, respectively. Figure 8 is a shaded relief map highlighting the deep ravines and steep elevation changes along the front and throughout the region.

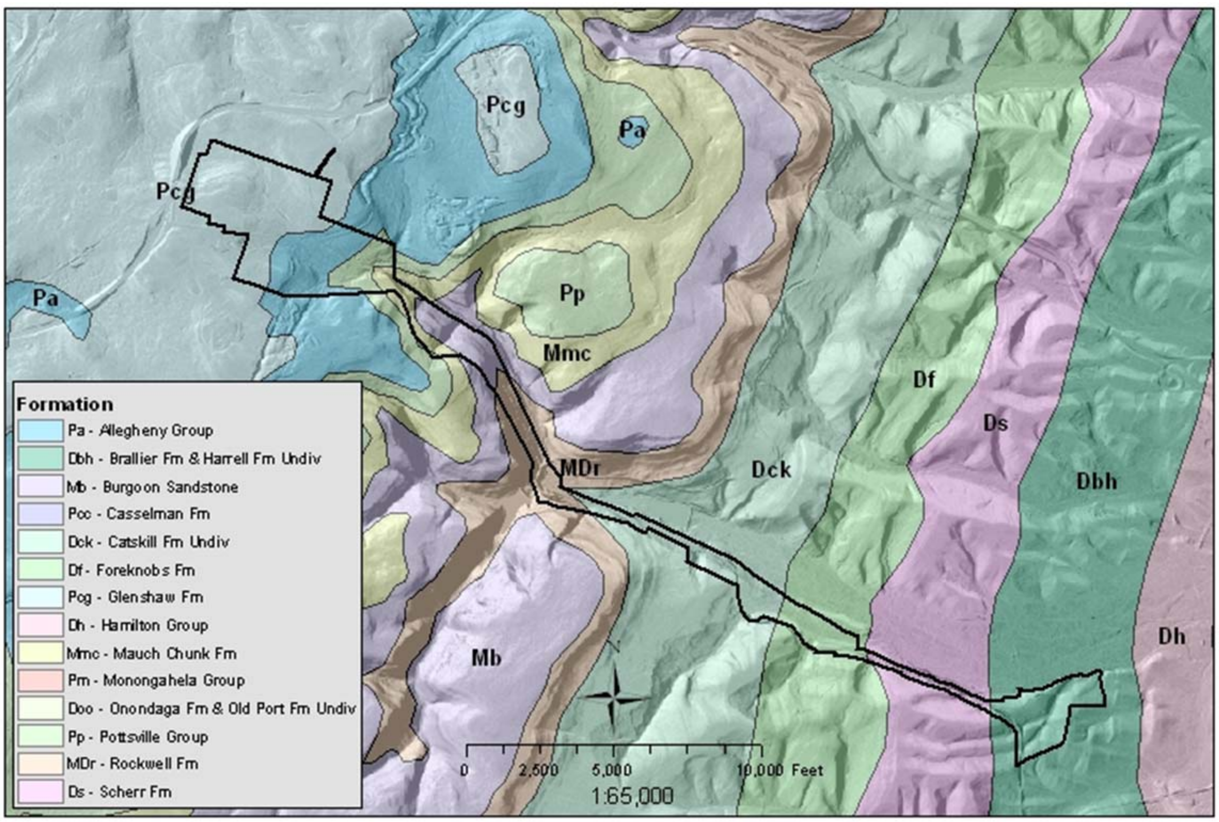


Figure 6. This map shows Pennsylvania's Surface Geology for the Main Unit of ALPO and helps to illustrate its placement along the Allegheny Front. The high resolution (1 m x 1 m) shaded relief depicts the topographic changes that occur as you move east to west up the Allegheny Front onto the Appalachian Plateau. Spatial data source: PA DCNR, Bureau of Topographic and Geologic Survey.

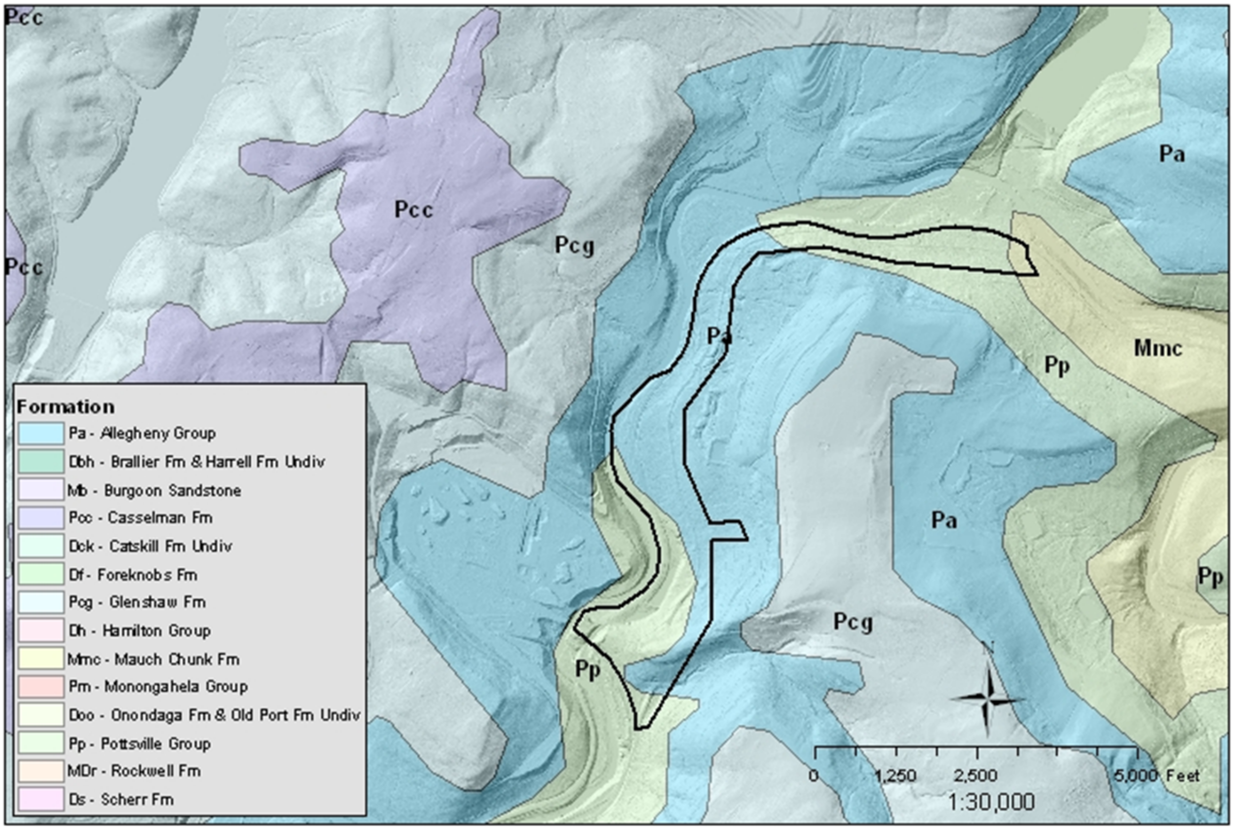


Figure 7. This map shows Pennsylvania's Surface Geology at the Staple Bend Unit of ALPO. The high resolution (1 m x 1 m) shaded relief depicts the topographic changes that occur in and near the park. Spatial data source: PA DCNR, Bureau of Topographic and Geologic Survey.

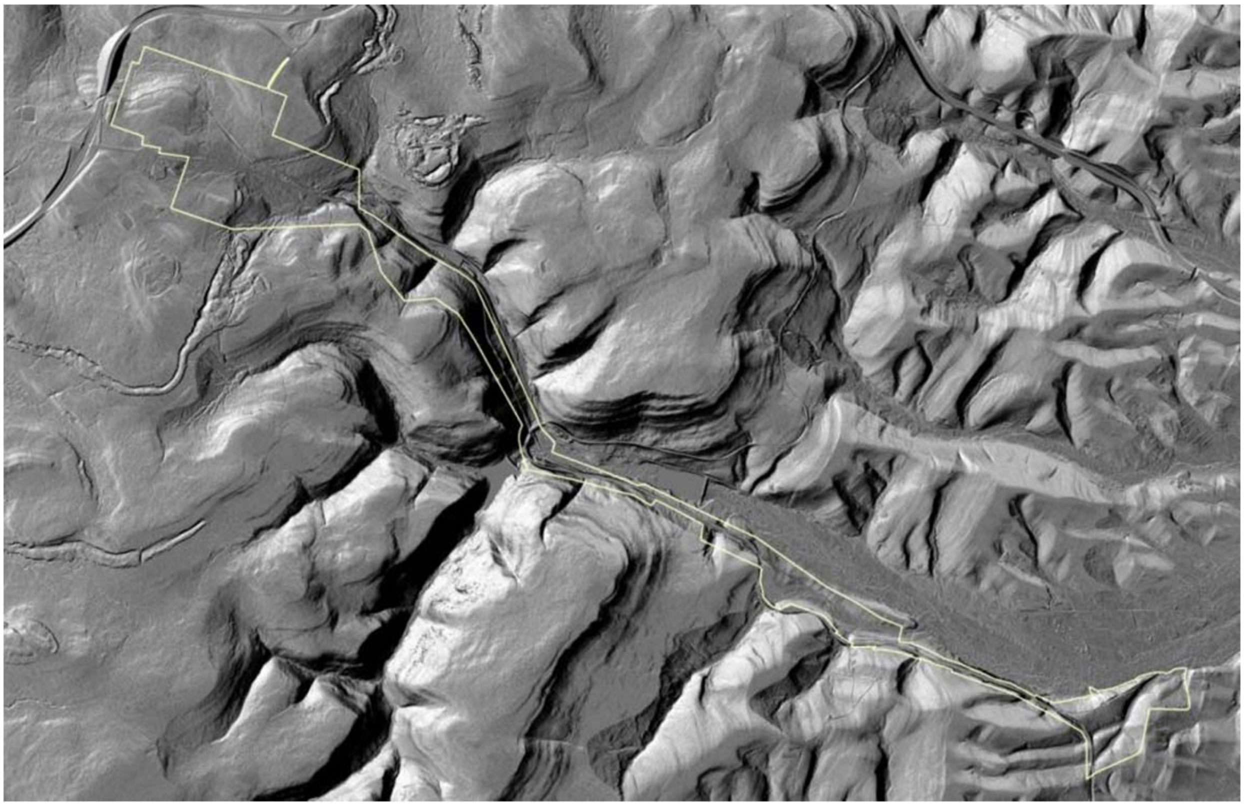


Figure 8. Shaded relief of the area around the main unit of ALPO. Shaded relief helps to enhance the visualization of changes in relief by casting a shadow on a surface with elevation data. This map shows the change in the main unit moving from high elevation on the left side down the Allegheny Front to the right. Spatial data source: PA DCNR, Bureau of Topographic and Geologic Survey.

2.2.2 Resource Descriptions and Ecological Units

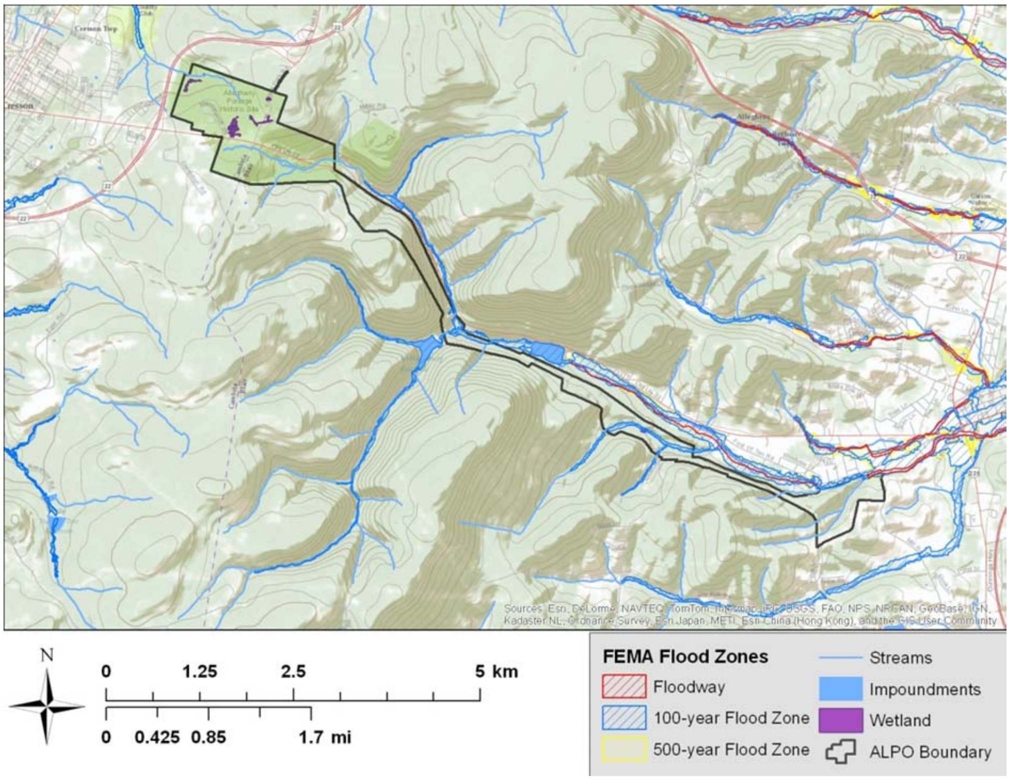
Water Resources

The lands of ALPO span the Eastern Continental Divide. The characteristic setting is one of small, high gradient mountain streams with some forested floodplain habitat and seeps, as well as steep, rocky slopes and bedrock outcrops. The majority of the park's Main Unit lies within the Susquehanna River Basin. The main watershed associated with the park Main Unit is Blair Gap Run, which the railroad followed. Blair Gap Run is designated a cold water fishery (Table 1). Its headwaters begin near the Cresson Summit and flow southwest to the Juniata River and eventually to the main branch of the Susquehanna River. The headwaters of Bradley Run flow just north of the main unit into the West Branch of the Susquehanna River (Table 1). Both Blair Gap Run and Bradley Run will eventually reach the Chesapeake Bay. The water authorities of Altoona and Hollidaysburg have three reservoirs immediately adjacent to NPS property on Blair Gap Run and/or its tributaries. The park's SBTU lies in the Ohio River Basin and is bordered to the west by the Little Conemaugh River which flows into the Allegheny River (via the Kiskiminetas River) and eventually the Gulf of Mexico (Table 1).

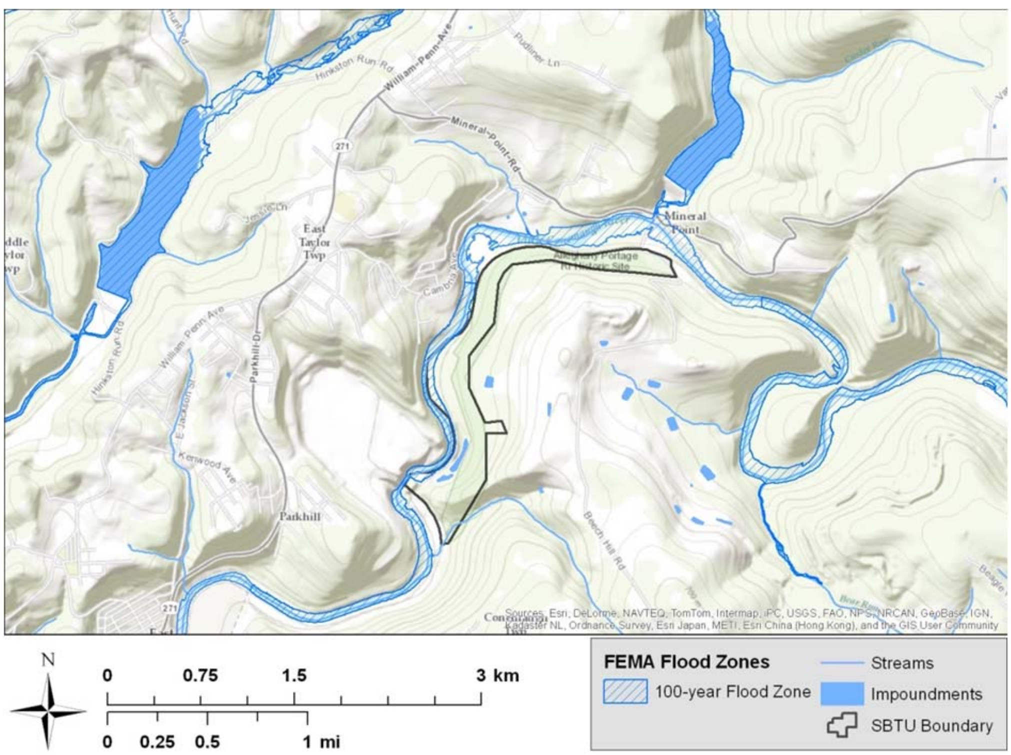
Table 1. Summary of ALPO's main tributaries, including reach description, stream miles, and whether the reach is considered to be of high quality based on state criteria (PADEP 2009a).

Stream Name	Reach Description	Stream Miles	High Quality
Bradley Run	Basin	0.65	No
Blair Gap Run	Basin: Source to Altoona (Plane 9) Reservoir at RM5.6	1.91	No
Blair Gap Run	Main stem Altoona (Plane 9) Reservoir at RM5.6 to mouth	0.54	No
Unnamed Tributary to Blair Gap Run	Basin: Altoona (Plane 9) Reservoir at RM5.6 to mouth	2.03	No
Unnamed Tributary to Blair Gap Run	Basin: North Branch Little Conemaugh River to confluence with Stony Creek	0.13	No

Wetlands are an important resource of the park, although they are not highly prevalent, representing a small percentage of land area. The Main Unit's Summit area and the headwaters of Bradley Run contain several small areas of wetland habitat, primarily in the form of wet meadows and patchy depressions, some of which are fed by groundwater seeps. The forested area south of Admiral Peary Highway (old Rt. 22) also contains some spotty wetland habitat but no seeps. In addition at the Incline 9 and the Foot of Ten areas there are some wooded wetlands and wet meadows. At the SBTU, wetland associations were identified in the vegetation classification and mapping report primarily near the river and there are two large ponds below the tunnel near the railroad tracks (Kathy Penrod, ALPO Natural Resource Manager, pers. comm.). Figure 9 shows the various water resources throughout both park units.



a.)



b.)

Figure 9. Water resources in ALPO's Main Unit (a) and SBTU (b) including streams, impoundments, and wetlands within the surrounding landscape. Park boundaries are indicated by black outlines.

Terrestrial Resources

From the summit of the mountain near Cresson, descending down the Allegheny Front in the valley of Blair Gap Run to the village of Foot of Ten, most of the land consists of forested slopes. At the eastern end of the park, near Foot of Ten and the town of Duncansville, are parts of a few abandoned farms. Most of the buildings have been removed and the previously cleared fields have been allowed to undergo old-field succession.

Forests are considered ALPO's primary natural resource. About 100 acres of forested areas are characterized by a mixture of hemlock (*Tsuga canadensis*) and hardwood species, making up the balance of natural forest types within the park. The majority of forested areas are deciduous forest with more than one-half of the park characterized as Allegheny Hardwood Forest (52%) and an additional 17 % as Northern Hardwood Forest (Perles et al. 2007). These types are typical of higher elevations of the Allegheny Plateau and represent the most common forest types in the Summit Level section of the Main Unit. This area, along with locations north and west of the Hollidaysburg Reservoir, contains the highest quality examples of these forest types. These associations are dominated by sugar maple (*Acer saccharum*), yellow birch (*B. allegheniensis*), and black cherry (*Prunus serotina*). Important associate species include white oak (*Quercus alba*), red oak (*Quercus rubra*), sweet birch (*Betula lenta*), bitternut hickory (*Carya cordiformis*), shag-bark hickory (*Carya ovata*), American beech (*Fagus grandifolia*), and tuliptree (*Liriodendron tulipifera*) and red maple (*Acer rubrum*). Three types of Hemlock forests (Eastern Hemlock-Northern Hardwood, Eastern Hemlock-Tuliptree-Birch, and Dry Eastern Hemlock-Oak) are scattered throughout the park. Hemlocks are considered one of the park's prize components. The remaining natural areas are comprised of floodplain forest, alder shrubland, grassland and open meadow habitats associated with rivers, streams, and other smaller drainages. Interspersed with these natural areas are conifer plantations, old fields and successional forests, the result of previous activities that removed the forested land cover. Most of the park's invasive species are found in these latter areas. Reed Canarygrass Riverine Grassland occurs along the Dry Run drainage near Foot of Ten and is dominated by the invasive *Phalaris arundinacea*. Forest types in the SBTU are generally of lower quality than those found near the Summit. The SBTU contains the highest abundance of Tuliptree-Beech-Maple Forest and the only patch of Alder-Riverine-Shrubland, as well as invasive stands of Japanese or Giant Knotweed Herbaceous Vegetation. Perles et al. (2007) provides extensive detail on habitat associations within ALPO, their extent and characteristic species.

Grasslands occur largely within the park's cultural zones, primarily as a result of mowing to maintain the cultural viewshed and maintain the historic time period scene. These areas are mainly classified as 'medium-tall sod temperate or subpolar grassland' formation (National Vegetation Classification System), which is characterized by early-successional communities common in mowed fields and former pastures, orchards and agricultural areas. Common herbaceous species include orchard grass (*Dactylis glomerata*) and goldenrods (*Solidago spp.*).

Field studies at ALPO conducted by the Western Pennsylvania Conservancy (Grund and Bier 2000) documented one Pennsylvania Vulnerable plant species, ginseng (*Panax quinquefolia*) on park property, and one Pennsylvania Threatened plant species, American bugbane (*Cimicifuga americana*) close to and down slope of the park boundary. No federal or state endangered plant species have been identified within the park.

Biological Resources

A variety of wildlife can be found at ALPO. Species present or probably present in the park include 30 mammals, 120 birds, 15 fish, 19 amphibians and 12 reptiles (https://irma.nps.gov/App/Species/). Mammals were surveyed at ALPO from March to October in 2004 and 2005 by Yahner and Ross (2006). Moist riparian areas provide habitat for several species of shrews including the masked shrew (*Sorex cinereus*) and the smoky shrew (*Sorex fumeus*). Upland areas provide habitat from species ranging from Eastern cottontail (*Sylvilagus floridanus*) to the gray fox (*Urocyon cinereoargenteus*). Pennsylvania is home to 11 species of bats, several of which are protected by state or federal agencies. The park provides potential habitat for one federally listed bat species that has not yet been found within the park, and at least one bat species of special concern has been identified within the park. The northern myotis (*Myotis septentrionalis*) is listed as a species of special concern. Bat populations in the northeastern US have declined dramatically in recent years due to White-nose Syndrome (WNS) (USFWS 2012). The bat community at Allegheny Portage Railroad NHS was surveyed in 1997, 2001, 2005-2006, and 2012. A survey of bat hibernacula by the Pennsylvania Game Commission completed in 1997 found four species of bats utilizing the Staple Bend Tunnel within the park (Yahner and Ross 2006). Acoustic and mist-netting surveys completed in 2005 and 2006 found that 6 of the 11 species found in Pennsylvania, occur within the park. The diversity in habitat such as forests, openings, water availability and is location within the broader landscape on the Allegheny Front likely contributed to the bat diversity (Gates and Johnson 2006).

The avian community was surveyed at ALPO during the spring migration period and summer breeding season of 1997 (Yahner and Keller 2000). Avian community surveys were completed in the spring of 1997 to assess spring migration within the park. Yahner and Keller detected 61 species and 43 species at two different sites. Of the most commonly detected species in each site only two species overlapped, the Ovenbird and the American Redstart. During the summer breeding season, these sites were resurveyed and found 37 and 33 species respectively. There were five species in common among the sites most common species detected, the Red-eyed Vireo, Ovenbird, Chipping Sparrow, Indigo Bunting and Song Sparrow. Yahner and Keller found that the most species detected within the park were long- and short-distant migrants, with fewest detections coming from resident species. When avian surveys were conducted two years later they found 113 species at ALPO. These surveys documented 39 new species previously unknown to the park. Additionally, annual surveys were conducted by the ERMN from 2007-2012 at three sites within the Park for the Louisiana Waterthrush (*Parkesia motacilla)* and “streamside” bird communities (Marshall et al. 2013).

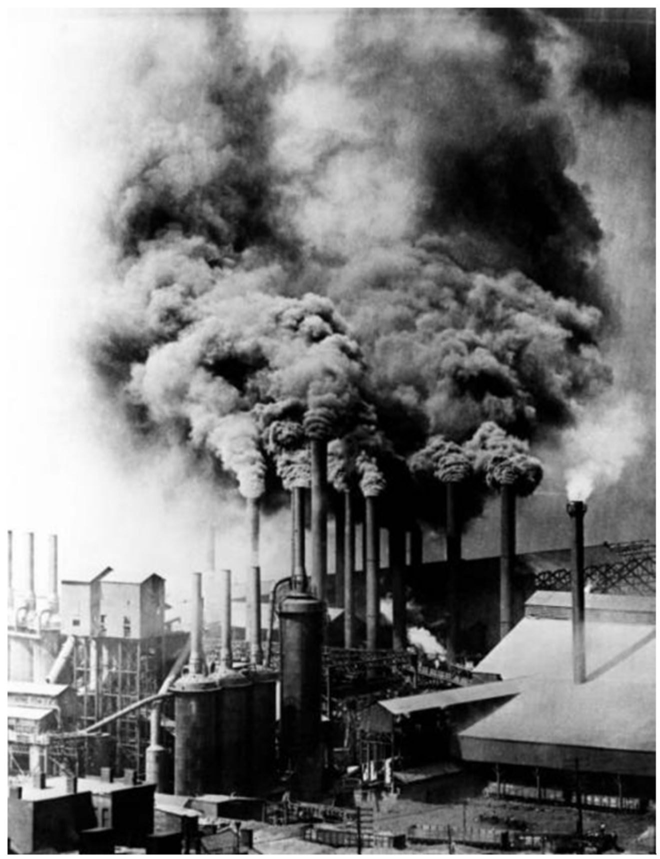
As a group, herptofauna have experienced extensive world-wide declines in population at a disproportionally high rate (Cushman 2006; Gibbons et al. 2000; Stuart et al. 2004). The inventory survey completed by Yahner and Ross in 2004-2005 found a wide variety of reptiles and amphibians that require both aquatic and terrestrial habitats (Yahner and Ross 2006). For terrestrial salamanders, both redback (*Plthodon cinereus*) and northern slimy salamanders (*Plethodon glutinosus*) were found in abundance and northern two-lined salamanders (*Eurycea bislineata*) were the most abundant aquatic salamander found within the Park (Yahner and Ross 2006). ALPO also supports populations of the smooth green snake (*Liochlorophis vernalis*) and the Eastern box turtle (*Terrapene carolina*) both of which are listed as species of special concern in Pennsylvania by the Pennsylvania Fish and Boat Commission.

Tzilkowski and Sheeder (2006) conducted a fish inventory of Blair Gap Run and its tributaries and found nine fish species typical of cool- and coldwater fish communities of the Susquehanna River drainage. No state or federally endangered species were captured and brown trout (*Salmo trutta*) was the only nonnative fish species encountered. The upper reaches of Blair Gap Run support a naturally reproducing native brook trout population, a species of special concern. Results from field surveys of brook trout (Tzilkowski and Sheeder 2006) suggested Blair Gap Run may meet the Class A wild trout water criteria.

2.2.3 Threats and Potential Stressors

Air Pollution/Industry

Early industrial advancement was not without a cost. Although smoke pollution was nothing new, that brought on by industrialization was much greater and more concentrated (Hardy et al. 2011). By 1884 the city of Pittsburgh was burning three million tons of coal per year and dumping hundreds of tons of pollutants in the streets and nearby valleys. Adjacent streams and rivers were used to carry away waste generated from factories, mills, and refineries. Runoff from coal mines rendered many waterways completely lifeless. The Little Conemaugh watershed was mined extensively for its vast coal reserves, creating an interconnected network of mines that resulted in large mine discharges that polluted much of the watershed's tributaries. Widespread air and water pollution continued in the region throughout the first part of the twentieth century, but air and water quality have been improving since the passing of the Clean Air and Water Acts in the latter half of the twentieth century.



Smoke spewing from a Pittsburgh steel mill during the peak of industrial production in the late nineteenth & early twentieth centuries. (Photo by Corbis-Bettmann. Donated to the PA Historical Commission. http://www.explorepahistory.com)

Invasive Species

Plantings of non-native plant species for gardens and ornamentals, agricultural hedgerows, wildlife habitat, and erosion prevention and bank stabilization allow numerous introduced non-native plants to invade nearby native woodlands and fields. Non-native plants are commonplace within and surrounding ALPO. Areas most sensitive to invasion include old fields and floodplains, as well as the areas along the old and new portage railroads and the modern highway(s).

At the Main Unit of ALPO, garden and ornamental plants that have invaded the park include the herbaceous plant, garlic mustard, and the vines, oriental bittersweet and Japanese honeysuckle. Garlic mustard occurs along the former railroad trace and streambanks from Foot of Ten to Incline 6 of the Main Unit; since 1999 the park is actively working to control it from invading the Summit area forests. Oriental bittersweet has invaded areas along the edges of the woods along the Admiral Peary Highway (old Rt. 22) corridor where the highway allows enough light for it to flourish, as well as some areas along the former railroad(s). The park controlled occurrences of oriental bittersweet at the Summit area of the old Rt. 22 corridor, but it remains a problem from Foot of Ten to Incline 6. Japanese barberry, once a common plant for agricultural hedgerows, can now be found scattered throughout woods from Foot of Ten to Incline 6 of the Main Unit; some control was done in the early 2000's at the Incline 6 area but new sprouts are again appearing in the landscape there. Japanese honeysuckle is not as prevalent in the landscape, but occurred commonly at the Foot of Ten area during an early 1980's survey. A few plants can now be found at the Summit area as well. Shrub honeysuckle persists in large areas at Foot of Ten and near utility corridors at the Summit. Likewise, multiflora rose, once thought to be a good wildlife plant, has become invasive in some area fields. Japanese knotweed was controlled along the new portage railroad corridor prior to the development of the hiking/biking trail in the mid-2000's to prevent spreading this non-native plant along the entire corridor. Despite the efforts of the park to control non-native plants, however, Japanese stiltgrass has become the newest threat to the park's woodlands and forests at the Main Unit, and the park has been aggressively treating Japanese stiltgrass since 2010 from Foot of Ten to Incline 8.

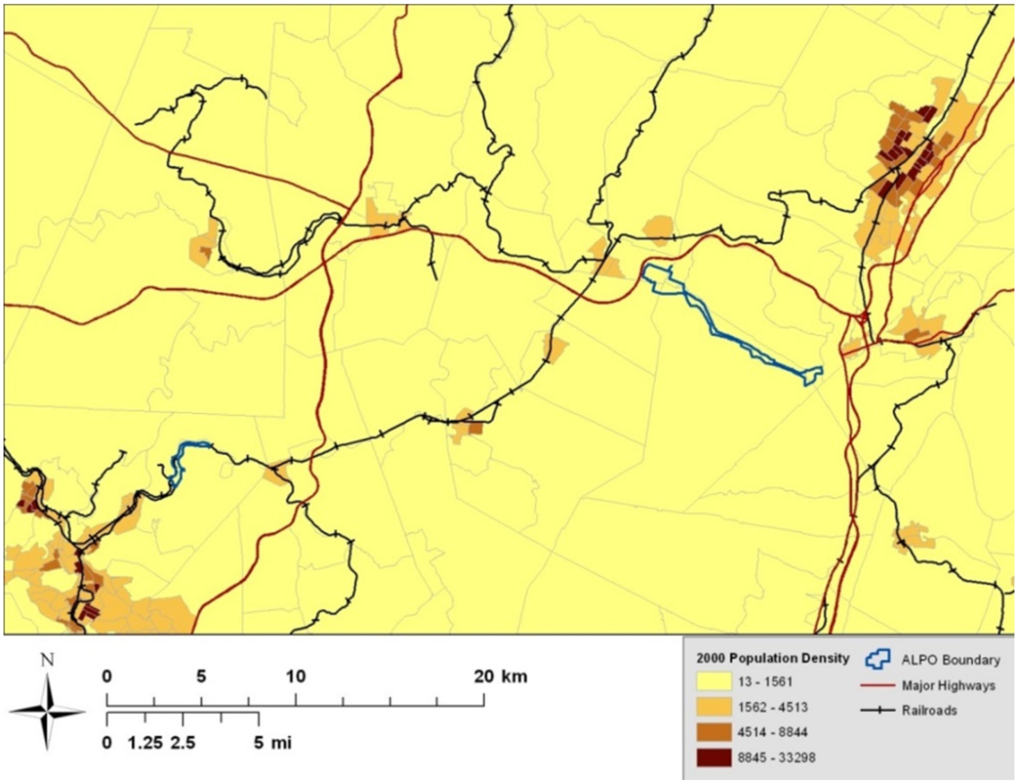
At SBTU, garlic mustard and multiflora rose occur and the park aggressively treated Japanese and giant knotweed and hybrids prior to and following the early 2000's development of the hiking/biking trail there. Common local folklore holds that railroads planted the knotweed for erosion control and bank stabilization. Knotweed was and is controlled along the Staple Bend Tunnel Trail locations at the old portage trace, but the park does not attempt to control the infestations along the modern railroad or park boundaries. Knotweed is widespread in the landscape surrounding the SBTU.

Non-native, invasive animal pest species threatening ALPO include the hemlock woolly adelgid. The park has approximately 100 acres of hemlock-hardwood stands throughout the Main Unit. Hemlock woolly adelgid was first identified at the Muleshoe to Foot of Ten areas in 2007. More recently, in the winter of 2011-12, it was found at the Summit area. The park is working to control this species at the highest priority hemlock-hardwood stands. Emerald ash borer, another non-native invasive pest, has been found in Cambria and Blair counties and is likely present in the park. However, this species is considered less of a threat than the hemlock woolly adelgid because ash is not a dominant species in the forest at ALPO.

Population Density

Changing human activities and the social, cultural, and economic conditions that ensue can affect park natural resources (Greb et al. 2009). Understanding the pressures that come with human development is essential for park managers to meet the complex challenges of conserving natural resources in a human environment.

Population density surrounding both park units of ALPO ranges between 13 and 1561 people/mi^2 and has remained relatively unchanged since 2000. The immediate area around the Main Unit has only 35 to 100 people/mi^2 (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml). Figure 10 compares population density of the region from (a) 2000 and (b) 2010. Both Blair and Cambria counties are considered to be in small metro areas with under 1 million residents. The 2010 Census reported populations of 127,089 and 143,679 people for Blair County and Cambria County, respectively. Denser populations occur northeast of the Main Unit (city of Altoona) and southwest of the SBTU (city of Johnstown). According to Greb et al. (2009), the percent population change has decreased between 2000 and 2006 (-7.6 to -2.0%) in both counties and the projected population change from 2006 to 2030 is negligible for Blair County (0.1 – 5.9%) and negative for Cambria County (-21.2 to 0.0). Farmland has also decreased. From 1997 to 2002, Blair County lost between 0.0 and 4.0% farmland and Cambria County lost between 4.1 and 9.2% farmland.



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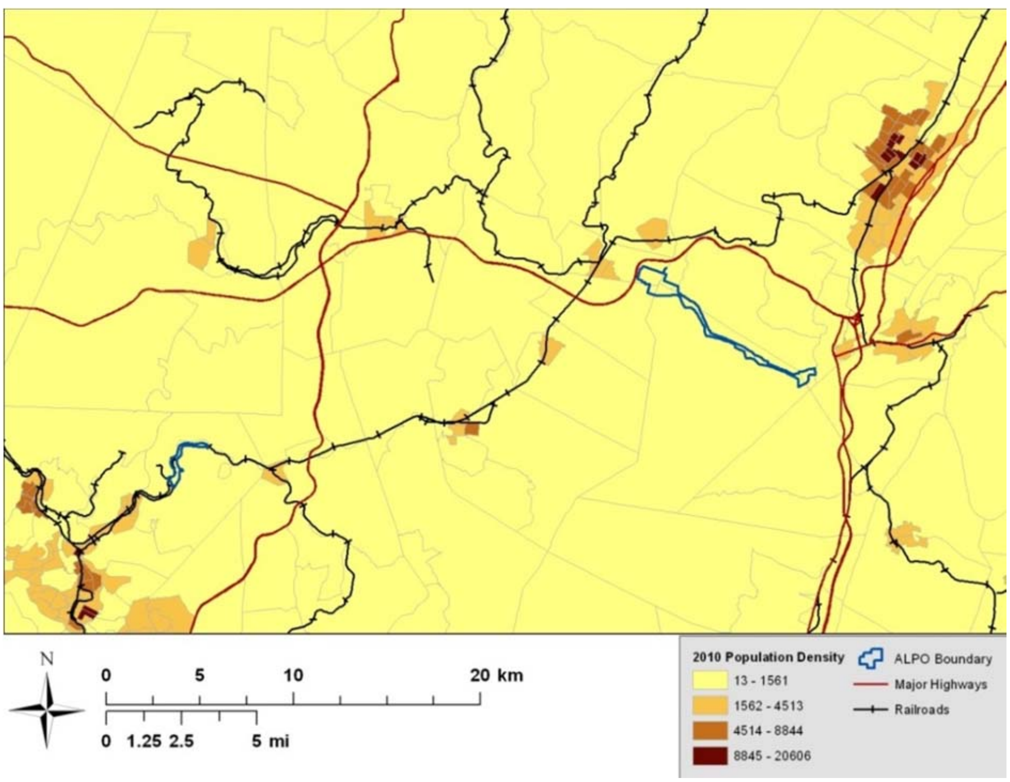


b.)

Figure 10. Population density by census tract in the vicinity of ALPO's Main Unit and SBTU for a) 2000 and b) 2010.

Transportation

As with most parks in Pennsylvania, a network of highways and railways surround and even cross through the park. Old Rt. 22 is a busy state road that goes through the Summit area of the Main Unit and parallels the park boundary along the Incline Planes to the 8 to 10 and the Foot of Ten area. A major highway, Rt. 22, runs north of the park and borders the northwest corner of the Summit area. The western border of the SBTU runs parallel to a busy modern railroad (Figure 11).

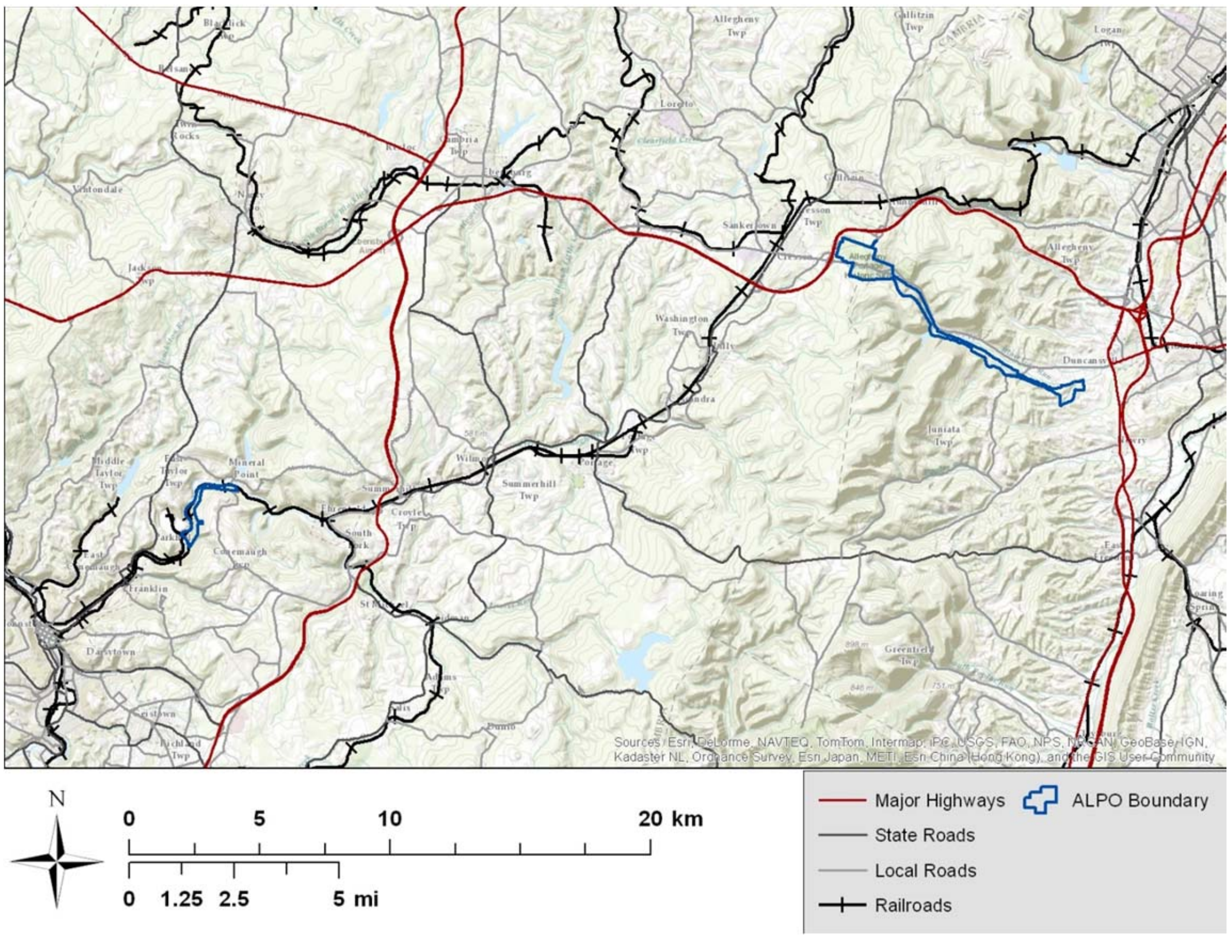


Figure 11. Major highways, roads, and railways surrounding ALPO's Main Unit and SBTU.

Land Use Development

Historic Land Use

Literally fueling urban and industrial development in the United States by the early 1900s most of the forests in Pennsylvania were gone. A state that was once almost completely forested was below 32% forest cover (Rhoads & Black 2005). Since that time the forests in many areas of the state have regenerated with total forest cover reported above 60% (Myers et al. 2000). Land conversion in Pennsylvania is consistent with it neighboring states in the mid-Atlantic region and, based on photointerpretation, ALPO is consistent with Pennsylvania. During the early part of the 20^{th} century the optimum agriculture areas in Pennsylvania (best soils with low slopes) remained cleared while the more rugged areas with poor soils regenerated back to forest. Since the mid-1900s land use change in the mid-Atlantic region has been dominated by the conversion from agriculture to urban and suburban land uses while overall forest cover remains consistent. The NRCS (2000) reported this at the regional level and our photointerpretation for ALPO has confirmed it for the areas near to the park (Figs. 12-15) (Table 2).

While the general forest trend is positive Pennsylvania's forests continue to be influenced by forest fragmentation pressures. Goodrich et al. (2002) reported that 57% of Pennsylvania's forest cover would be considered edge forest or forest within 100 m of a disturbance such as agriculture, suburban, urban or roads. Bishop (2008) showed this trend continuing while also reporting that average forest patch size was decreasing in Pennsylvania.

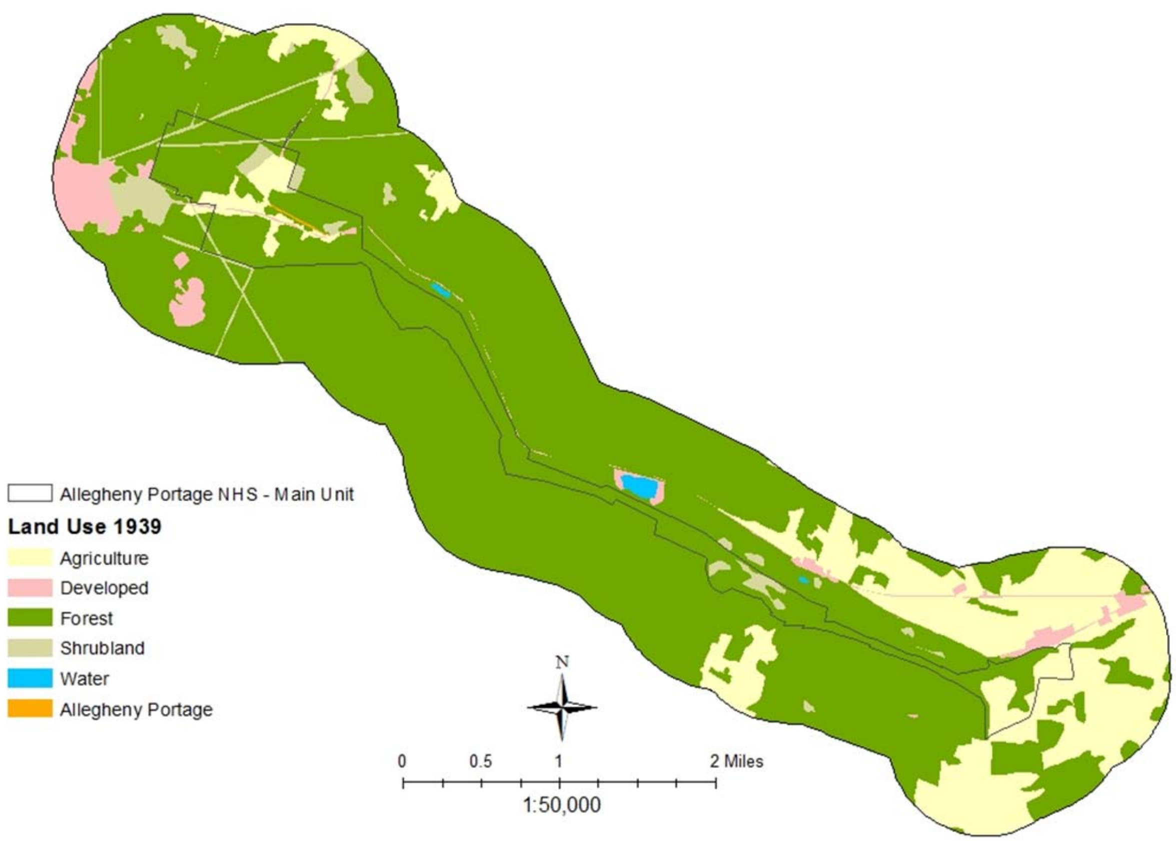


Figure 12. Historical Land Use based on aerial photography from 1939. Displayed is an Anderson Level 1 land use interpretation (Anderson et al. 1976) for an area within a 1 km buffer zone around the Main Unit of ALPO. Most of the natural forest conversion that had occurred by the late 1930s was for agricultural lands near "Foot of Ten" the eastern end of the park outside of Duncansville, PA. There was some suburban development from Cresson, PA at the western end. Most of the land use interpreted as shrubland was for energy transmission corridors in the "Summit" area.

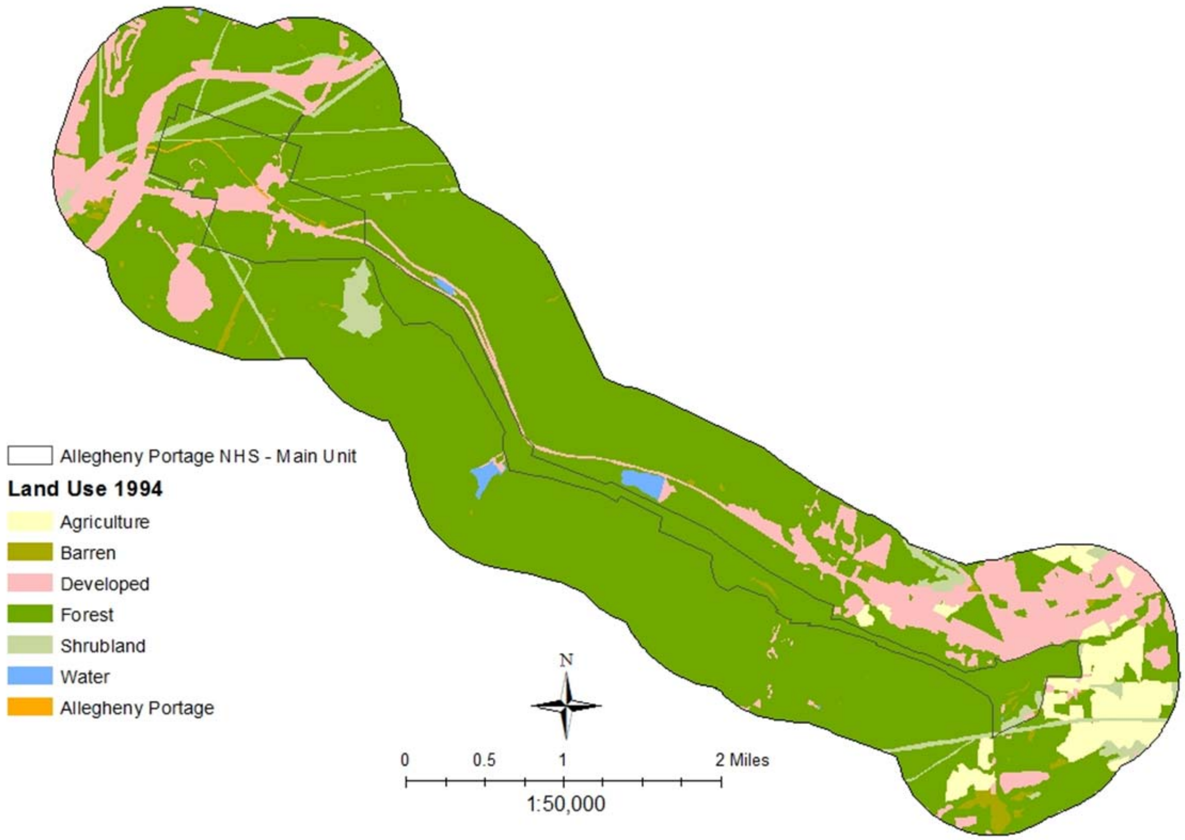


Figure 13. Historical Land Use based on aerial photography from 1994. Displayed is an Anderson Level 1 land use interpretation (Anderson et al. 1976) for an area within a 1 km buffer zone around the Main Unit of ALPO. The natural forest conversion had stabilized by the mid-1990s. The once agricultural lands, near "Foot of Ten", had converted to suburban Duncansville, PA and Cresson, PA near the "Summit" area had grown as well. Another important land use change was from the construction of US-22 near Cresson as well as an increase in the number of energy transmission corridors near and within the park boundary.

Table 2. Land use areas, based on interpretation of historic aerial photography for three sets of images (1939, 1994, and 2006).

Land Use	Hectares 1939	Acres 1939	Hectares 1994	Acres 1994	Hectares 2006	Acres 2006
Agriculture	608.64	1542.15	132.72	327.95	142.27	351.56
Forest	2467.74	6097.91	2571.20	6353.58	2561.42	6329.41
Developed	117.69	290.81	457.08	1129.48	438.53	1083.63
Barren	N/A	N/A	37.11	91.70	43.12	106.55
Shrubland	119.94	296.38	107.72	266.18	120.08	296.72
Water	9.03	22.31	17.17	42.43	17.59	43.46

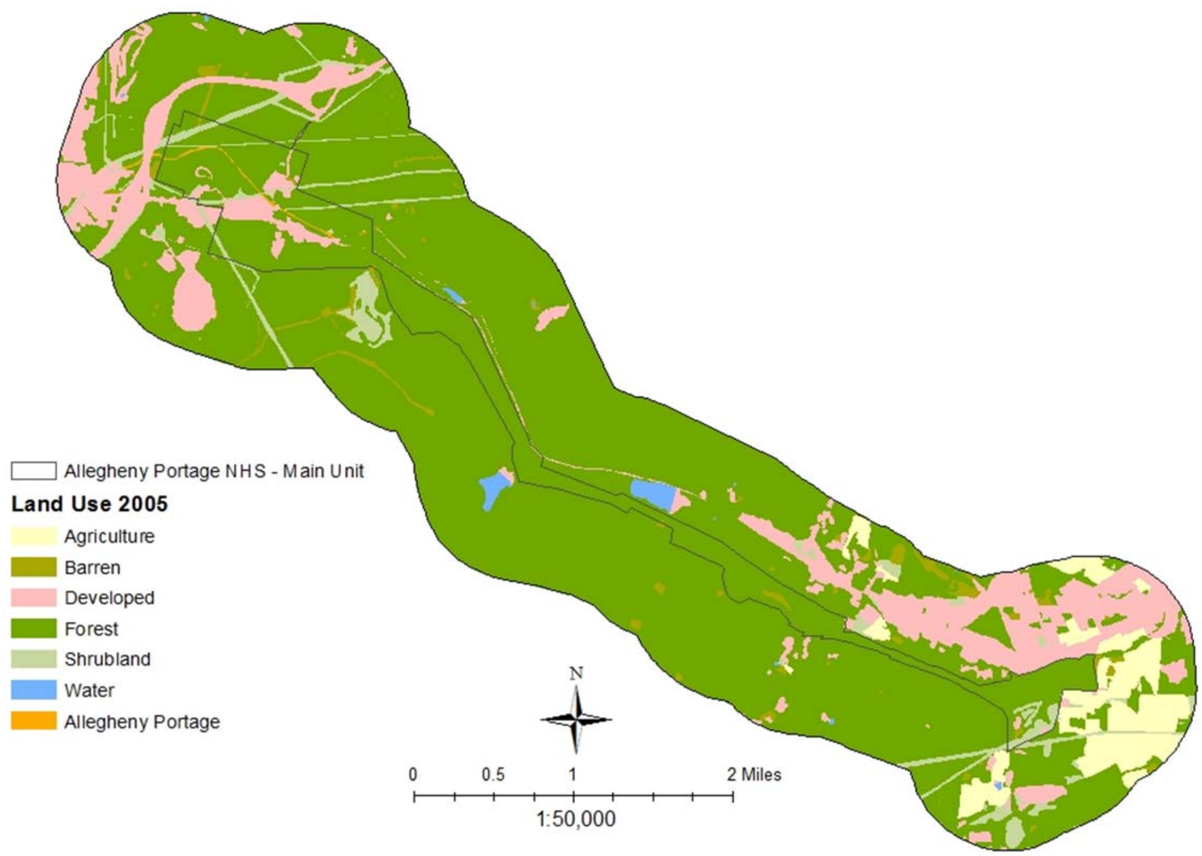


Figure 14. Historical Land Use based on aerial photography from 2006. Displayed is an Anderson Level 1 land use interpretation (Anderson et al. 1976) for an area within a 1 km buffer zone around the Main Unit of ALPO. The natural forest conversion appears to have stabilized and there were no significant changes in forest, agriculture or development (urban and suburban) between 1994 and 2006 in fact much of the agricultural land inside the park boundary at “Foot of Ten” had reverted back to forest by 2006.

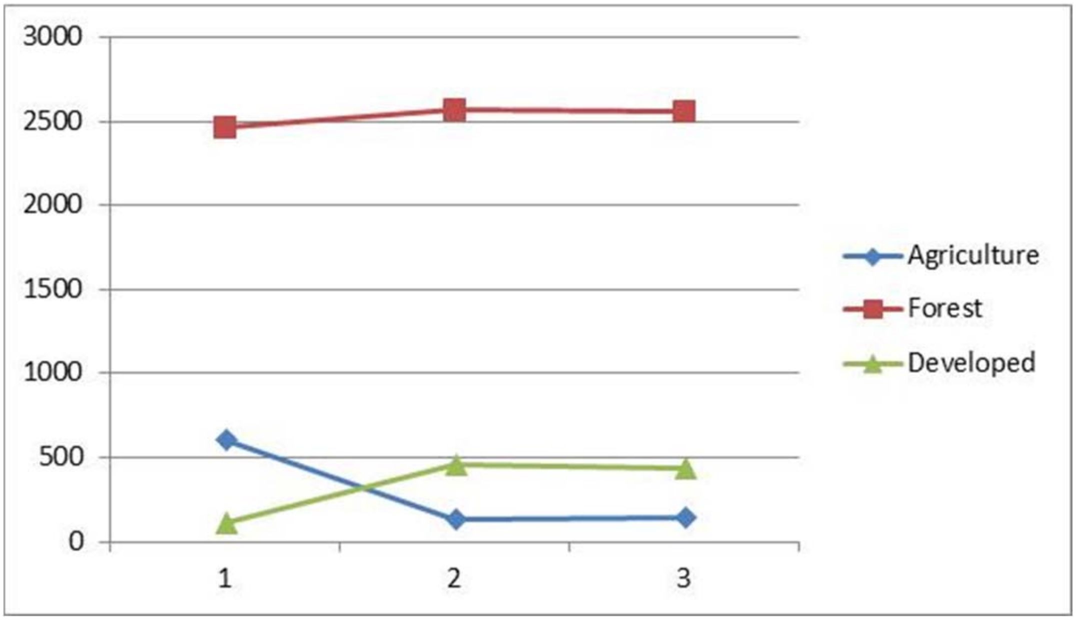
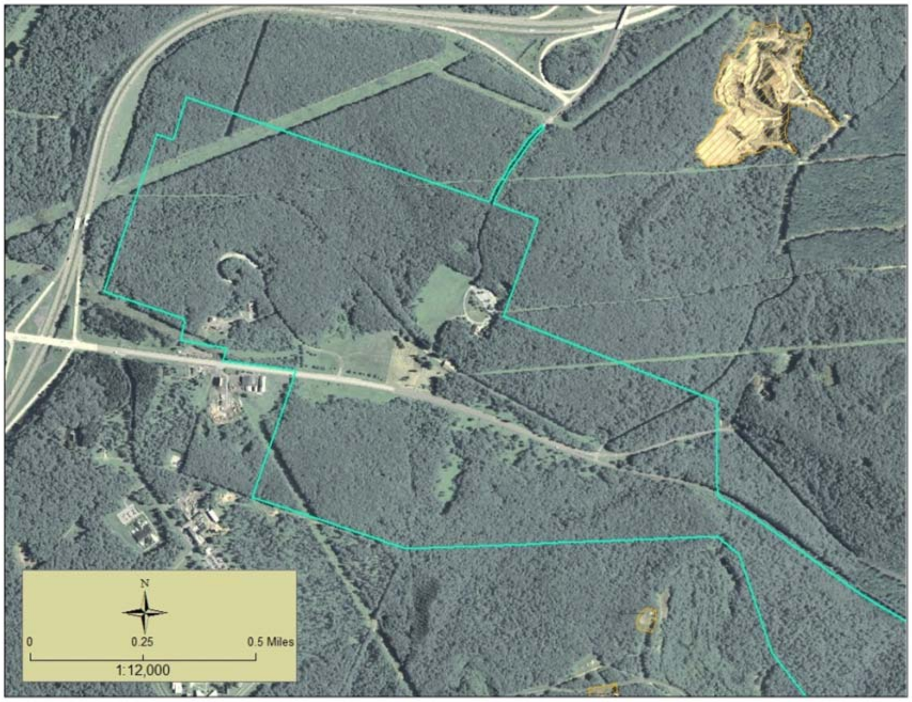


Figure 15. Graph depicts the land use conversion for the three major land use types (agriculture, forest, developed) for the three aerial photography dates (1=1939, 2=1994, 3=2006).

At a local level the forests within ALPO are experiencing these same fragmentation pressures. Urban and suburban expansion is occurring at both ends of the Main Unit, energy transmission corridors inside the boundary predate the park and major roads such as Old Route 22 and the newer US-22 influence and fragment habitats. Surface mining in the region further impacts natural habitats through surface disturbance and impacts on ground and surface water quality, increasing the likelihood of abandoned mine drainage (AMD), which can be very acidic. Two new development pressures have begun influencing forest habitats in the region. The first is the development of the Marcellus gas shale and the second is wind energy development. Both of these are increasing forest fragmentation along with additional impacts on habitat quality.

Mining (Abandoned Mine Drainage)

Abandoned mine drainage (AMD) can occur naturally, but is primarily an artifact of prior or current mining of coal (sometimes clay) from either surface (strip) mines or subsurface (deep) mines (Figure 16). AMD can be highly acidic, or, if the soils have enough acid-neutralizing capacity, can be net-alkaline. Drainages at ALPO's SBTU are acidic while some drainages at the Summit area of the Main Unit are thought to be net-alkaline. Although the pH may be neutral, net-alkaline mine drainage is still considered to be contaminated by metals, salts, or other dissolved solids. AMD discharges are common in the bituminous coal regions of Pennsylvania, which include portions of the central region of the Commonwealth, and most of the western region.



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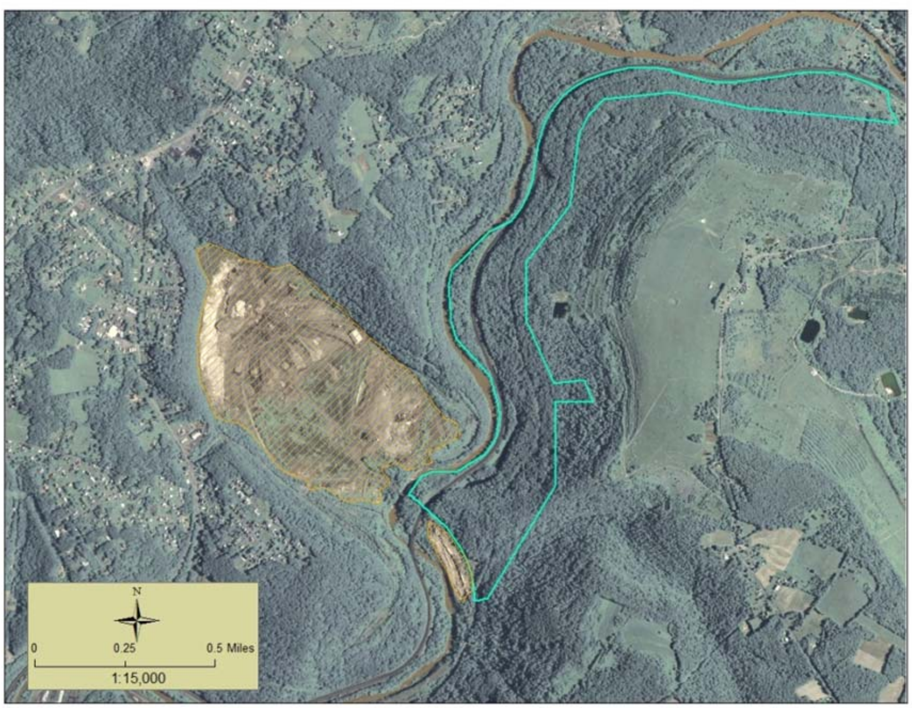


b.)

Figure 16. Photo images from 2010 show the locations of surface mines adjacent to a) the Main Unit and b) the SBTU of ALPO. The surface mine near the Main Unit in a) is relatively new. It was not visible in the 2006 aerial photography, but older surface mine areas have since reforested. The steel mill spoil piles west of the SBTU pre-dates the 1939 aerial photography and the surface mines to the east of SBTU (light green areas) remain active to the present day.

Abandoned mine drainage (AMD) can occur naturally, but is primarily an artifact of prior or current mining of coal (sometimes clay) from either surface (strip) mines or subsurface (deep) mines. AMD can be highly acidic, or, if the soils have enough acid-neutralizing capacity, can be net-alkaline. Drainages at ALPO's SBTU are acidic while some drainages at the Summit area of the Main Unit are thought to be net-alkaline. Although the pH may be neutral, net-alkaline mine drainage is still considered to be contaminated by metals, salts, or other dissolved solids.

AMD discharges are common in the bituminous coal regions of Pennsylvania, which include portions of the central region of the Commonwealth, and most of the western region.

AMD can be a stressor to the ecological integrity of aquatic ecosystems whenever it occurs. Whether a source originates within a park unit, or drains into one from an external source, in either case, it can exceed Water Quality Standards (WQS) and/or degrade the condition of aquatic resources. Once groundwater is contaminated by AMD, these polluted surface waters tend to remain contaminated for decades, unless treatments or re-mining of the source area are instituted. Portions of ALPO were previously mined, and are currently impacted by AMD. These include an unnamed tributary to Bradley Run and the Staples Bend Tunnel Unit. There are other areas that remain relatively unaffected by AMD, such as the primary stream running through the park unit, Blair Gap Run. Although it does have some impacts form mine drainage, the stream is of high enough quality to naturally buffer the drainages.

A comprehensive study of water quality and AMD in the Little Conemaugh River watershed (Barbin 1995) stated that the AMD discharges of the SBTU represented just over 1% of the total pollutant load entering the entire watershed (sample points LCR-84, LCR-98 contributed about 1,234 lbs./day, which ranked them together as 12 of 37 sampling points with regard to pollutant load from the entire watershed. Kaktins and Carney (2002) conducted water chemistry sampling and found evidence of AMD in six drainages flowing from abandoned mines and three iron mounds at the SBTU. A U. S. Geological survey study (Cravotta 2005) documented AMD flows either passing under the railroad bed into the Little Conemaugh River or into a ditch that collects AMD from several seeps and discharges into two ponds on park property. Inglis (2007) conducted a site visit to assess the feasibility of converting these ponds into settling basins to treat AMD in the SBTU. The recommendations indicated that the ponds could be rebuilt into an AMD treatment system, although numerous hydrologic, construction, and permitting issues were raised. Most recently, Calibre Systems, Inc. (2012) conducted an inventory and assessment of abandoned mine sites within ALPO and also noted a series of sites in the SBTU that discharge measurable flows of AMD in to the Little Conemaugh River.

Marcellus Shale Development
Development of the Marcellus shale gas reaches about 75% of Pennsylvania. Pennsylvania had its first well drilled in 2007 and since then 3078 (as of 12/1/2012) wells have been permitted (PSU Marcellus Center 2013).

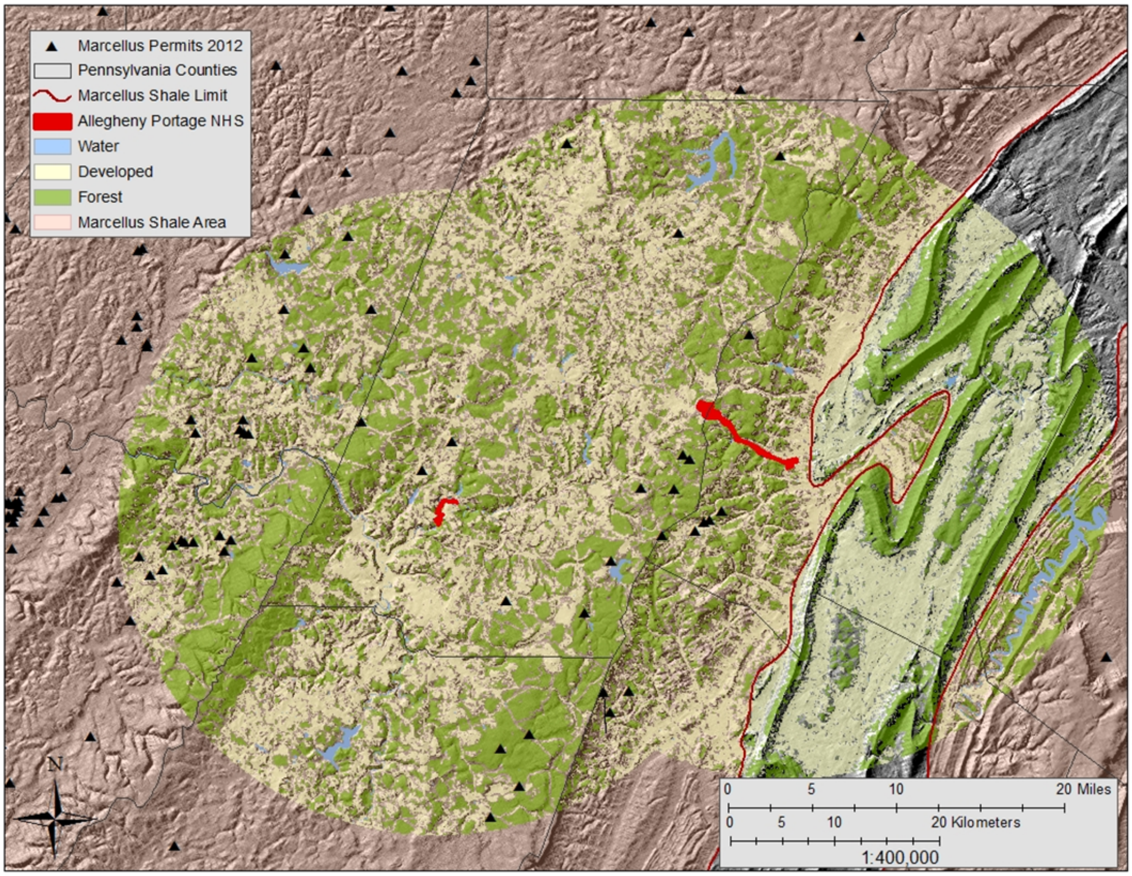
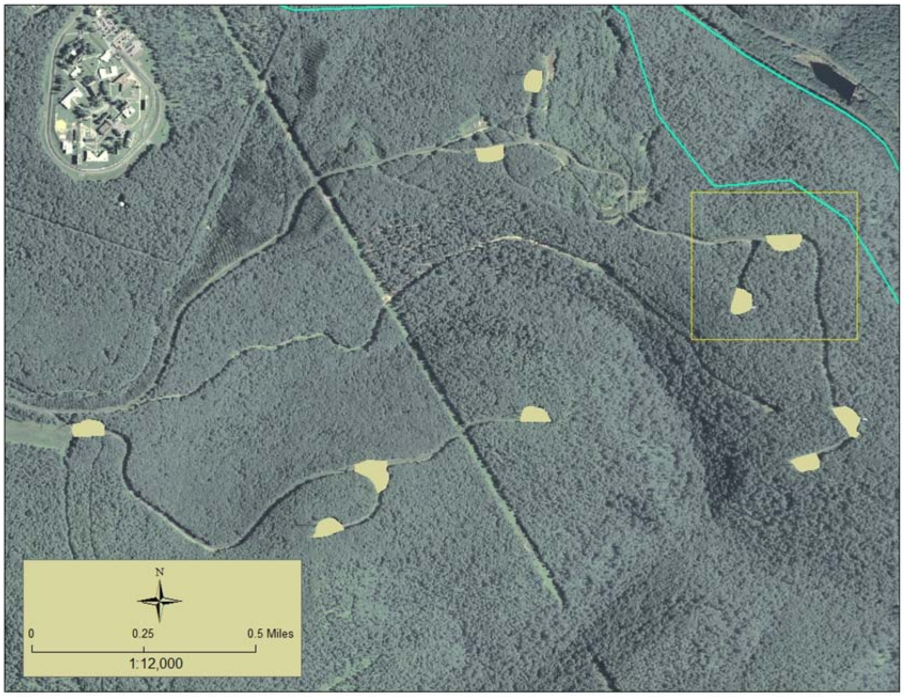


Figure 17. Locations of Marcellus Shale permitted pads (drilled or planned) within 30-km surrounding ALPO. There are 48 potential pad locations within this area based on permit information acquired from the Pennsylvania Department of Environmental Protection (PADEP), February 2012.

In the 30-km region around ALPO there were 48 well pads permitted by February 2012 and, based on 2010 aerial imagery 11 of those sites had begun pad construction (Figure 17). Impacts to habitat from increased fragmentation along with potential impacts to water quality are some important issues with this development. Based on well pad data through 2011, Drohan et al. (2012) reported that the average well pad footprint was 3 ha (6.7 acres) but in addition to the pad footprint fragmentation is increased by an additional 3.6 ha (8.8 acres) from linear road and pipeline development (Johnson et al. 2010).

Wind Turbines

Wind energy development has been increasing along the Allegheny Front and many wind turbines are located or planned near ALPO. There is a cluster of nine active turbines within 1-km of the park west of the Blair Gap Reservoir (Figure 18). For these nine pads average pad size is 0.59 ha (1.46 acres) but, like Marcellus development, more land is disturbed and then maintained in a disturbed condition for access roads and transmission lines thus increasing forest fragmentation. In addition to forest fragmentation wildlife, particularly bats and birds, are impacted from collisions with the turbine blades especially at night (Miller 2012).



a.)

b.)

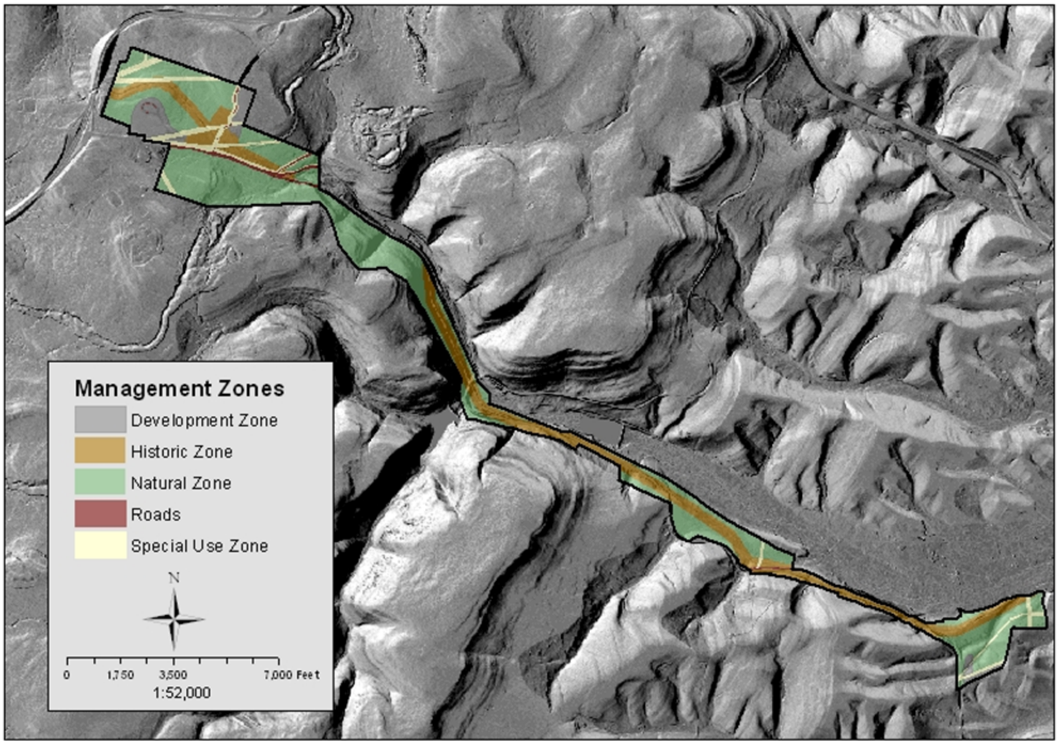
Figure 18. Wind turbine locations adjacent to the ALPO Main Unit. There are several wind farm developments along the Allegheny Front near ALPO. The ten turbines (tan areas) closest to the park are close to the Blair Gap Reservoir adjacent to the park boundary. The tan box in figure 18a represents the area of figure 18b. Looking closely you can see the white tops of each wind turbine and a black thin shadow extending west from the turbine's base.

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

According to the park's General Management Plan (NPS 1980), "resources management will focus on historic resources, with natural resources providing a supporting role. The natural environments that formed the settings for the historic events will be redeveloped where necessary to support the primary story." Cultural resource management goals are "to identify, evaluate, protect, maintain and interpret the park's cultural resources" and "to preserve and maintain…the setting of the Allegheny Portage Railroad to approximate conditions during the 1834-57 period." Natural resource management goals are "to perpetuate natural ecological communities in the park's natural zone and to enhance the value of these lands as aesthetic buffers around historically significant resources" (NPS 1980). Natural resource management issues at ALPO include air and water quality, invasive non-native plants, non-native insect pests, and abandoned mine drainage, and natural resource stewardship. Park management strategies and activities regarding these issues, however, depend on several factors, including whether they are regional in nature or apply to specific management zone(s). The park is divided into four primary management zones, each with a different management strategy (Figure 19):

- HISTORIC ZONE – "Lands that will be managed for the preservation, protection, and interpretation of cultural resources and their settings, and to provide for their use and enjoyment by the public." These areas include historic structures and cultural landscapes throughout the park.
- NATURAL ZONE – "Lands and waters that will be managed to conserve natural resources and ecological processes and to provide for their use and enjoyment by the public. In many areas of the park, the natural zone offers a buffer to historic resources from intrusive adjacent land uses or activities." The natural zone is those areas not a part of other zones.
- PARK DEVELOPMENT ZONE – "Lands that will be managed to provide and maintain facilities serving park visitors and management." This zone includes the modern Visitor Center and maintenance buildings and parking lots.
- SPECIAL USE ZONE – "Lands and waters that will continue to be used for activities not appropriate in other zones, such as non-federal lands within the boundary used for transportation and utility corridors, industry and commerce." (NPS 1992)



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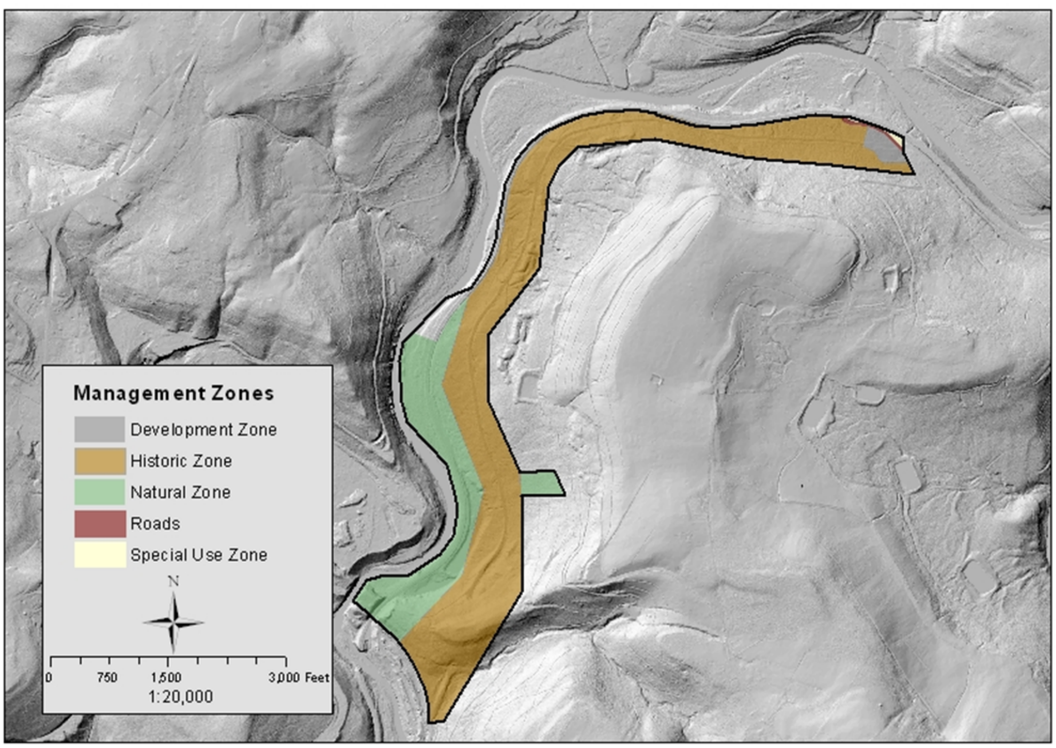


b.)

Figure 19. Management zone maps for the Main Unit (a) and the SBTU (b). Aerial imagery from 2006 was used to aid interpretation. Note that the "Historic Zone" is located along the Allegheny Portage Railroad bed and that the Special Use Zones tend to be utility corridors.

To ensure that all parks, including smaller units, can effectively address threats to their natural resources, the Service created regional, servicewide, and network programs to coordinate efforts and operate at multiple levels. Realizing that the goals of the Organic Act could not be achieved without sound scientific understanding of natural resource condition, they included among these the Inventory and Monitoring Network, which is designed to help "improve park management through the greater reliance on scientific knowledge" (http://www.science.nature.nps.gov/im/index.cfm).

ALPO is part of the Eastern Rivers and Mountains Network (ERMN). The ERMN inventories and monitors the natural systems within the park and any human influences upon them in order to detect changes in condition and develop appropriate management actions (NPS Management Policies 2006; http://www.science.nature.nps.gov/im/units/ermn/history.cfm).

2.3.2 Status of the Supporting Science

We based this natural resource condition assessment on the ERMN's Vital Signs indicators (Table 3). The following excerpt is from the ERMN's Monitoring webpage and provides background vital signs monitoring (http://science.nature.nps.gov/im/units/ermn/monitor/index.cfm):

"The intent of park vital signs monitoring is to track a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. The broad-based, scientifically sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

The five Goals of Vital Signs Monitoring that the 32 networks of parks are addressing as they design and implement their natural resource monitoring programs are as follows:

1. Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and Congressional mandates related to natural resource protections and visitor enjoyment.
5. Provide a means of measuring progress towards performance goals."

Table 3. Vital Signs selected for monitoring by the Eastern Rivers and Mountains Network.

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 Chemistry--Expanded	Water Chemistry--Expanded
		Aquatic Macroinvertebrates	Aquatic Macroinvertebrates
Biological Integrity	Invasive Species	Invasive/Exotic Plants and Animals	Invasive/Exotic Plants, Animals and Diseases--Status and Trends
		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
		Riparian Communities	Rare, Riparian Plant Communities
		Birds -- Riparian Communities	Louisiana Waterthrush
Landscapes (Ecosystem Pattern and Processes)	Landscape Dynamics	Land Cover and Use	Landscape Dynamics
		Landscape Pattern	

The optimal choice of vital signs for inventory and monitoring varies by park. As part of the selection process, each vital sign or indicator was ranked according to individual park priority, identified as a threat to the park (if applicable), noted if current inventory and monitoring data existed, and assigned a timeline for protocol development and monitoring (Table 4).

Table 4. Vital signs ranked by priority for ALPO, including classification as a threat, status of existing data, and protocol development and monitoring timeline.

Vital Sign (Level 3)	Park Ranking	Monitoring	Related Park Objectives/ Threats	Existing Data
Wet and Dry Deposition	1	•	x	x
Weather and Climate	1	†	x	x
Wetland Water Dynamics	2	◊		
Groundwater Dynamics	3	◊		
Water Chemistry-core	1	†	x	x
Water Chemistry-expanded	1	†	x	x
Aquatic Macroinvertebrates	2	†	x	x
Invasive/Exotics--status and trends	1	†	x	
Invasive/Exotics--early detection	1	†	x	x
Shrubland Forest and Woodland Comm.	1	†		x
Riparian Communities	2	†		x
Birds--Riparian Communities	2	◊		
Birds--Breeding Communities	2	†		
T&E Species & Communities--State	1	†		x
T&E Species & Communities--Federal	1	†		
Land Cover and Use	1	†	x	x

• = monitored by another park, program, or federal/state agency
† = network will develop protocols and implement monitoring
◊ = monitoring will likely be done in the future but cannot currently

Several inventory and monitoring reports currently exist for ALPO (Tables 5 and 6). Data from these reports was requested from NPS staff and used in the condition assessment.

Table 5. Compiled list of inventory reports available and used for the ALPO NRCA.

INVENTORY REPORTS
Geology
ALPO Geologic Resource Evaluation Report (Thornberry-Ehrlich, September 2008)
Weather and Climate
Weather and Climate Inventory, National Park Service, ERMN (Davey et al., September 2006)
Aquatic
Aquatic Macroinvertebrate Bioassessment Programs Throughout the ERMN Region: Commonalities Among Regulatory Authorities (Tzilkowski, January 2008)
Assessment of Wild Trout Populations in Blair Gap Run, ALPO (Tzilkowski & Sheeder, June 2006)
Condition Assessment of 5 Tributary Watershed Ecosystems at ALPO and NERI (Laubscher et al., April 2007)
Level I Water Quality Inventory and Aquatic Biological Assessment of the ALPO and the JOFL (Sheeder and Tzilkowski, October 2006)
Vegetation
A method for Developing Ecological Systems Maps from US National Vegetation Classification Association-level Vegetation Maps for Eight National Parks in the ERMN of the National Park Service (Largay and Sneddon, May 2009)
Vegetation Classification and Mapping of ALPO (Perles et al., March 2007)
Distribution and Abundance of Nonnative Plant Species at JOFL and ALPO (Zimmerman, March 2007)
Biological Integrity
Global Conservation Status Ranks of State-Rare Vegetation Associations in the Eastern Rivers and Mountains Network
Inventory of Amphibians, Reptiles, and Mammals at ALPO and JOFL (Yahner & Ross, March 2006)
Bat Inventory of ALPO, JOFL, FRHI, FONE (Gates and Johnson, November 2007)
Inventory of Bird and Butterfy Diversity at ALPO and JOFL (Yahner & Keller, February 2000)
Comprehensive Inventory Program for Birds at Six Pennsylvania National Parks (Yahner et al., December 2001)
Status of Native and Invasive Crayfish in Ten National Park Service Properties in Pennsylvania (Lieb et al., April 2007)

Table 6. Compiled list of monitoring reports available and used for the ALPO NRCA.

MONITORING REPORTS
Weather and Climate
Weather of Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Eastern Rivers and Mountains Network summary report for 2011 (Knight et al., October 2012)
Weather of Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Eastern Rivers and Mountains Network summary report for 2010 (Knight et al., September 2011)
Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Weather of 2009 (Knight et al., September 2010)
Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Weather of 2008 (Knight et al., September 2010)
Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Weather of 2007 (Knight et al., September 2010)
Aquatic
Wadeable Stream Monitoring in Allegheny Portage Railroad National Historic Site, Delaware Water Gap National Recreation Area, Johnstown Flood National Memorial, and Upper Delaware Scenic and Recreational River: Eastern Rivers and Mountains Network (Tzilkowski et al., December 2011)
Wadeable Stream Monitoring in the Eastern Rivers and Mountains Network: 2009 & 2010 Summary Report (Tzilkowski et al., March 2011)
Integrity of Benthic Macroinvertebrate Communities in Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Eastern Rivers and Mountains Network 2008 Summary Report (Tzilkowski et al., February 2010)
Vegetation & Soil
Long-term Forest Health Monitoring Program in the Eastern Rivers and Mountains Network: Evaluation of the Statistical Power to Detect Temporal Trends (Perles et al., October 2012)
Condition of Vegetation Communities in Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial: Eastern Rivers and Mountains Network Summary Report 2007 & 2009 (Perles et al., March 2010)
Biological Integrity
Early Detection of Invasive Species - Surveillance Monitoring and Rapid Response: Eastern Rivers and Mountains Network 2011 - 2012 Summary Report (Manning and Keefer, January 2013)
Early Detection of Invasive Species - Surveillance Monitoring and Rapid Response: Eastern Rivers and Mountains Network Summary Report 2010 (Keefer, March 2011)
Early Detection of Invasive Species - Surveillance Monitoring and Rapid Response: Eastern Rivers and Mountains Network Summary Report 2008 - 2009 (Keefer, March 2010)
Streamside Bird Monitoring: Eastern Rivers and Mountains Network 2007 - 2012 Summary Report (Marshall et al., March 2013)
Landscape Dynamics
Socioeconomic Indicator Mapping, Eastern Rivers and Mountains Network (Greb et al., 2009)

Chapter 3 Study Scoping and Design

3.1 Preliminary Scoping

3.1.1 Park Involvement

The process for developing the condition assessment for ALPO began with a kickoff meeting hosted by NPS personnel on November 18-19, 2010. NPS participants, including park superintendent, natural resource manager, monitoring network personnel, and NRCS supervisor, presented information on the park's natural resources, available monitoring data and protocols, and guidelines for development of the NRCA. An important conclusion drawn from the discussion was that natural resource condition and management were often reflected by the park's management zones (cultural, natural, developed, and special use). For example, the only grassland habitat within the park occurs within the cultural zone and is primarily the result of mowing to keep the cultural viewshed open and maintain the historic time period scene. Although some provisions for natural resources are made (e.g., delayed mowing until fall to allow for bird breeding season and other animal habitat provisions) management is directed toward recreating the historic scene of the railroad time period. Another example is the conflict created by the spatial configuration of the management zones (e.g., the railroad trace, which bisects the park's natural zone, is managed as a cultural resource and serves as an important vector for invasive species—a serious threat to the vegetative communities in the park).

As a result of several meetings and conference calls, primary data sources from past inventory and monitoring studies were provided by (1) the park's natural resource manager in the form of electronic data files, hard copies of reports, and compiled notes; (2) the Eastern Rivers and Mountains Network monitoring data; (3) NPSpecies data; and (4) NPScape (science.nature.nps.gov/im/monitor/npscape/). Additional datasets and information were obtained for air quality (National Atmospheric Deposition Program and the State of Pennsylvania's State Acid Deposition Network), weather and climate (National Weather Service Cooperative Observer Program), forests (land records from the Pennsylvania Historical and Museum Commission 2011), wetlands (delineation results provided by P. Sharpe), and landscapes (National Land Cover Data, Pennsylvania Land Cover Data (via PASDA,) and historic and current aerial photography from PA DCNR, Bureau of Topographic and Geologic Survey).

A series of conference calls in 2011 through 2012 between NRCS supervisors, ERMN staff, ALPO's natural resource manager, and Riparia provided information transfers, collaboration and feedback. These calls combined with email correspondence and visits with the park's natural resource manager and ERMN staff produced a list of natural resource indicators for the condition assessment, as well as discussions on approaches, datasets, metrics and other references for each indicator. These communications were essential in understanding both the natural resource issues at ALPO and the goals and expectations of the NRCA.

3.2 Study Design

3.2.1 Assessment Framework

Our approach utilizes the ERMN's 'vital signs' framework for reporting natural resource condition (Marshall and Piekielek 2007). This allows NPS to utilize these NRCA results in conjunction with ERMN's long-term monitoring, especially since the latter is intended to evaluate trends in condition. This report also allows one to identify gaps in existing data for the park. Several of the ERMN vital signs not included in this assessment were lacking data for ALPO or had very limited data where only heuristic or qualitative assessments were possible. Figure 20 displays the ERMN vital signs for ALPO and the resources and indicators used for the NRCA. Resources and indicators related directly to the vital sign are emphasized by color.

3.2.2 Reporting Areas

The condition assessment consists of six broad categories: *Air Quality, Weather & Climate, Water Quality, Ecosystem Integrity, Biological Integrity*, and *Landscapes*. A total of 27 indicators are dispersed across these categories and are listed in Figure 20. Each indicator was evaluated for both park units, unless data was unavailable.

The main focus area for reporting condition depended on the resource and available data. Air quality and weather and climate are regional resources and are reported as such. Water quality results are most useful when one can distinguish between areas of good water quality and impacted areas. Thus, results for this resource are reported hierarchically, first by site, then by stream segment, followed by park unit. Forest/wood/shrubland condition and wetland condition are reported first by forest association and then scaled up to park unit. Grassland condition is reported for each habitat patch and then for the Main Unit. Biological integrity results were reported by park unit, if possible, or parkwide. Landscapes, although considered a regional resource/indicator, were analyzed at multiple scales beginning with the park boundary and scaling up to park boundary + 1-km, park boundary + 30-km, and catchment; thus, the results are presented by park unit. The final summary of condition results is summarized first by resource to include information on data sources and references, followed by summaries by regional resources and park units to facilitate management interpretations.

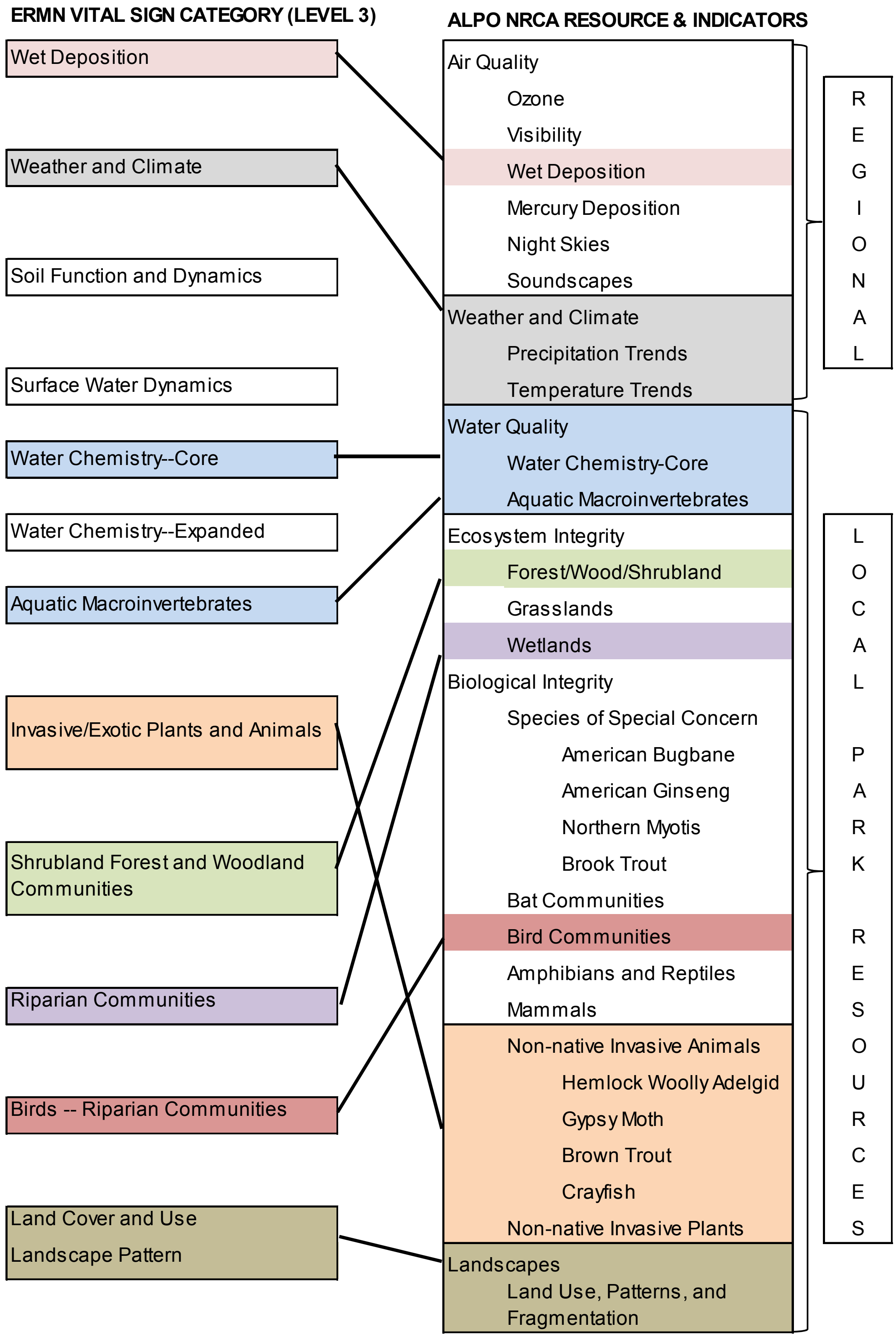
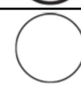
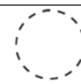


Figure 20. ERMN vital signs and their relation to ALPO's NRCA resources and indicators. Resources and indicators related directly to the vital sign are emphasized by color. ERMN Vital Signs (left column) in white boxes had limited and/or inconsistent data and were not assessed.

3.2.3 General Approach and Methods

Chapter 4 is broken down by the six broad resource categories. Each resource category contains the relevant indicators of condition. Results for each indicator begin with a discussion on the relevance and context of the indicator, as well as the metrics chosen to represent that indicator. This is followed by an overview of the methods describing our approach and/or metric computation and analysis and a section defining the reference condition and how each metric is scored. When possible, reference conditions and scoring criteria were based on federal or state agency regulations or criteria, peer-reviewed research, or NPS Vital Signs (various networks) condition categories. If possible, each metric was assessed in terms of percent attainment of reference (e.g., 67% of samples met criteria for reference or *good* condition). In many cases, the data was qualitative and required best professional judgment to assign a condition category. In these latter cases, we provided justification for our decisions. The section on current condition and trends contains the specific results of the condition assessment presented as either *good* (green circle), *moderate concern* (yellow circle), or *significant concern* (red circle) and, if trends analysis was possible, an upward arrow for *improving* condition or a downward arrow for *deteriorating* condition, and a two-way arrow for *unchanging* condition. The level of confidence in the assessment is also included in the outline of the condition symbol as either bold (*high* confidence), medium (*medium* confidence), or dashed (*low* confidence) (Table 7). Final sections include a brief explanation regarding data gaps and level of confidence and a list of sources of expertise utilized.

Table 7. Symbol key legend used to report resource condition, trend, and confidence levels in the ALPO NRCA.

CONDITION STATUS		TREND IN CONDITION		CONFIDENCE IN ASSESSMENT	
	Resource is in Good Condition		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Warrants Significant Concern		Condition is Deteriorating		Low

Chapter 4 Natural Resource Conditions

4.1 Air Quality

Air pollution can be a serious threat to both natural and cultural resources, causing injury to sensitive plant species, acidifying waterways, eroding buildings and monuments, leaching nutrients from the soil, and reducing visibility. Not only does air pollution harm NPS resources but it can also detract from the enjoyment of our parks for both present and future generations and can also affect human health (US EPA 2010a). NPS is bound, not only by the Organic Act of 1916 but also by the Clean Air Act (CAA) of 1970 and CAA Amendments to protect the resources within the national parks and participate in national and regional initiatives to control, mitigate, monitor and research air pollution and its effects in national parks. The Air Resources Division (ARD) oversees management of the national program for the NPS, working in conjunction with parks and regional offices in a variety of air quality initiatives, including monitoring of sources and researching the effects of air pollution. Refer to the following webpages for more information on (1) law and policy and (2) partnerships:

(1) http://www.nature.nps.gov/air/regs/laws_Regs.cfm
(2) http://www.nature.nps.gov/air/regs/partnership.cfm.

One of the tools that can be used by NPS to assess air pollution within and around park units is the CAA's National Ambient Air Quality Standards (NAAQS). Specifically, the NAAQS has set standard limits or thresholds for six "criteria pollutants," including ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2). "Primary standards" are intended to protect human health, while "secondary standards" are intended to protect human environmental welfare, which includes natural resources. It is important to realize that these national standards are continuously being reviewed and revised to incorporate new research findings and provide better protection. In addition, the CAA's Prevention of Significant Deterioration (PSD) of Air Quality program provides additional protection for national parks and other areas of special value to avoid adverse effects that may occur due to industrial development even if NAAQS are not violated. The PSD "Class I areas" identified in the PSD program receive the highest level of protection with only very little deterioration of air quality allowed and include international parks, national wilderness areas and national memorial parks greater than 5,000 acres, and national parks in excess of 6,000 acres that existed as of August 7, 1977. All other NPS areas are designated Class II where only moderate air quality deterioration is allowed (NPS ARD 2011). The NPS ARD developed methods for determining air quality conditions for park planning and condition assessments that use NAAQS as a benchmark to help estimate how air pollution affects park resources (NPS ARD 2013). This ARD guidance is applied in this document to help assess the condition of ALPO's air resources.

The NPS Air Monitoring Program focuses primarily on visibility, ozone, and atmospheric deposition and includes air monitoring stations throughout the nation that are operated by different organizations (http://www.nature.nps.gov/air/monitoring/index.cfm). The NPS Inventory and Monitoring program also provides valuable assistance in monitoring and tracking air pollution effects in national parks. For example, ERMN identified several resources within their park units that may be adversely affected by changes in air quality (the Clean Air Act refers to these types of resources as air quality related values or AQRVs). AQRVs identified for ALPO include visibility, vegetation, surface waters, and fish and wildlife. Air-related vital signs selected for long-term monitoring in the ERMN are ozone, visibility, wet deposition, mercury deposition, and particulate matter. We did not include discussion of the NAAQS for particulate matter (PM) in this NRCA, because the guidance for visibility condition assessment established by the ARD appropriately covers PM effects on natural resources. Table 8 provides a summary of the air quality monitoring networks (including state-level) involved and a list of nearby monitoring locations for ALPO's air quality -related vital signs. Figure 21 shows the nearest monitoring stations providing the data for the different air quality condition assessments for ALPO.

In this NRCA, we applied the NPS ARD developed condition assessment guidance for assessing air quality within NPS units (NPS ARD 2013). Supplemental information used in this NRCA includes data and produces from an annual report on conditions and trends produced by ARD (NPS ARD 2010). These NPS ARD assessment guidance uses reports summarize data collected over five-year periods from all available monitoring data to generate interpolations for the continental United States. Estimates are derived from these interpolations to determine an index of condition for ozone, wet deposition, and visibility (http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm). Based on these interpolations, the NPS ARD assessment guidance assigns one of three condition categories is then assigned to each park:

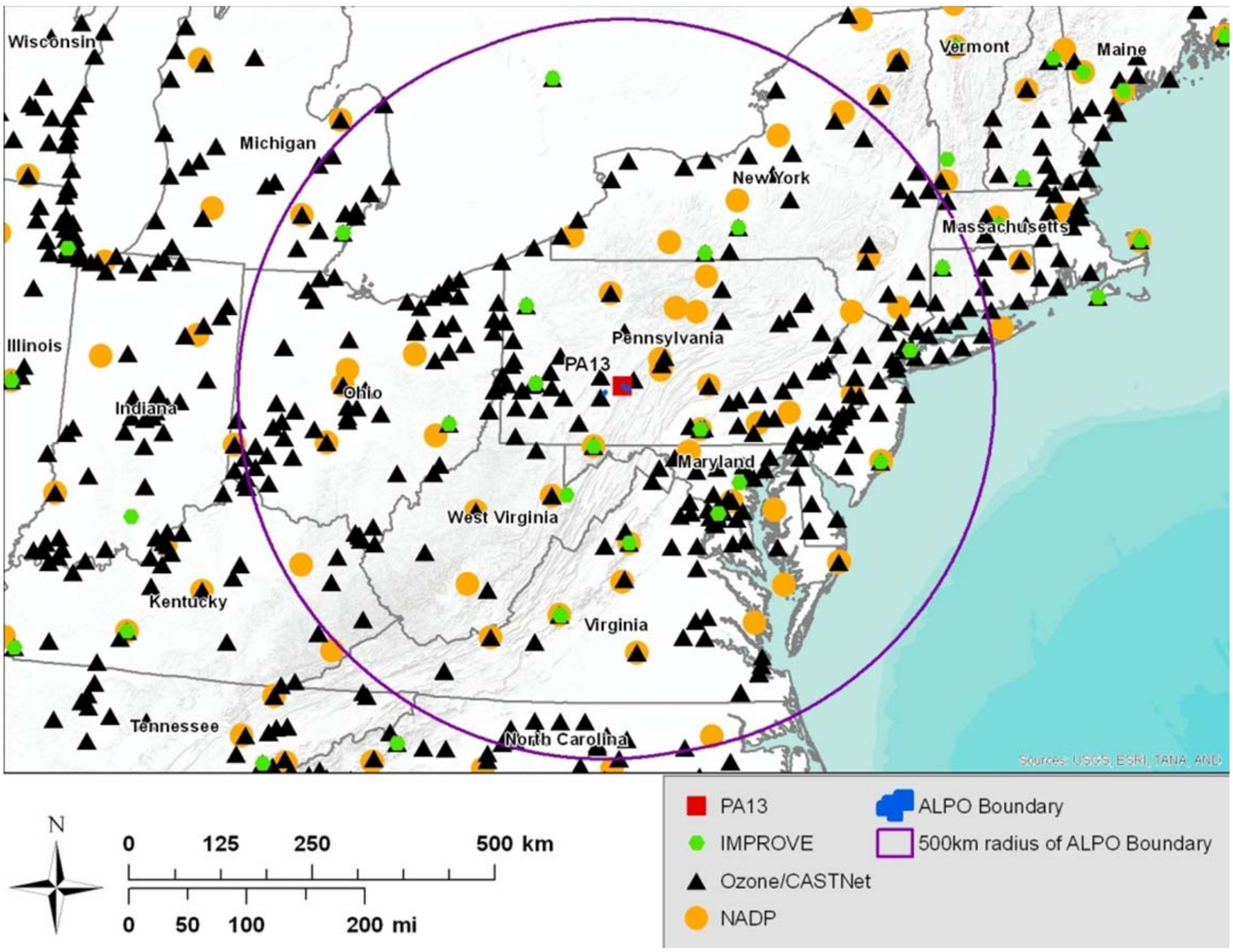
Air Quality Warrants Significant Concern (●)
Air Quality Warrants Moderate Condition (●)
Air Quality is in Good Condition (●).

Table 8. List of air quality networks and monitoring locations in or near ALPO.

PARAMETER	NETWORK	SITES	LOCATION
OZONE	CASTNet[1]	PSU106 LRL117	State College, PA (65 km NE) Laurel Hill State Park, PA (80 km SW)
	COPAMS[2]	42-013-0801-44201 42-021-0011-44201	Altoona, PA (10 km NE) Johnstown, PA (30 km SW)
VISIBILITY	IMPROVE[3]	AREN1 DOSO1	Arendtsville, PA (100 km SE) Davis, WV (165 km SW)
WET DEPOSITION (Nitrogen, Sulfur)	NADP/NTN[4]	PA13 [6] PA42 PA15	On-site (Summit area of ALPO) Pine Grove Mills, PA (60 km NE) State College, PA (65 km NE)
	CASTNet[1]	PSU106 LRL117	State College, PA (65 km NE) Laurel Hill State Park, PA (80 km SW)
WET DEPOSITION (Mercury)	NADP/MDN[5]	PA13	On-site

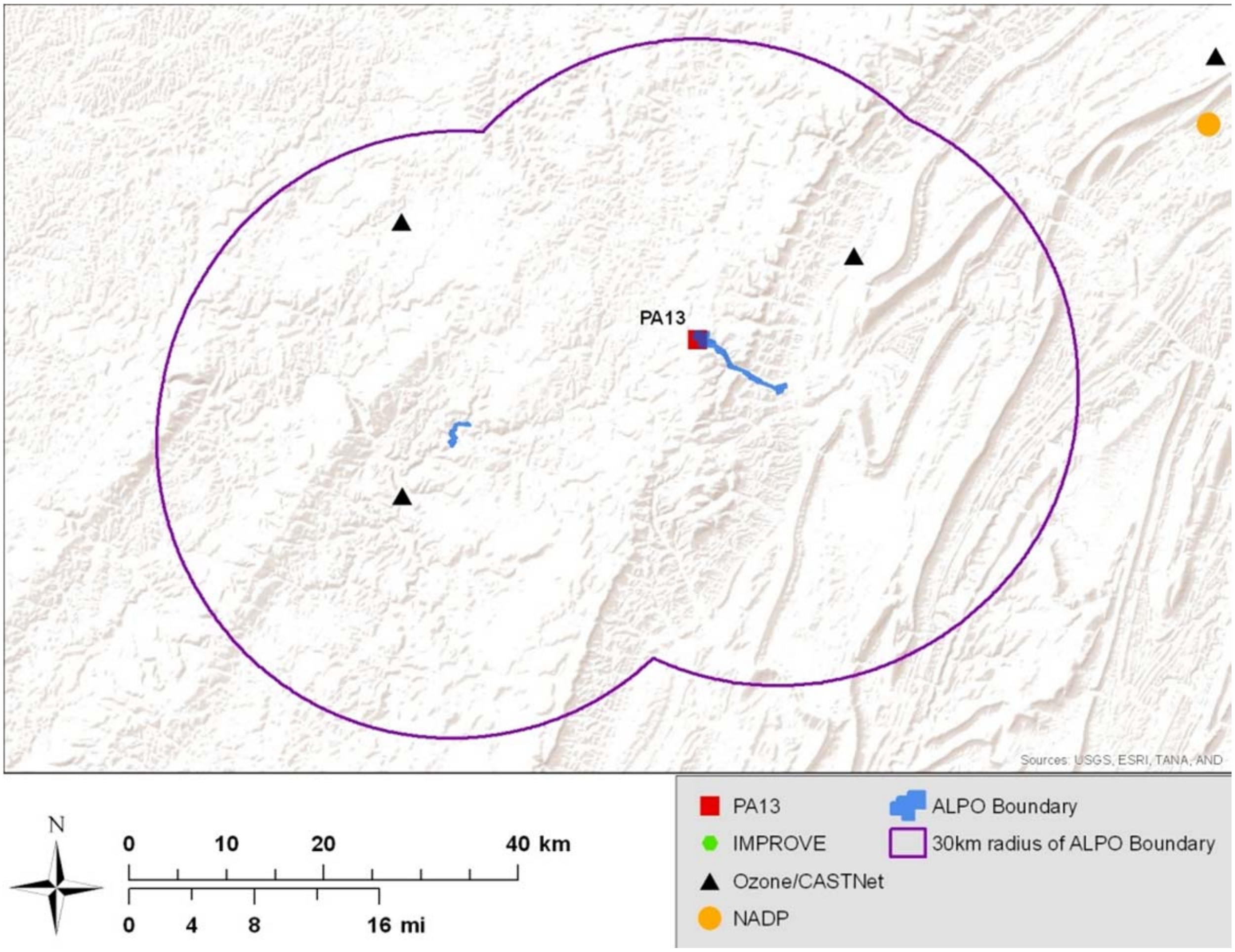
[1]CASTNet = Clean Air Status and Trends Network
[2]COPAMS = Commonwealth of Pennsylvania Air Monitoring system
[3]IMPROVE = Interagency Monitoring of Protected Visual Environments
[4]NADP/NTN = National Atmospheric Deposition Program/National Trends Network
[5]NADP/MDN = National Atmospheric Deposition Program/Mercury Deposition Network
[6]PA13 joined the NADP/NTN network in 2011; prior to that it was part of the Pennsylvania Atmospheric Deposition Monitoring Network (PADMN)

For the ALPO NRCA, we used the interpolated information from the NPS ARD guidance to report current condition, if on-site monitoring data was not available (e.g., ozone, visibility). The NPS-ARD advises against using these 5-year averages for trends analysis, however, due to the inaccuracies and low resolution of interpolation methods (Drew Bingham, personal communication). We did include regional trends reported by NPS ARD for parks with on-site monitoring (NPS ARD 2010). For air quality parameters monitored within the park (wet deposition of nitrogen, sulfur, and mercury), we supplemented the interpolated estimates with these park-specific results and used the latter to estimate trends.



a.)

Figure 21. Map showing air quality monitoring stations within a) 500-km radius and b) 30-km radius of ALPO. All stations within a 500-km radius (except PA-13) were used in the NPS-ARD interpolation estimates (inverse distance weighted).



b.)

Figure 21 (continued). Map showing air quality monitoring stations within a) 500-km radius and b) 30-km radius of ALPO. All stations within a 500-km radius (except PA-13) were used in the NPS-ARD interpolation estimates (inverse distance weighted).

4.1.1 Ozone

Relevance and Context

Ozone is an important phytotoxic air pollutant, especially in the eastern United States (Chappelka et al. 1999). Ground-level ozone (O3) is the main component of smog and forms when sunlight reacts with methane (CH4), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic carbons (VOCs), most of which originate from man-made sources like burning of fossil fuels (US EPA 2010b). Ozone pollution is not confined to urban areas, however, and is of particular interest to natural resource managers, since it can be transported over long distances to forested regions. Ozone affects both biochemical and physiological processes in plant tissue, interfering with food production and storage, and eventually leading to foliar injury, reduced growth and increased susceptibility to disease and insect damage (Porter 2003, US EPA 2010b). Although studies of foliar injury have not been conducted at ALPO, they have been well documented in other national parks (Kohut 2005).

Chappelka et al. (1999) documented foliar injury from ambient ozone concentrations on mature black cherry trees in Great Smoky Mountains National Park (GRSM) and Shenandoah National Park (SHEN). Injury was greatest to trees in higher elevations where ozone concentrations were also high.

Method

NPS has been monitoring ozone levels since the late 1970's in concert with the EPA Clean Air Status and Trends Network (CASTNet). To assess park air quality, the NPS ARD assessment guidance estimates ozone condition based on a five-year average of the 4th highest 8-hour ozone concentration. This value is then compared to an index of reference condition to determine the air quality condition category. ALPO does not have onsite monitoring within the park; therefore, ozone estimates for the park are provided by the NPS Air Atlas ARD through spatial interpolations. Currently, six five-year air quality estimates are available for ALPO through the ARD website, providing a broad picture of the conditions at the park since 1999 (http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm). Since the accuracy of the interpolation method used in calculating the six five-year air quality estimates cannot be statistically assessed, trends were not derived from these estimates. However, we do include the trend results presented for ALPO in the NPS ARD 2009 Annual Progress Report.

Because ozone pollution is a regional pollutant shown to exhibit visible and well-documented injury to sensitive plant species, the final determination of the ozone condition can be lowered if the risk of foliar injury is high. The ERMN methodology for this risk assessment is based on the premise that a plant's response to ozone will depend primarily on the interaction of three factors: 1) the interaction of the plant, 2) the level of exposure, and 3) the exposure of the environment (NPS 2004). For example, the risk of ozone injury is highest when the plant species is sensitive to ozone, the level of exposure exceeds the threshold for foliar injury, and the environmental conditions foster gas exchange (e.g., low soil moisture). Two indices for characterizing the threshold for ozone foliar injury to vegetation are the Sum06 and the W126 (NPS-ERMN 2004). The Sum06 index is comprised of the 90-day maximum sum of the 0800 through 1959 hourly ozone concentrations $\geq$ 60 ppb (0.60 ppm). The W126 index is the weighted sum of the 24 one-hour ozone concentrations daily from April through October, and the number of hours of exposure to concentrations $\geq$ 100 ppb (0.10 ppm) during that period. Ozone-sensitive plant species have been identified at ALPO (Table 9). Nineteen are considered at risk by the NPS Ozone Injury Risk Assessment (NPS-ERMN 2004); the remaining eight species (gray) are listed in the NPS 2003 workshop summary (NPS-ARD 2003).

Table 9. Plant species in ALPO sensitive to ozone (asterisk denotes plants also considered bioindicators of ozone). “Sensitive” plants are those that typically exhibit foliar injury at or near ambient ozone concentrations in either fumigation chambers or in multiple field observations by more than one observer. “Bioindicator” species are those sensitive plant species that are widely distributed throughout the region and exhibit easily identifiable features with respect to both taxonomy and foliar injury. Plants shaded in gray are not listed in ERMN’s risk assessment for ALPO (NPS-ERMN 2004) but were listed in the Appendix from the invasive plant workshop (NPS-ARD 2003).

Scientific Name	Common Name	Lifeform	Category
Ailanthus altissima	Tree-of-heaven		Sensitive*
Apocynum androsaemifolium	Spreading dogbane	forb/herb	Sensitive*
Asclepias syriaca	Common milkweed	forb/herb	Sensitive*
Aster acuminatus (Oclemena acuminata)	Whorled wood aster	forb/herb	Sensitive*
Fraxinus americana	White ash	Broad-leaved deciduous tree	Sensitive*
Liriodendron tuilipifera	Tuliptree	Broad-leaved deciduous tree	Sensitive*
Parthenocissus quinquefolia	Virginia creeper	Vine	Sensitive
Pinus banksiana	Jack pine		Sensitive
Pinus rigida	Pitch pine		Sensitive
Pinus virginiana	Virginia pine		Sensitive
Platanus occidentalis	American sycamore	Broad-leaved deciduous tree	Sensitive*
Populus tremuloides	Quaking aspen	Broad-leaved deciduous tree	Sensitive*
Prunus serotina	Black cherry	Broad-leaved deciduous tree	Sensitive*
Rhus copalina	Winged sumac	Broad-leaved deciduous shrub	Sensitive
Robinia psuedoacacia	Black locust	Broad-leaved deciduous tree	Sensitive
Rubus allegheniensis	Allegheny blackberry	Broad-leaved deciduous shrub	Sensitive*
Rudbeckia laciniata	Cutleaf coneflower	Forb/herbaceous	Sensitive*
Sambucus canadensis	Common elderberry	Broad-leaved deciduous shrub	Sensitive*
Sassafras albidum	Sassafras		Sensitive
Apios americana	Groundnut	vine/forb/herb	Sensitive*
Apocynum cannabinum	Indianhemp, Dogbane	forb/herb	Sensitive
Aster macrophyllus	Big-leaf aster	forb/herb	Sensitive*
Corylus americana	American hazelnut	Broad-leaved deciduous shrub	Sensitive*
Eupatorium rugosum (Ageratina altissima)	White snakeroot	forb/herb	Sensitive*
Gaylussacia baccata	Black huckleberry	Broad-leaved deciduous shrub	Sensitive*
Prunus virginiana	Choke cherry	Broad-leaved deciduous shrub	Sensitive
Solidago altissima	Canada goldenrod		Sensitive

Reference Condition

The USEPA sets the ozone standards for both human health (primary standard) and natural resources (secondary standard) at the same level of 75 ppb (i.e., ozone concentrations at any given monitor should not exceed 75 ppb over an 8-hour period). This statistic was calculated based on the 4th highest 8-hour value in the most recent year averaged with the 4th highest 8-hour values from the two previous years. However, numerous studies of the effects of cumulative exposure to high-risk groups (e.g., asthmatic children) and sensitive vegetation (e.g., black cherry) have prompted EPA to consider lowering the standard to 60 -70 ppb. (http://www.epa.gov/air/ozonepollution/standards.html). Current NPS-ARD assignations for ozone condition ratings within national parks are as follows: $\leq$ 60 ppb = *good* condition; 61 – 75 ppb = *moderate concern*; and $\geq$76 ppb = *significant concern* (Table 10). Only exposure levels are considered when defining reference condition. ERMN's established criteria for assessing risk to plant resources are also shown (Table 10; NPS-ERMN 2004).

Current Condition and Trend

The 2006 – 2010 data estimates ALPO levels of ozone as 72.2 ppb, which is considered to be of *moderate concern* (Table 10). This represents an improvement in NPS Air Quality estimates (5-year averages) in the park since 2001 when the interpolated 4th -highest daily maximum 8-hour ozone concentration rated a significant concern at 85.9 ppb (Figure 22). These results are consistent with the improving trend in ozone concentrations monitored throughout the state (www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/pollutants.htm) and for much of the eastern United States between 1999 and 2008 (Figure 23; NPS-ARD 2010). Note that the NPS-ARD reports an improving trend as a downward blue arrow (Figure 23), while this report and other NRCAs show improving trends with an upward facing arrow indicating improving condition (Table 10). Trend results reported in the NPS-ARD 2009 Annual Progress Report also showed that ALPO exhibited a statistically significant improving trend (-1.80 ppb/yr, p-value < 0.01), as well as reporting a similar decrease in ozone estimates for other park units in the eastern U. S. (Figure 23, NPS-ARD 2010).

ERMN's risk assessment of ozone-induced foliar injury to sensitive plant species at ALPO is considered moderate, which indicates that foliar injury will most likely occur within the park, but it is not expected to be regular or frequent (NPS-ERMN 2004). Although exposure levels exceeded the thresholds for foliar injury, the final condition assignment was *moderate concern*, because soil moisture levels were usually low during periods of high exposure, thereby reducing the risk of injury (Table 10; NPS-ERMN 2004).

Data Gaps and Confidence in Assessment

Confidence in the current assessment was *medium* for ALPO, due to lack of measured data within the park. Confidence in the assessment of trend from the Condition and Trends report, which was derived from actual measured data, was *high*. Confidence in the risk of foliar injury to plants within the park was *medium* due to the lack of field documentation.

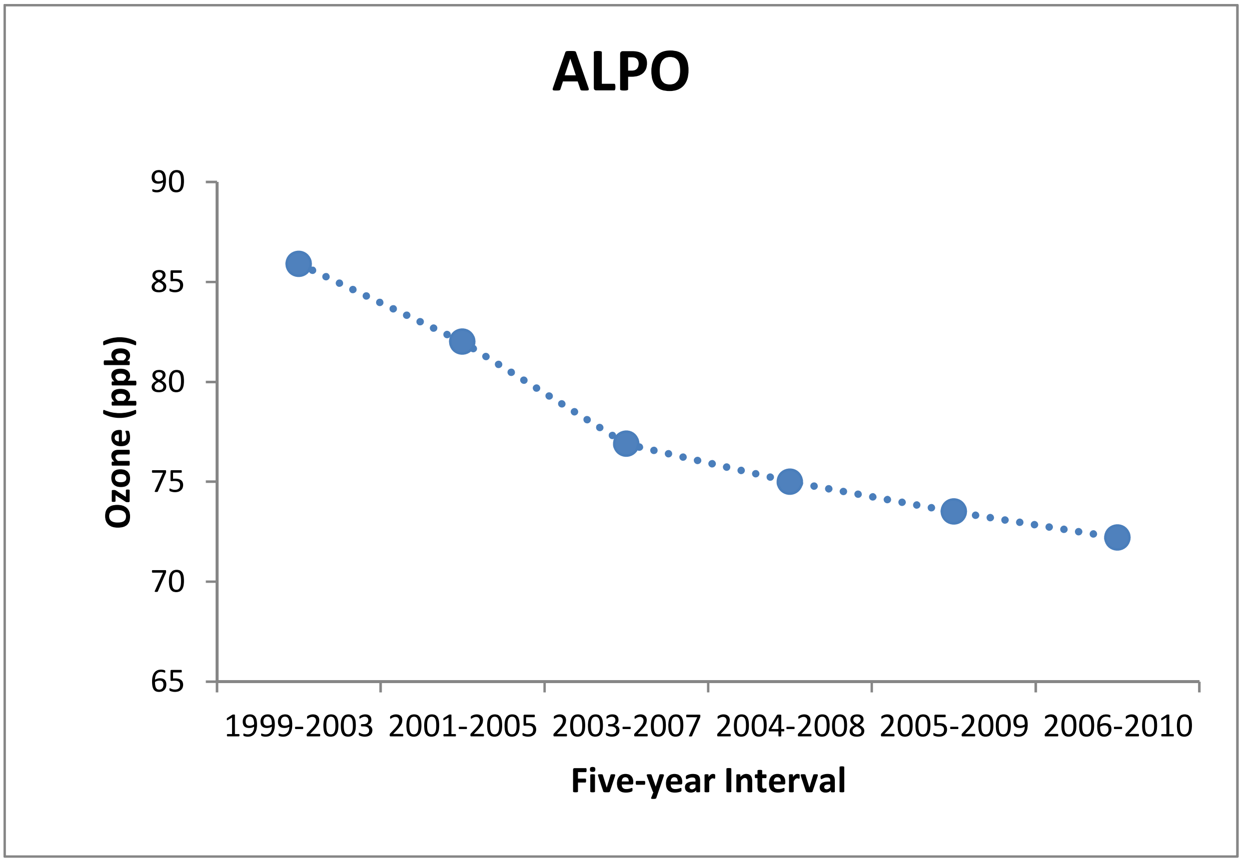


Figure 22. Five-year estimates of ozone concentration over an approximate 10-year period for ALPO derived from interpolations of 4th-highest daily maximum 8-hour ozone concentrations (NPS-ARD).

Table 10. Ozone condition assessment results for ALPO based on reference criteria for human and natural resource exposure. Trend arrow is based on NPS-ARD interpolation estimates and indicates an improving condition (i.e., decreasing regional ozone concentration estimates).

	Human Health Ozone Concentration			Ecological Health Ozone Exposure (SUM 06)			Ecological Health Ozone Exposure (W126)		
Condition Category	**Reference Criteria**	**Current Condition**	**Condition Rating**	**Reference Criteria**	**Current Condition**	**Condition Rating**	**Reference Criteria**	**Current Condition**	**Condition Rating**
Good	≤ 60 ppb	72.2 ppb		< 8 ppm-hrs	13.1		< 7 ppm-hrs	10.3	
Moderate Concern	61 - 75 ppb			8 - 15 ppm-hrs			7 - 13 ppm-hrs		
Significant Concern	≥ 76 ppb			> 15 ppm-hrs			> 13 ppm-hrs		

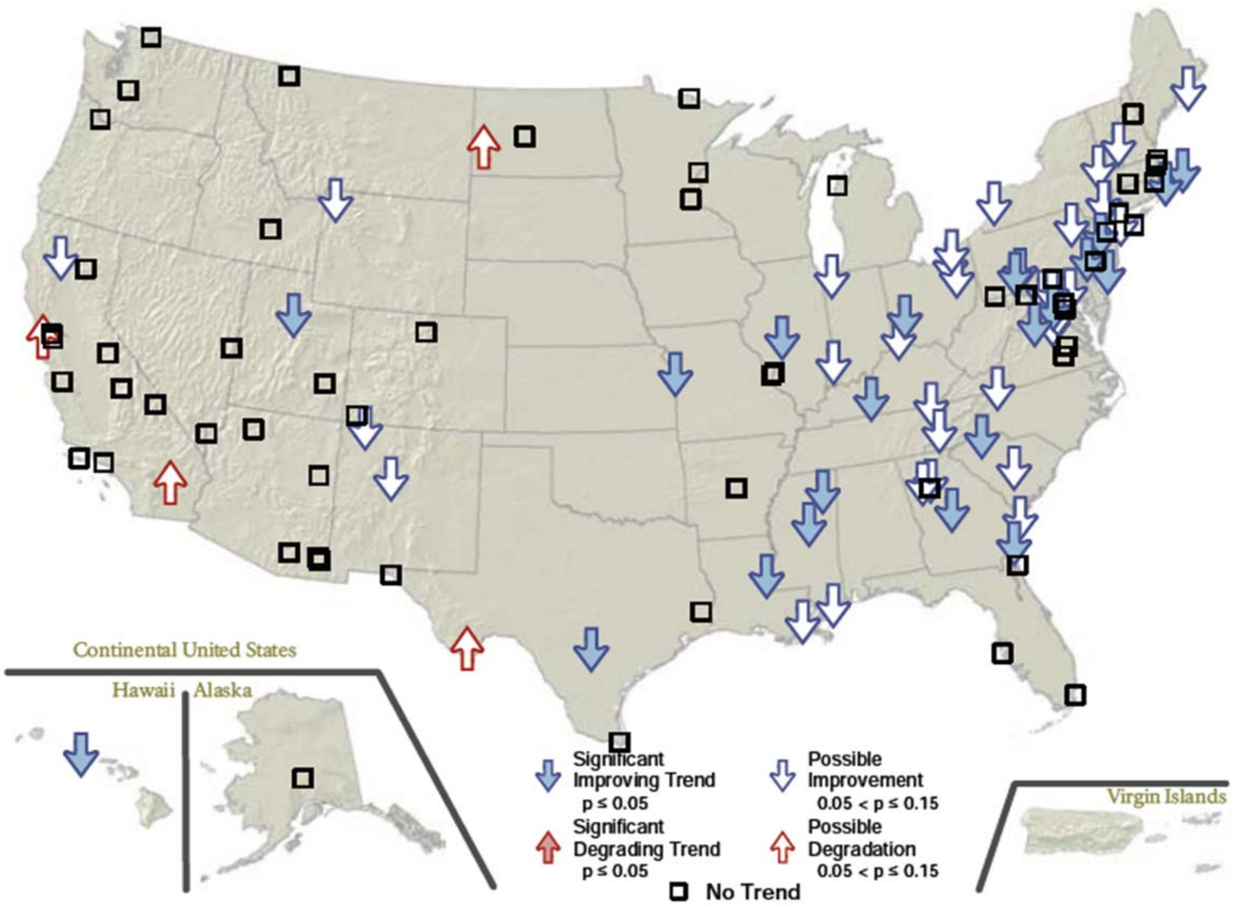


Figure 23. Trends in annual 4th-highest 8-hour ozone concentration, 1999 – 2008 (NPS ARD 2010).

4.1.2 Visibility

Relevance and Context

There are many ways to explain 'visibility'. Originally it was defined in terms of visual range as "the greatest distance at which an observer can just see a black object viewed against the horizon sky;" (Malm 1999). However, the importance of visibility in altering the perception of one's view and experience of landscape features and vistas goes far beyond the ability to see an object at a distance. Rather it involves a multitude of factors, including characteristics of the observer (e.g., value judgments), as well as optical characteristics of (1) illumination, (2) the viewed target, and (3) the intervening atmosphere. In the most general sense, visibility can be considered as the effect that various types of aerosol and lighting conditions have on the appearance of landscape features (Malm 1999).

Natural visibility in the east is estimated to be between 60 and 80 miles (110 – 115 miles in the west) (Malm 1999). Most issues with visibility impairment are caused by five main particulates in combination with water vapor: sulfates, organic matter, soil (dust), elemental carbon (soot), and nitrates (National Research Council 1993, Malm 1999). These particles can be carried up to thousands of kilometers and remain in the air for several days. For the eastern half of the United States major reduction of visibility is contributed to sulfate particulates (~60 – 90% visibility reduction) (Malm 1999). Much is emitted from the burning of coal in electric boilers (National Research Council 1993).

In response to the Clean Air Act (1977), NPS and USEPA started a visibility monitoring program called the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to protect monitor visibility in Class I air quality areas. This program is a cooperative effort involving multiple federal agencies, including NPS, and is designed to measure visibility, identify emission types and sources, record long-term trends and ultimately 'preserve the ability to see long distances, entire panoramas, and specific features associated with the statutory Class I areas' (http://www.nature.nps.gov/air/regs/visbility.cfm). Class II areas, such as ALPO, are not required to meet this visibility mandate. However, ALPO can benefit from regional reductions goals of sulfates set by this visibility mandate. In addition, given the small size of the park and its proximity to urban areas, managers are severely limited in their ability to control visibility levels in the park. However, they can monitor this indicator for their park through interpolation of the results from the Class I parks located closest to them. Refer to http://www.nature.nps.gov/air/monitoring/vismon.cfm for more information on visibility monitoring.

Methods

The NPS-ARD incorporates a five – year period of monitored data (most recently 2006 – 2010) from the IMPROVE sites, the closest of which is approximately 115 miles from ALPO in Arendtsville, PA (Table 8, Figure 21). These interpolated values (available at www.nature.nps.gov/air/who/npsPerfMeasures.cfm) are compared to an index assigning air quality to one of three categories where air quality warrants *significant concern*, *moderate concern*, or *good* condition (Table 11). Park scores of visibility conditions are based on the current Group 50 visibility (the mean of visibility observations between the 40th and 60th percentile) conditions from an estimated Group 50 natural visibility (natural visibility in the absence of humans). This is expressed in terms of a Haze Index measured in deciviews (dv), with visibility decreasing as the Haze Index increases. Refer to the following for more information on visibility and the haze index: www.nature.nps.gov/air/Planning/docs/AQ_ConditionsTrends_Methods_2013.pdf. We based the trend assessment on the NPS-ARD regional ten-year trends (NPS-ARD 2010).

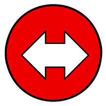
Reference Condition

These averages in dv provide a visibility condition score. NPS-ARD defines $\leq$ 2 (dv) as the reference visibility condition or *good* condition. Values of visibility ranging between two and eight dv above natural conditions are assigned the label of *moderate concern*. Estimates higher than eight dv above natural conditions are regarded as a condition warranting *significant concern* (Table 11). These values are reflective of the possible variation with visibility while it is important to remember the main threshold of 2.0 dv and above are undesirable conditions.

Current Condition and Trends

The most recent data from 2006-2010 value is 11.4 dv of visibility for ALPO warranting *significant concern* (Table 11). This is much higher than the reference standard of 2.0 dv but does represent a slight reduction compared to estimates from previous time periods (Figure 24).

Table 11. ALPO condition assessment results for visibility based on NPS ARD 5-Year Interpolated Visibility Values for ALPO.

Visiblity Condition	Current Group 50 - Estimated Group 50 Natural (dv)	Current Condition	Condition Rating
Good	< 2		
Moderate Concern	2 - 8	11.4	
Significant Concern	> 8		

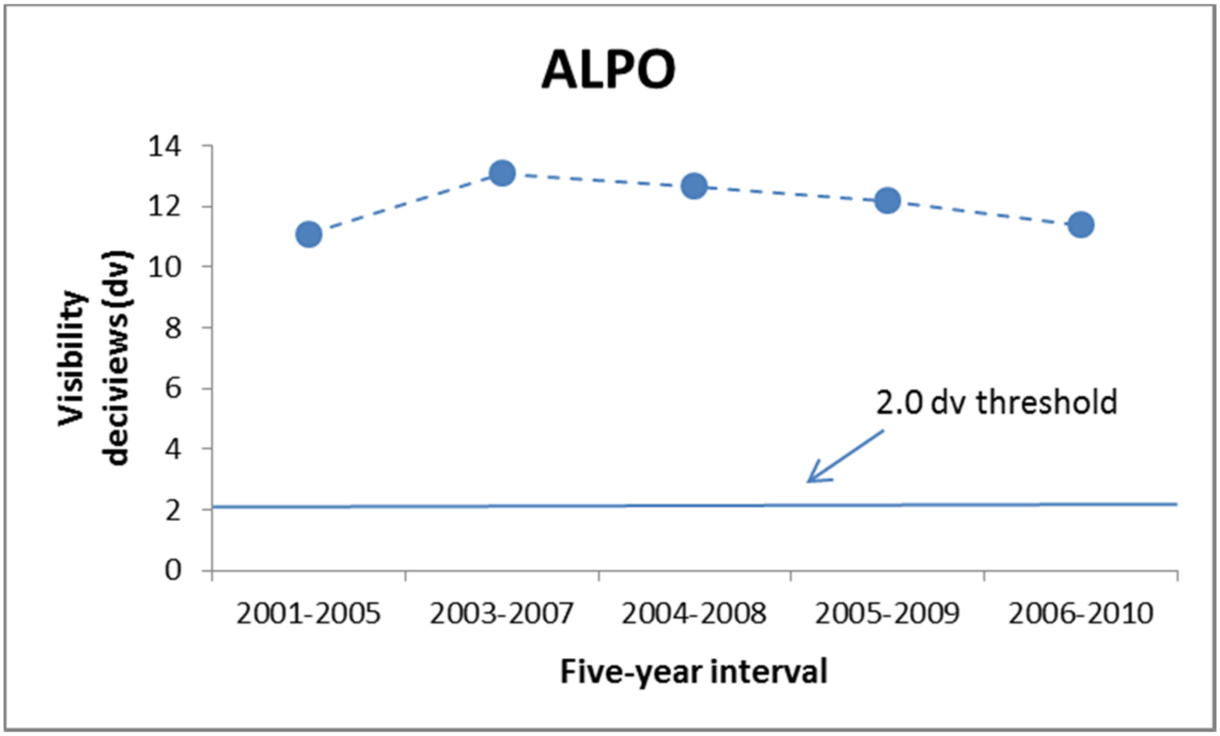


Figure 24. Five-year estimates in haze index (dv) for ALPO (NPS-ARD 2011).

However, the national assessment of 10-year trends showed no parks with degrading trends in haze index on haziest days (most parks in the east showed possible improvement) and only five parks showing a degrading trend in haze index on either clear or hazy days, translating to 97% of NPS reporting parks showing improved or unchanging trend in attainment for the national visibility goal (Figures 25 and 26). Continued improvement is expected in the eastern US with further reduction in sulfur dioxide and nitrogen oxide emissions (NPS-ARD 2010).

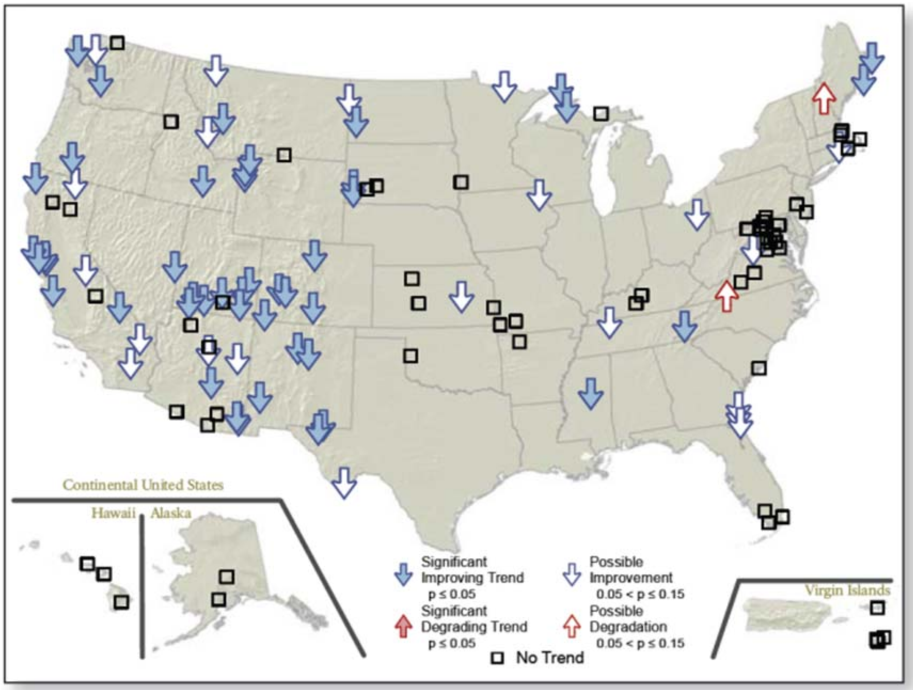


Figure 25. Trends in haze index (dv) on clearest days, 1999 – 2008 (NPS-ARD 2010).

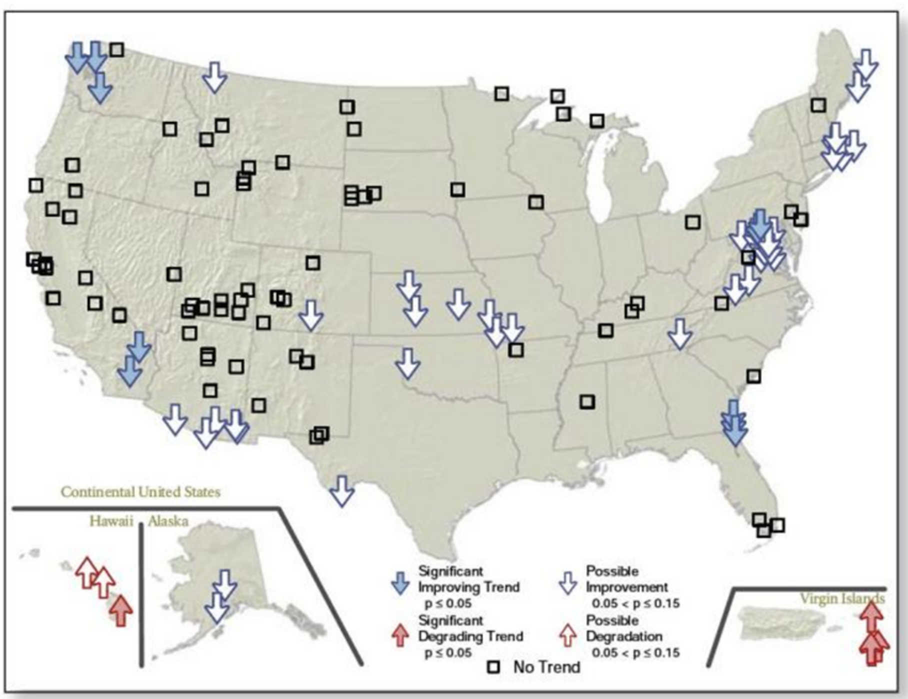


Figure 26. Trends in haze index (dv) on haziest days, 1999 – 2008 (NPS-ARD 2010).

Data Gaps and Level of Confidence

The lack of ambient air quality monitoring for visibility within the park and the necessity of relying on regional interpolations to evaluate condition contribute to uncertainty of the assessment. However, the current location of IMPROVE monitors being within at least 185 km of the park allows us to rate our confidence in the current assessment as *high.*

4.1.3 Wet Deposition

Background

Atmospheric deposition is a process where airborne particles and gases are deposited onto the Earth's surface in the forms of wet and dry deposition. Wet deposition occurs through precipitation (rain, snow, clouds, and fog), while complex atmospheric processes of settling, impaction and absorption constitute dry deposition (Porter and Morris 2005). The sources of this deposition can be both natural and anthropogenic, transporting compounds hundreds of miles through the atmosphere where they react with water, oxygen, and other chemicals to form acidic solutions (USEPA 2007). Primary pollutants associated with atmospheric deposition are oxides of sulfur (SO_x), oxides of nitrogen (NO_x), and reduced forms of nitrogen (NH_x). In the United States, sulfur emissions and oxidized forms of nitrogen are derived mainly from electricity generating power plants, as well as industrial and mobile exhausts, while the reduced forms of nitrogen (primarily ammonia or NH_3) are derived mainly from agriculture via volatilization of N contained in animal manures and fertilizers (Sullivan et al. 2011c). Introduction of these compounds into both terrestrial and aquatic ecosystems can produce serious ecological effects, primarily acidification of surface waters and nutrient enrichment (Driscoll et al. 2001, NPS-ARD 2010, USEPA 2010).

Terrestrial effects involve four major issues: (1) toxicity of aluminum (Al) to plants, (2) depletion of nutrient base cations (e.g., calcium, potassium, magnesium) from soil, (3) N saturation, and (4) nutrient enrichment and resulting 'unnatural' growth. Acidification lowers pH in soil solution, which leads to increases in aluminum toxicity. As pH levels drop below 5.5, Al becomes increasingly more soluble in soil water thus enriching Al concentrations and eventually becomes toxic to plant roots. Not only does Al toxicity reduce a plant's ability to uptake nutrient base cations, but the increased supply of highly mobile anions from increased acid deposition also accelerates the depletion of these cations from the soil, further decreasing nutrient availability to plants. The health of sugar maple trees is strongly influenced by the availability of calcium (Ca) and other base cations in the soil, making this species one of the most sensitive to acidification. Nitrogen saturation occurs when the input of N to the ecosystem exceeds the nutritional requirements of the terrestrial biota and the resulting excess N leaches as NO_3^- through soil water, further acidifying soil and surface water and accelerating loss of base cations, resulting in reduction in tree growth and death of sensitive species. The degree of N saturation is strongly dependent on both vegetation (e.g., hardwoods are capable of retaining more N than conifers) and land use history (e.g., affects soil retention capacity). In the eastern United States, atmospheric deposition of ~10 kg N/ha/yr or higher is required in order for appreciable amounts of NO_3^- to leach to surface waters (USEPA 2008, Sullivan et al. 2011a). Nutrient enrichment describes a suite of environmental changes that can occur in both terrestrial and aquatic ecosystems as the result of increases in a key nutrient, which causes some species to thrive at the expense of others and alters species composition (Sullivan et al. 2011c).

Aquatic effects of acidification are primarily through decreases in acid neutralizing capacity (ANC), decreased pH, and increased Al concentration. Many species of fish, aquatic invertebrates, and phytoplankton are sensitive to acidification, and highly acidic waters can result in localized extinction of aquatic life. In addition, nutrient enrichment (also known as eutrophication) can severely reduce biodiversity by favoring certain plant species (often invasive) at the expense of others, creating excessive plant growth and decay and resulting in oxygen deficits, impaired water quality, and impacted biota (USEPA 2010). Factors influencing ecosystems sensitivity to acidification include geology (e.g., surface waters underlain by sandstone bedrock have low ANC), soil chemistry, topography, hydrologic flow paths, and land use history (e.g., loss of base cations through erosion and timber harvesting). In the northeast decreased base cation concentrations are limiting recovery of ANC and pH in surface waters, despite large decreases in S deposition from emissions control programs (Sullivan et al. 2011a).

Methods

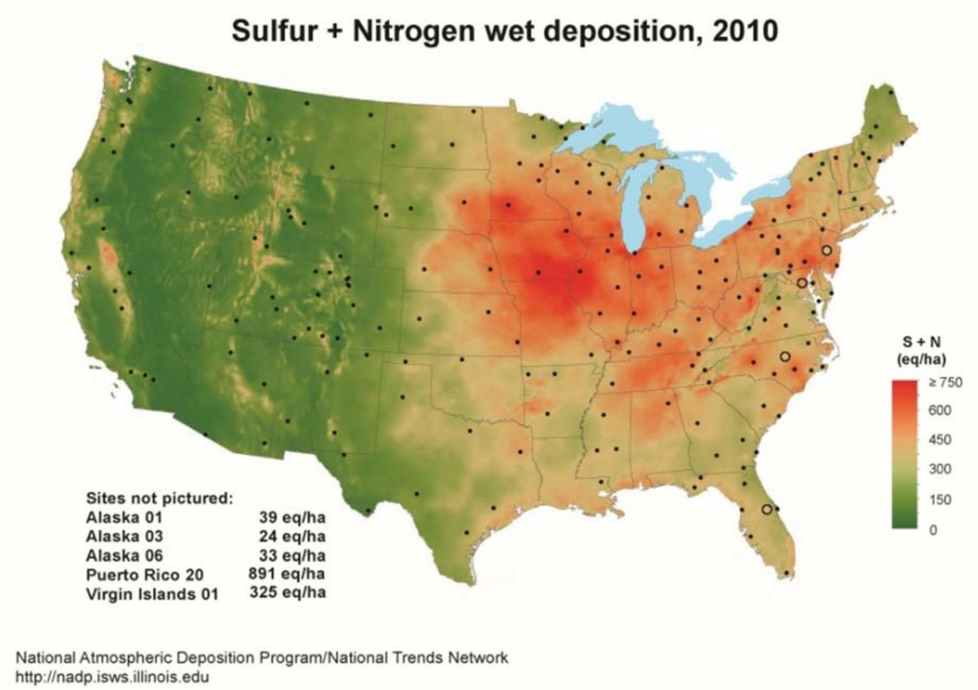
The NPS-ARD uses monitoring data collected from the National Atmospheric Deposition Program/ National Trends Network (NADP /NTN) to estimate wet deposition (N and S) for all parks within the network. The deposition measures are determined by estimating the contribution of nitrogen from both ammonium (NH_4^+) and nitrate (NO_3^-) measurements in precipitation and the contribution of sulfur from sulfate (SO_4^{2-}) measurements in precipitation. Because this effort occurs at a national scale, estimates for each park are based on interpolations from nearby monitoring stations (within 500 km) (Figure 21). There are several NADP/NTN monitoring sites near ALPO, including one monitoring station located within the park (PA-13) (Figure 21). However, the PA-13 station was not part of the NADP/NTN until mid-2011; therefore, results from this station are not reflected in the NPS-ARD air estimate tables. Rather we obtained wet deposition data and results for station PA-13 from the 2010 scientific report to the state (Boyer et al. 2010). These results are part of The State of Pennsylvania's State Acid Deposition Network. From this data, estimates for both S and N were calculated and compared with the surrounding site full records (i.e., air quality estimates) (David Gay, personal communication). Both data were compared to the threshold value to determine percent attainment of condition. We reported results for wet sulfur and wet nitrogen deposition from the NPS-ARD report and the PA-13 station separately and used the latter to report trends.

We do not have data to report for dry deposition, or cloud or fog, primarily due to the difficulties in measuring these components and the uncertainties involved in estimating deposition (Sullivan et al. 2011a). However, it is important to note that CASTNet has monitored dry deposition at a few locations and found that it can be higher than wet deposition, especially near large emission sources. Cloud or fog deposition has rarely been measured and is generally considered a substantial source of deposition in the eastern United States at elevations above 1500m (Sullivan et al. 2011a). According to the NPS-ARD wet deposition monitoring protocol (Porter and Morris 2005), where only wet deposition is measured, total deposition should be estimated by doubling wet deposition.

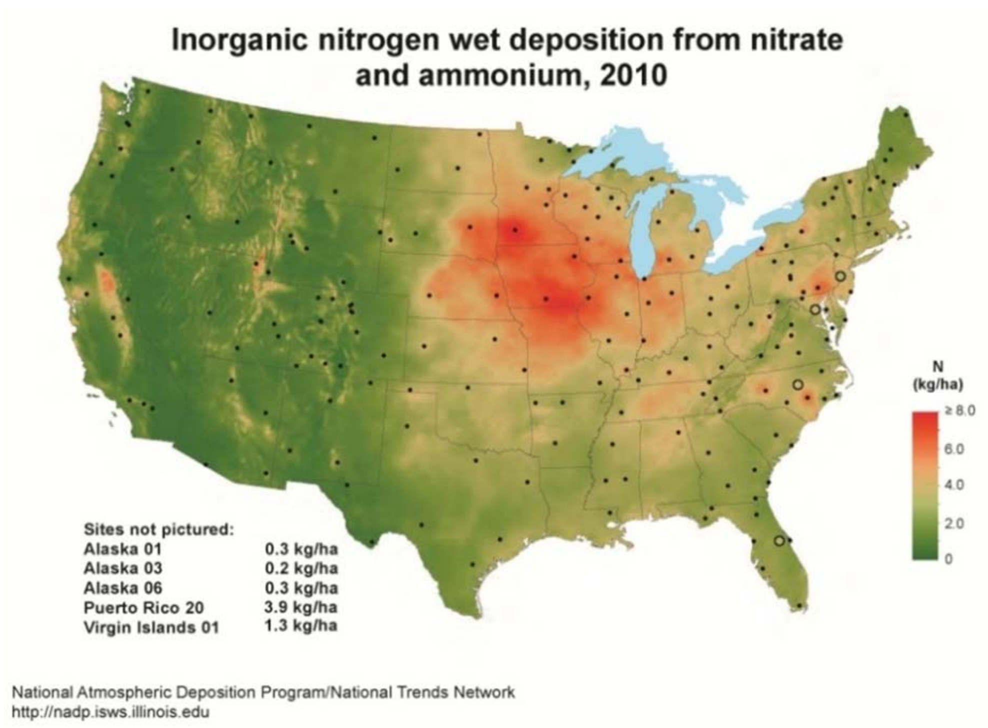
In addition, we summarized the results from the NPS-ARD sensitivity reports, which evaluated the sensitivity of ALPO's natural resources to both acidification and nutrient enrichment (Sullivan et al. 2011a, b, c and d). These assessments estimated park risk by considering the following three factors: (1) pollutant exposure, (2) inherent ecosystem sensitivity, and (3) park protection mandates. The national assessment ranked all parks according to each of these factors and assigned a summary risk ranking (calculated by averaging the three separate rankings). Pollutant exposure variables included emissions, average deposition, human population, and percent developed and agricultural land. Ecosystem sensitivity was defined by park location within an area known to be sensitive to soil and water acidification, the coverage of vegetation types containing red spruce and/or sugar maple, and the abundance of high-level lakes and headwater streams prone to acidification. Park protection was based on PSD classification, with Class I and wilderness areas considered most sensitive (Sullivan et al. 2011a, b, c, and d).

Reference Condition

Both natural background deposition estimates as defined by Porter and Morris (2005) and effects on ecosystems are included in rating condition. Total natural background deposition estimates for nitrogen or sulfur in the eastern United States are 0.50 kg/ha/yr (Porter and Morris 2005). Some sensitive groups are impacted by levels of wet deposition around 1.5 kg/ha/yr, but no evidence exists to conclude that wet deposition below <1 kg/ha/yr causes harm. Thus parks with wet deposition values below this threshold are considered to be in good condition. Although patterns of deposition are highly complex (being influenced by such factors as meteorology, atmospheric transport, precipitation patterns, land forms, etc.), both sulfur (S) and nitrogen (N) deposition is generally considered to be high in the eastern United States (Sullivan et al. 2011a, Figure 27).



a.)



b.)

Figure 27. Sulfur and nitrogen wet deposition (a) and total inorganic nitrogen deposition (b) for the United States in 2010.

Current Condition and Trends

The yearly wet deposition of total sulfur (S) and nitrogen (N) in kg/ha/yr measured at the PA-13 station at ALPO's Summit area were well above the threshold of 1.0 kg/ha/yr but appear to have decreased in recent years (Figure 28). Trend analyses conducted by Boyer Water Quality Lab on the deposition data collected at PA-13 since 1997 confirm this decreasing trend in both nitrate and sulfate annual wet deposition (Figure 29).

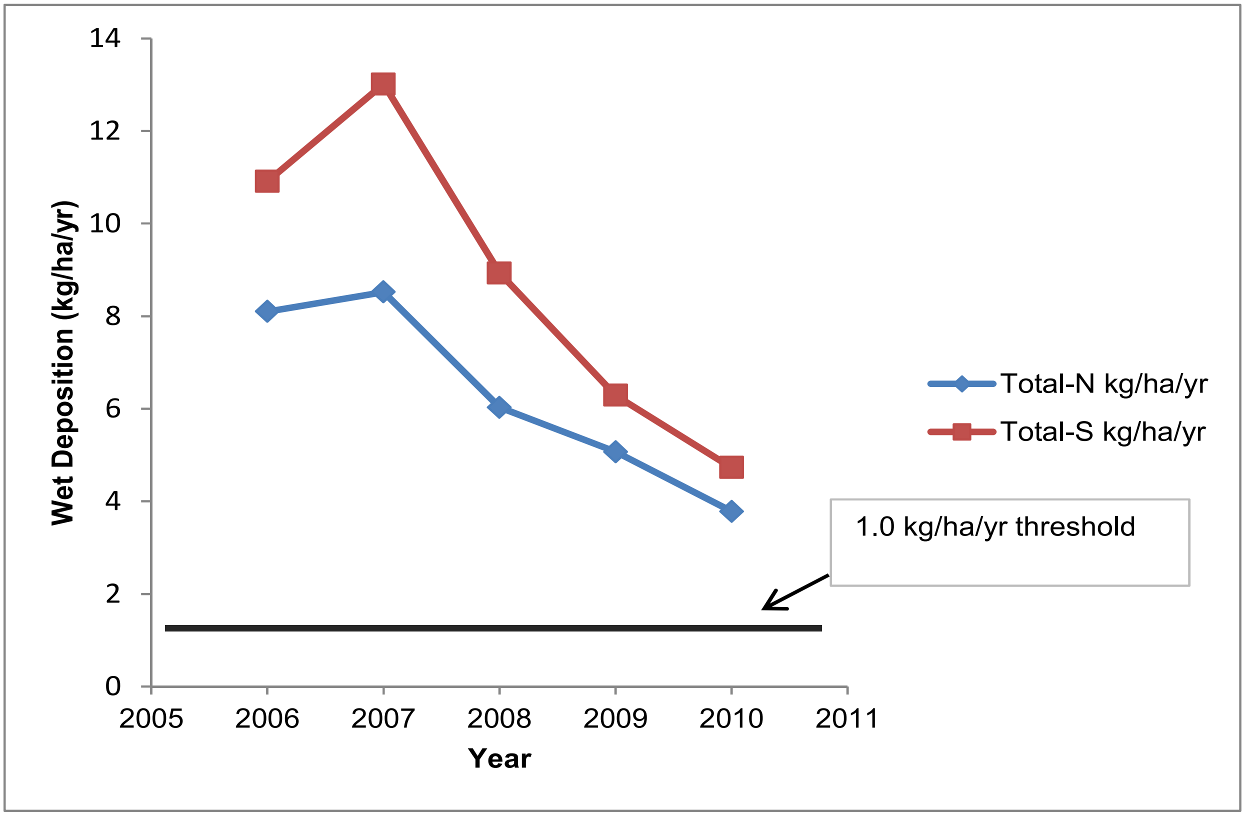
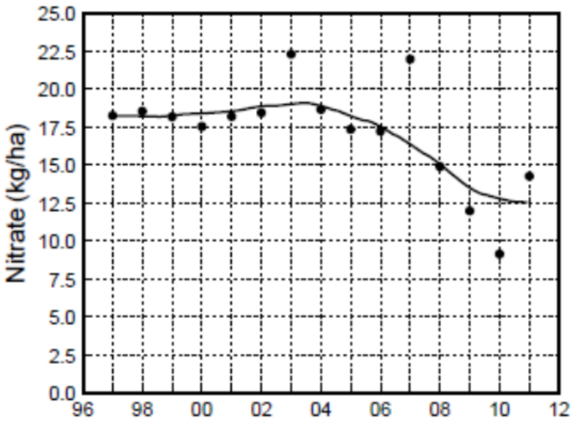
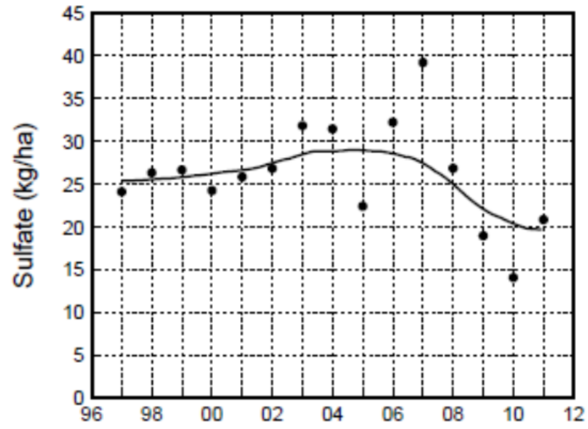


Figure 28. Total wet deposition of sulfur and nitrogen per year measured at the PA-13 station from 2006 through 2010. The black line represents the threshold above which may cause harm. Data was used to determine the five-year average for PA-13 in Figure 30.

The graph of NPS-ARD estimated five-year averages in total sulfur and total nitrogen wet deposition also show a decrease in concentration of both parameters with the latest five-year average, although a trend cannot be assumed from this data (Figure 30). The five year averages for both sulfur (red square) and nitrogen (blue square) determined from the PA-13 data displayed in Figure 28 are also shown for comparison. Given the stringent quality control measures applied to collection and analysis of the PA-13 data (i.e. the low probability of human error contributing to these results), these results suggest the area in and immediately surrounding ALPO receives greater wet deposition of nitrogen and sulfur than the estimated average for the region.



a.)



b.)

Figure 29. Smoothed line trends in annual wet atmospheric deposition for nitrate (a) and sulfate (b) from 1997 – 2011 at station PA-13 located within ALPO. Courtesy of Boyer Water Quality Lab at Penn State University and the Pennsylvania Department of Environmental Protection.

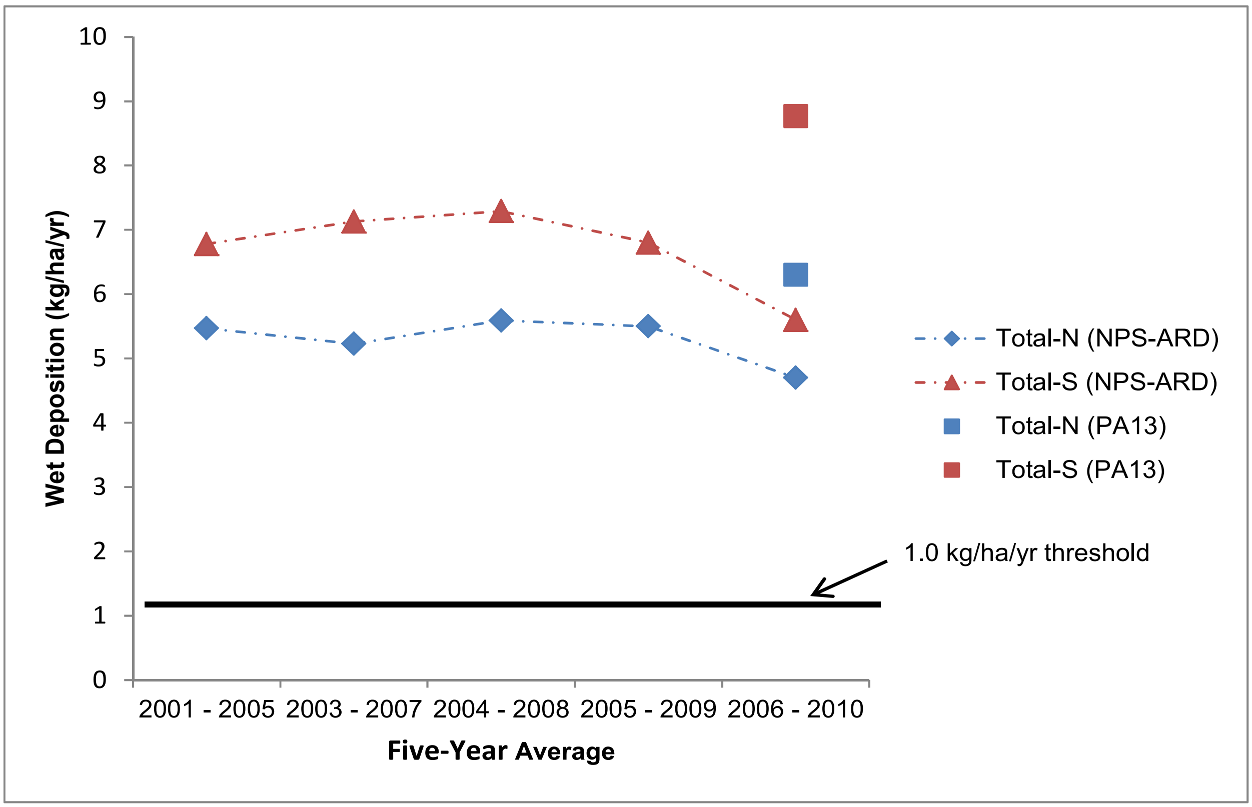
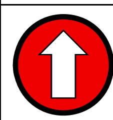
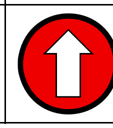


Figure 30. Five-year averages for total nitrogen and sulfur deposition in precipitation (wet deposition) from the surrounding site full records (NPS-ARD). The latest five-year average (2006 – 2010) from the yearly measured PA-13 data presented in Figure 28 is added for comparison. The latter is provided courtesy of Boyer Water Quality Lab at Penn State University, the Pennsylvania Department of Environmental Protection, and the NADP/NTN.

The above results are summarized in the condition assessment below (Table 12), which used the most recent five-year averages from both the NPS-ARD estimate and the PA-13 measured data (Figures 28 and 30). The most recent NPS-ARD five-year average (2006-2010) is 4.7 kg/ha/yr of nitrogen wet deposition and 5.6 kg/ha/yr of sulfur wet deposition. Estimates from measured data on site are even higher (6.3 and 8.77 kg/ha/yr of nitrogen and sulfur, respectively) (Table 12). Both sets of values more than exceed the reference standard of 1.0 kg/ha/yr, resulting in 0% attainment of reference condition and warrants s*ignificant concern* for both nitrogen and sulfur deposition.

Table 12. ALPO condition assessment results for nitrogen and sulfur wet deposition using NPS ARD 5-Year interpolated Sulfur and Nitrogen Wet Deposition Values and PA13 data obtained at the Summit area of ALPO. Note the arrow indicates improving condition resulting from decreasing concentrations of both N and S wet deposition.

Condition Category	Wet Deposition N - (NH_4 + NO_3) (kg/ha/yr)				Wet Deposition S - (SO_4) (kg/ha/yr)			
	Reference Criteria	Current Condition		Condition Rating	Reference Criteria	Current Condition		Condition Rating
		NPS-ARD Estimate	PA13 Data			NPS-ARD Estimate	PA13 Data	
Good	< 1				< 1			
Moderate Concern	1 - 3	4.7	6.3		1 - 3	5.6	8.77	
Significant Concern	> 3				> 3			

Results for the acidification risk assessment for ALPO were similar to those for the other parks in the ERM N. Both the park and network were perceived to be at very high risk for pollutant exposure and ecosystem sensitivity (Table 13). According to Sullivan et al. 2011(b), annual S and N emissions for Blair and Cambria Counties ranged from greater than 1 and up to 20 tons per square mile with a number of nearby western counties showing total S emissions up to 939 tons per square mile and N emissions up to 50 tons per square mile. These areas coincided with substantial point sources of both SO_2 and nitrogen oxides and an urban center with population between 100,000 and 500,000. Total S deposition for the park (both wet and dry forms) was quite high (30 – 133.5 kg/ha/yr). Total N deposition (wet/dry/oxidized/reduced) within the park ranged from 15 – 20 kg/ha/yr. Land cover types within the park were primarily forest with pasture/hay and developed areas. Watershed slope for the park was in the 20° and 30° range. Both the park and the network areas are largely characterized by acid-sensitive geology and water, the presence of acid-sensitive tree species, and relatively steep slopes giving rise to low-order, relatively high-elevation streams. All of these results in a very high perceived ecosystem sensitivity risk. The overall perceived acidification risk for ALPO was higher than that for the network, primarily due to an increased ranking for park protection (Sullivan et al. 2011a, b). The ERMN does not have any Class I areas or any designated wilderness areas managed by NPS; therefore, park protection rankings for all parks in the ERMN network were ranked as 'Moderate'. Because the network ranking was based on comparisons with other NPS Inventory & Monitoring networks that have Class I areas and/or designated wilderness areas, the overall park protection ranking for the network was much lower than that of the park.

Table 13. Results for the acidification risk assessment for the ERMN and ALPO. All information was compiled from Sullivan et al. 2011 a, b, c, and d.

	ACIDIFICATION RISK				NUTRIENT ENRICHMENT RISK			
	Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk	Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
ERMN	VERY HIGH	VERY HIGH	VERY LOW	HIGH	VERY HIGH	VERY LOW	VERY LOW	VERY LOW
ALPO	VERY HIGH	VERY HIGH	MODERATE	VERY HIGH	VERY HIGH	LOW	MODERATE	HIGH

The perceived risk for nutrient enrichment was higher for ALPO than for the network. According to Sullivan et al. 2011(d), both the park and network were considered very high risk for pollutant exposure, again due primarily to relatively high emissions and deposition of nitrogen oxides (see above). Unlike acidification, the perceived nutrient enrichment risk to ecosystem sensitivity in the park and network were low and very low, respectively, due to a lack of high elevation lakes and limited coverage of sensitive vegetation types.

Data Gaps and Confidence in Assessment

Confidence in the quality of the site assessment (PA-13) is *high*, while that of the regional interpolation estimates is also *high*. Sample collection and data management of both datasets follows standard quality control and assurance procedures. We assigned a higher rating to the results from the PA-13 assessment because (1) onsite data will be more accurate than estimates from locations as far as 500 km away, and (2) the PA-13 site includes onsite precipitation data collected simultaneously, while the NADP/NTN calculates wet deposition by multiplying the dry deposition concentration by the PRISM 30-year average precipitation (Beth Boyer and Drew Bingham, personal communication). However, PRISM is based upon 7,000 observations over the country and is considered to be highly verifiable in its ability to provide a good regional signal, thus, confidence in the regional assessment results remain high. Confidence in the park risk assessments is fair, because the authors (Sullivan et al. 2011 a, b, c, and d) define these assessments as coarse approximations of true risk. Confidence in the overall assessment of condition is moderate to high, given (1) the lack of data on dry deposition and cloud or fog deposition, and (2) the fact that many factors affect the distribution and concentration of S and N compounds in the environment and the impacts to both terrestrial and aquatic ecosystems.

4.1.4 Mercury Deposition

Relevance and Context

The metal mercury (Hg), also known as quicksilver, is a heavy, silvery-white liquid under standard temperature and pressure conditions that can vaporize under ambient conditions and enter the atmosphere by both natural and anthropogenic activities. Inorganic mercury is emitted into the air as either elemental mercury, reactive gaseous mercury, or particulate-bound mercury. All forms can be deposited on plants, surface waters, and land via wet and dry deposition. Wet deposition is episodic and occurs when atmospheric gaseous mercury and particulate-bound mercury are transferred to precipitation. Dry deposition is the continuous transfer of atmospheric mercury to all surfaces and can potentially be greater than wet deposition in some ecosystems, especially in the northeastern United States (Driscoll et al. 2007, Risch et al. 2012).

Following deposition, biological processes can convert these biologically unavailable forms of mercury into the more toxic form of methylmercury (MeHg), which remains in bodily tissues and accumulates up the food chain. Methylmercury acts as a potent neurotoxin in high doses, so bioaccumulation in ecosystems is an important concern to NPS, for both human health and wildlife exposure. Fish consumption is considered to be the most important pathway for MeHg exposure to both humans and wildlife (www2.nature.nps.gov/air/AQBasics/mercury.cfm). In addition, geology, climatic variables, watershed characteristics and other factors influence the rates of Hg deposition and uptake of MeHg. For example, the presence of sulfate from acid rain may increase mercury methylation, as well as biotic uptake (NPS 2006). Certain environments, such as high-elevation forests and wetlands or other surface waters that generate large amounts of dissolved organic carbon also favor MeHg production (Shanley et al. 2005, Driscoll et al. 2007). Seasonal changes influence patterns of mercury deposition, as well, with more mercury deposited during the summer months in the northeastern United States (Vanarsdale et al. 2005).

Naturally occurring sources of mercury include gases emitted from volcanoes and geothermal vents and evaporation from soils, wetlands, and oceans. Although it is used in a variety of industrial, commercial, medicinal, and other products, the US EPA estimates ~48% of U.S. anthropogenic emissions comes from coal-fired power plants (http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydoc). Approximately 95% of atmospheric mercury is elemental mercury, which can circulate as long as a year, possibly transporting it thousands of miles from the source of emission and thus, has implications for both global and regional deposition (Butler et al. 2007). Since the industrial revolution, global atmospheric emissions of mercury from anthropogenic sources have increased 3-fold, primarily due to increased emissions in Asia (Lamborg et al. 2002, Butler et al. 2007). Conversely, in North America efforts to reduce emissions resulted, at least in part, to declining emission and deposition estimates (cores from lakes and bogs in the Eastern United States show mercury deposition peaked in the 1970's) (Butler et al. 2007). Model estimated geographical distributions of atmospheric mercury deposition show high levels in the eastern portion of the country, with the most likely cause attributed to point sources from the industrial beltway of the Midwest (Butler et al. 2007).

All of the above factors suggest that ALPO most likely receives enhanced mercury deposition, not only due to its location downwind of suspected regional sources of mercury emissions but also due to the large proportion of high-elevation forests within the park, especially along the Summit area of the Main Unit. Thus, mercury deposition is an important indicator of air quality to monitor for this park.

The National Atmospheric Deposition Program's Mercury Deposition Network (NADP/MDN) monitors wet deposition of mercury throughout the nation. It was formed in 1995 to collect weekly samples of precipitation with the major objective being to monitor the amount of mercury in precipitation on a regional basis (http://nadp.sws.uiuc.edu/mdn/). At the end of 2007, there were 112 sites in the network, including PA-13 located within ALPO's boundary.

Figure 31 shows the NADP MDN's 2011 estimates for total mercury wet deposition across the contiguous United States. According to this map, mercury wet deposition in the area surrounding ALPO in 2011 was approximately between 10 to 12 μg/m^2; however, considering dry deposition can represent as much as 60-70% of total deposition, this estimate may be only half of the actual amount. As of 2011, the MDN did not collect information on dry deposition. However, in 2012, NADP undertook two new initiatives to monitor mercury dry deposition. One initiative, "Estimating Dry Deposition of Reactive Gaseous Mercury Using Surrogate Surfaces at MDN Wet Deposition Sites", utilizes a membrane filter apparatus to collect atmospheric mercury samples. The other, "Litterfall Mercury Monitoring Initiative", collects leaf fall in passive containers on the forest floor near MDN wet deposition sites. PA-13 is participating in both of these new initiatives for mercury monitoring. In addition, PA-13 participated in a pilot dry deposition study during the summer and autumn of 2011, and a pilot litterfall study for the eastern United States in the autumn of 2008 and 2009 (Risch et al. 2012).

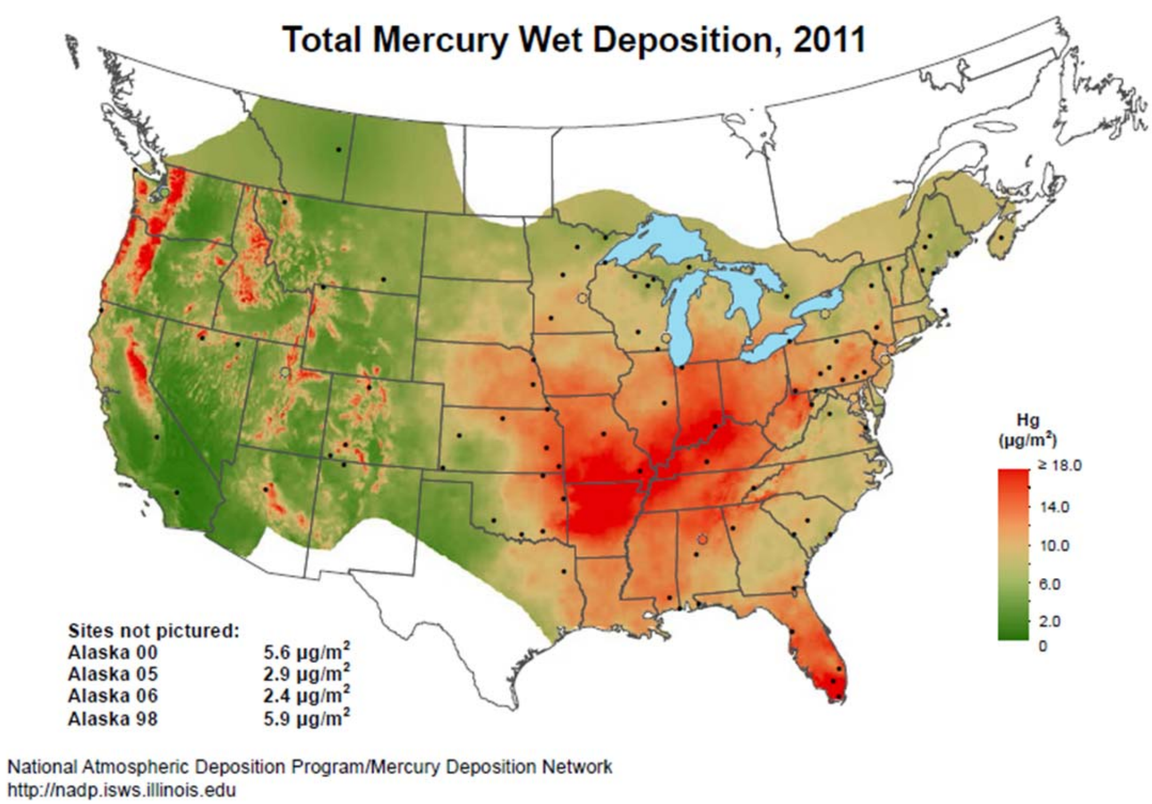


Figure 31. Total wet deposition of mercury in 2011. Source: NADP.

Method

The Pennsylvania Department of Environmental Protection in cooperation with NPS has been monitoring mercury wet deposition within the park (PA-13) since 1997. This data is housed and analyzed by the Boyer Water Quality Lab at Penn State University. Results were obtained from the 2010 scientific report to the state (Boyer et al. 2010) and used to determine the condition rating. Annual mean mercury concentrations in precipitation collected weekly from the PA-13 monitoring site were compared to the threshold value to determine percent attainment of condition. Statistical analyses of long-term trends in ion concentration and wet deposition at the PA-13 monitoring site were based on a least squares general linear model which controlled for the cyclical seasonal variability inherent in precipitation chemistry and volume. The trend model incorporated precipitation chemistry data that was summarized into six, bi-monthly seasons for each year during the trend analysis period. Concentrations were summarized as precipitation-weighted mean concentration and the total seasonal precipitation volume.

Reference Condition

NPS ARD has not yet established condition categories for mercury. However, USEPA's fish tissue criterion for human consumption should not exceed 0.3 mg/kg wet weight of MeHg (US EPA 2001). Ecological modeling results by Meili et al. (2003) equate 2 ng/L of mercury in precipitation to 0.5 mg/kg wet weight of MeHg in freshwater fish. Using these guidelines, we considered values above the threshold of 2 ng/L of Hg in precipitation to be non-attainment status and cause for significant concern (Table 14).

Current Condition and Trend

With the exception of 2001, Hg wet deposition concentrations throughout the monitoring period (1997 – 2011) have ranged between 7.06 and 9.37 ng/L with the 2011 estimate being 8.55 ng/L (Figure 32).

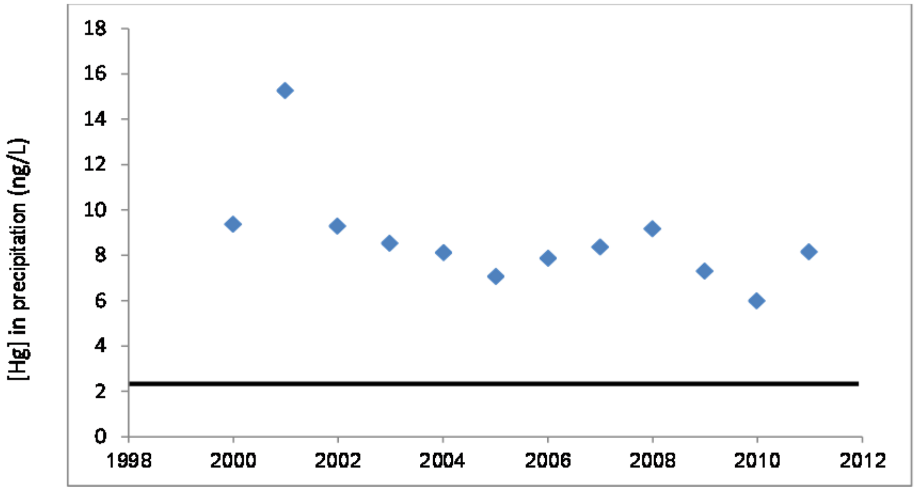
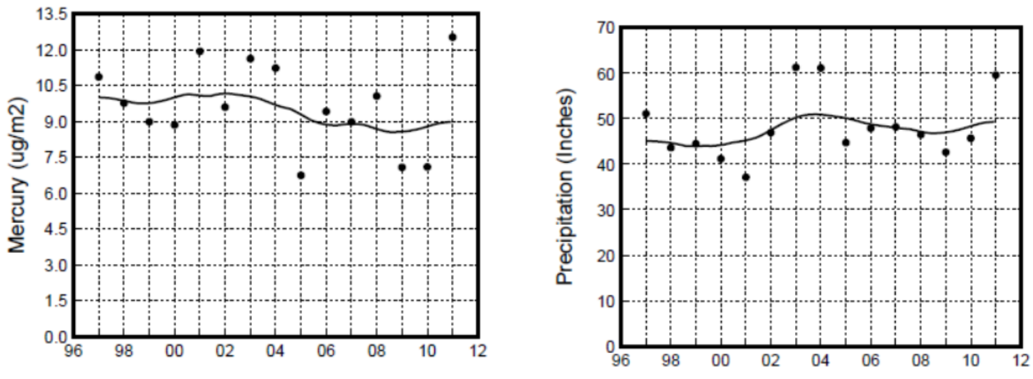


Figure 32. Annual volume-weighted total mercury concentrations (ng/L) in precipitation for PA-13 monitoring site (2000 – 2011). The line represents the indirect regulatory threshold of 2 ng/L modeled by Meili et al. (2003) for MeHg fish concentrations.

The total annual (a) wet mercury deposition and (b) precipitation measurements collected from ALPO during the monitoring period (1997 – 2011) (Figure 33), as well as changes in mercury ion concentration and the long-term trends from 1997 – 2011 (Figure 34) are shown below. Seasonal linear trend models show a declining trend in mercury concentration from 1997 to 2011 (-3.39 percent/year, $p = 0.0001$) (Figure 34) but no significant decrease in mercury wet deposition (Figure 35). The lack of a significant decrease in wet mercury deposition over the monitoring period is most likely because wet deposition is a property of both concentration and precipitation, the latter of which remained relatively the same from year to year (Figure 35).



a.) **b.)**

Figure 33. Annual (a) wet mercury deposition and (b) precipitation for ALPO monitoring site (PA-13) from 1997 – 2011 (Boyer et al. 2010).

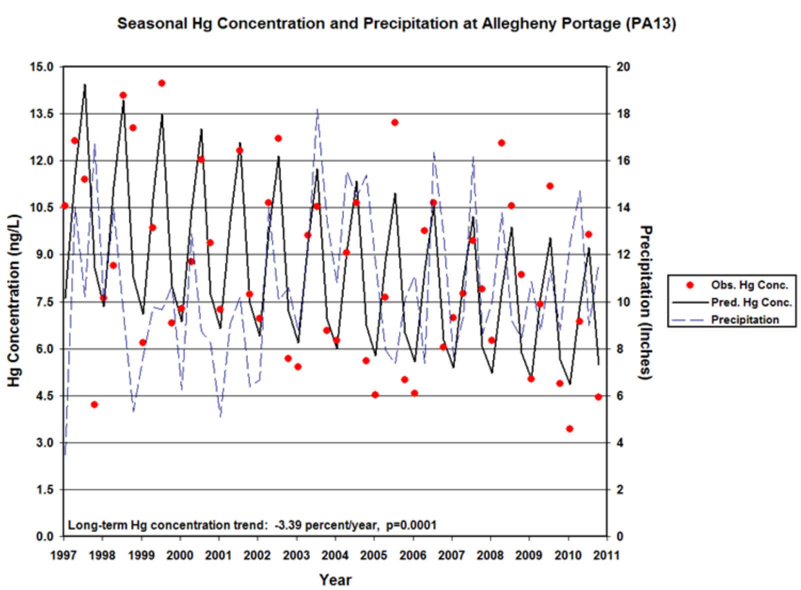


Figure 34. Seasonal trends in total mercury concentrations at the ALPO MDN site (PA-13) in Cambria County, Pennsylvania from 1997 through 2010. A standard linear trend model reveals significant decrease in total mercury concentration (Boyer et al. 2010).

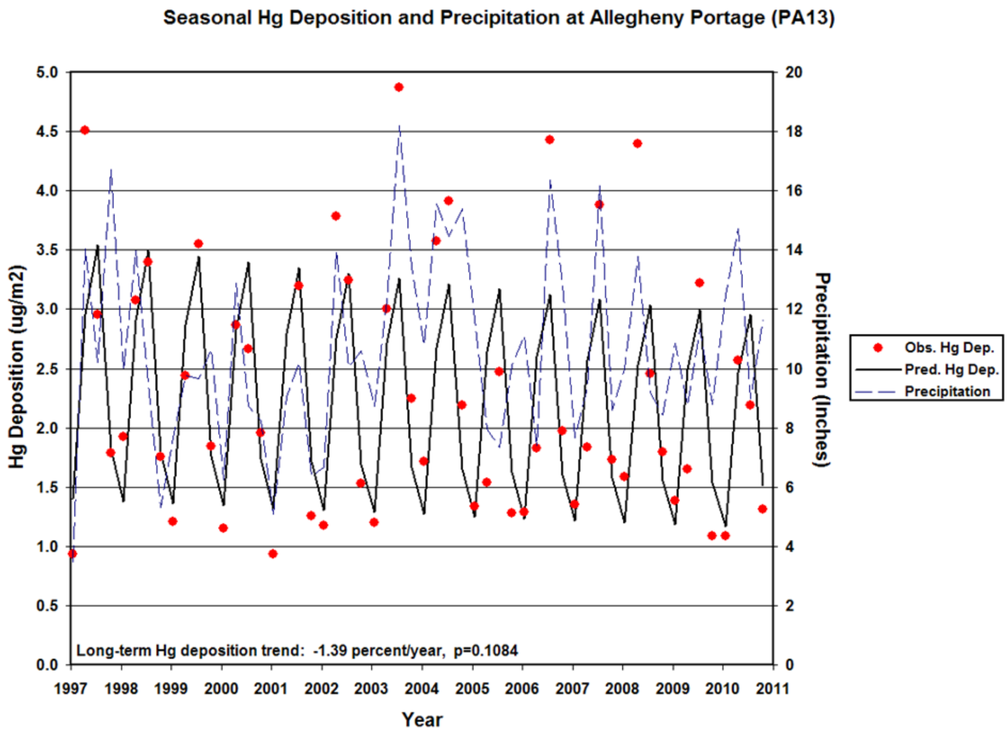
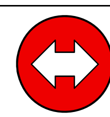


Figure 35. Seasonal trends in total mercury wet deposition and precipitation at the ALPO MDN site (PA-13) in Cambria County, Pennsylvania from 1997 through 2010. A standard linear trend model reveals no significant change in mercury wet deposition (Boyer et al. 2010).

The current condition (2011 estimate) for wet mercury deposition at ALPO is 8.55 ng/L, well above the indirect regulatory mean annual threshold of 2 ng/L in rain water (Table 14). This resulted in 0% attainment of reference condition and warrants *significant concern*. Although the total mercury concentration declined from 1997 through 2010 (Figure 34), mercury wet deposition did not show a declining trend (Figure 35). Thus, we reported the trend as unchanging (Table 14).

Table 14. ALPO condition assessment for mercury wet deposition from measured data at the PA-13 monitoring site located within ALPO's Summit area.

Condition Category	Wet Deposition Hg (ng/L)		
	Reference Criteria	Current Condition	Condition Rating
Good Significant Concern	< 2 ng/L in rainwater > 2 ng/L in rainwater	8.55	

These results differ somewhat from the NPS-ARD's 2009 Annual Progress Report (NPS-ARD 2010), which reported a significant improving trend for wet mercury deposition at PA-13 (slope = -0.17, p = 0.02).

Results from the dry mercury deposition litterfall study suggest that annual litterfall mercury dry deposition measured in 15 states across the eastern USA was significantly higher than annual mercury wet deposition, with a mean ration of dry to wet Hg deposition of 1.3 to 1 (Risch et al. 2012). At PA-13 the dry percentage of total deposition (dry plus wet mecury deposition) from 2007 – 2009 was 62% (Risch et al. 2012).

Data Gaps and Confidence in Assessment

Confidence in the quality of the data is high (i.e., onsite field measurements conducted by trained personnel and precipitation data also collected simultaneously onsite). However, NPS-ARD has not yet established condition categories for mercury deposition. Therefore, confidence in the condition assessment is *medium*, primarily because (1) defining and scoring condition must consider the effects or levels of methylmercury, which were not directly measured (a.k.a. acceptable condition is defined through methylmercury levels but needs to be interpreted and translated from wet and dry mercury deposition results), and (2) the effects of mercury dry deposition were not included in the final assessment of condition. Many factors affect the distribution and concentration of mercury in the environment and the subsequent uptake of methylmercury by biota. For example, forested landscapes dominated by streams and wetlands that generate dissolved organic carbon tend to have elevated levels of mercury in both the environment and the biota (Shanley et al. 2005).

4.1.4 Night Skies

Relevance and Context

An important mission of the National Park Service is to preserve dark night skies. Excellent dark skies provide clear views of the constellations, the Milky Way and other celestial bodies. In addition, they provide natural light and dark patterns, which are important for the proper functioning of ecosystems. Light pollution is defined as any adverse effect of artificial light on living organisms and includes sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste (Holker et al. 2010). The contiguous United States, especially the northeast portion, is one of the most light-polluted areas of the world with 71% of people unable to see the Milky Way and 99 of every 100 individuals living in areas considered by the IDA to be light polluted (Figure 36). Consequently, managing for dark skies can be difficult for a small park located near urban areas (Figure 36).

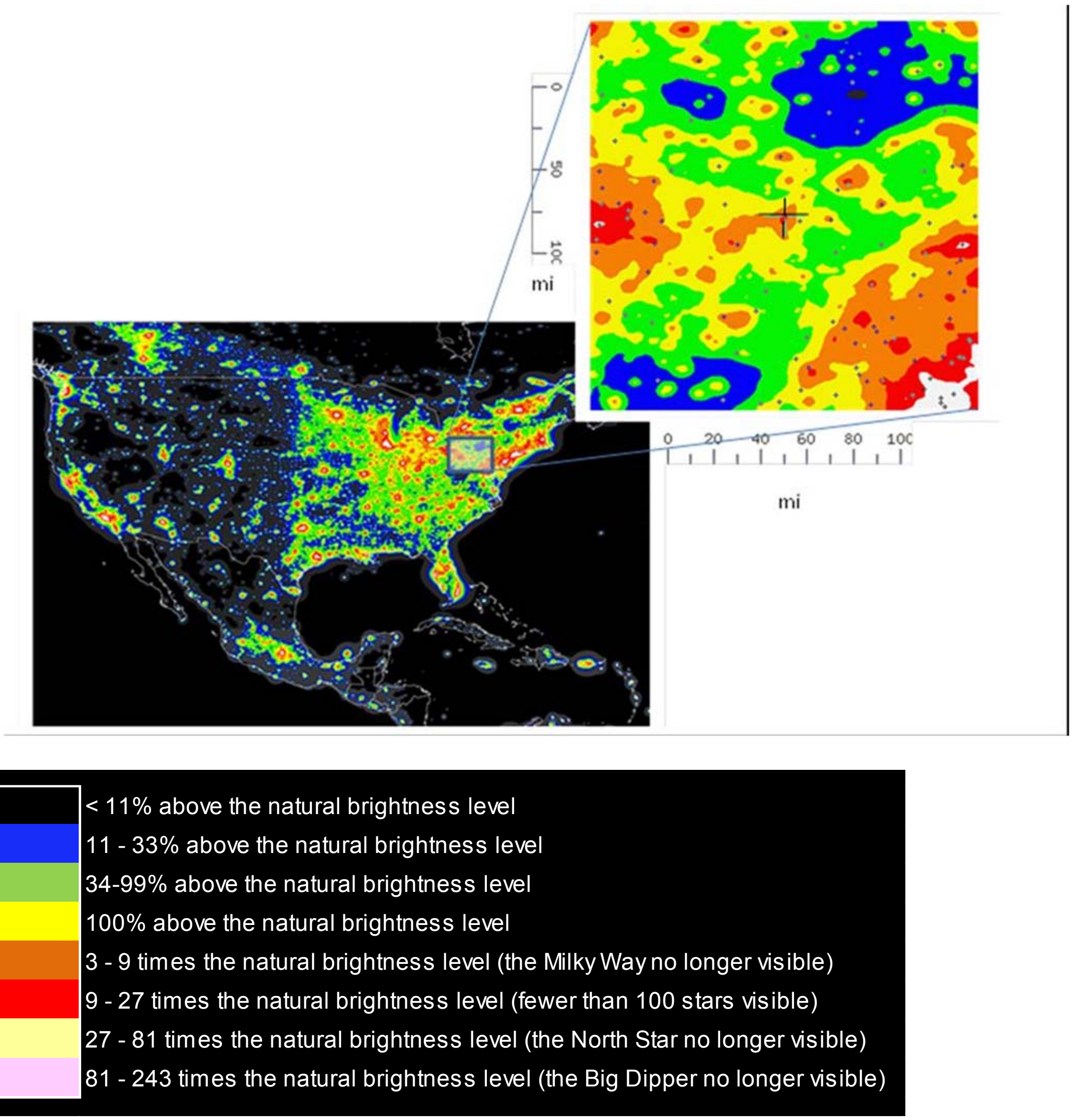


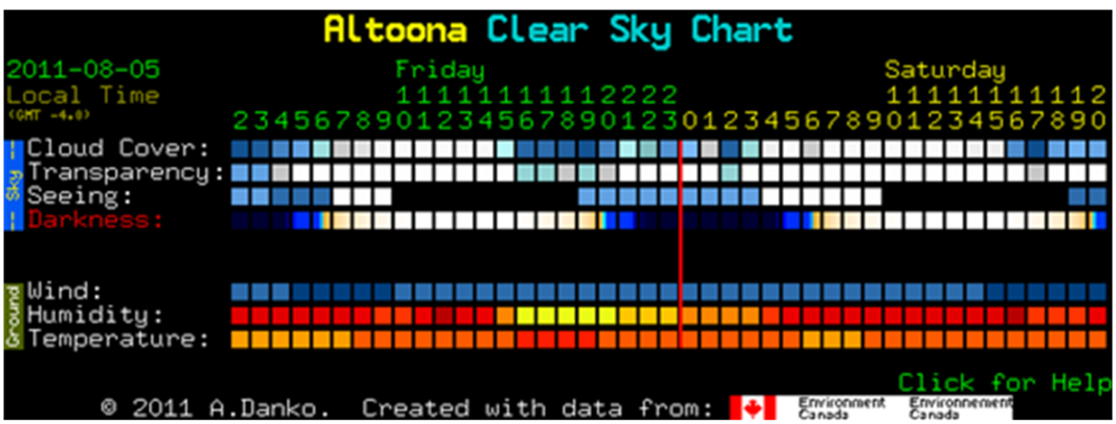
Figure 36. Artificial night sky brightness at sea level showing levels of pollution in the atmosphere for North America. The map is based on upward light measured by the Defense Meteorological Satellite Program after accounting for propagation and scattering of that light in the atmosphere. Inset is a close-up view of the 175 mile east-to-west by 230 mile north-to-south area that houses the location of the park. The central cross marks the location of the Altoona sky chart; the Main Unit of the park is located approximately 17 miles southwest of Altoona. P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder). Copyright Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science (www.lightpollution.it/dmsp/).

Light pollution and its effects can be defined in many ways, but for the purpose of resource management in national parks, two categories stand out—astronomical and ecological light pollution. Astronomical light pollution prevents people from seeing the stars and other features of the night sky. Ecological light pollution can have serious detrimental effects on wildlife behavior, habitats and overall survival. For example, lights can alter reproduction in song birds, disorient migrating birds, negatively affect feeding, breeding, and movements of many invertebrates (especially polarized light, which is often mistaken for water by aquatic species), disrupt melatonin and hormone production in frogs and salamanders, and interfere with bat flight paths, making them more vulnerable to predators (Kempenaers et al. 2010, Bruce-White and Shardlow 2011).

The NPS monitors light pollution at many of its parks, most of which are located in the western half of North America. Using a research grade digital camera attached to a robotic mount and laptop computer, background brightness levels are recorded individually and joined together to form a panorama of sky brightness (www.nature.nps.gov/night/methods.cfm). However, these methods are utilized in large parks with impressive night vistas accessible to visitors, while ALPO is closed from sunset to sunrise. With respect to ecological light pollution, however, simple qualitative appraisals of the night sky may be beneficial.

Methods

One qualitative method is the Bortle Dark-Sky Scale, which uses visual observations to rate the night sky on a scale of 1 (pristine) to 9 (strongly light polluted) (Table 15). These observations must be done on clear nights with good viewing probability, in order for comparisons to be relevant (Bortle 2001). This can be accomplished by referring to the Altoona Clear Sky Chart to plan observations with accommodating conditions (Figure 37).



Cloud Cover	Overcast	90% covered	80% covered	70% covered	60% covered	50% covered	40% covered	30% covered	20% covered	10% covered	Clear

Transparency	Poor	Below Average	Average	Above Average	Transparent

Seeing	Bad 1/5	Poor 2/5	Average 3/5	Good 4/5	Excellent 5/5

Darkness	-4	-3	-2	-1	0	1.0	2.0	3.0	3.5	4.0	4.5	5.0	5.2	5.4	5.6	5.8	6.0

Figure 37. The Altoona Clear Sky Chart (http://www.cleardarksky.com/c/AltoonaPAkey.html) provides weather predictions for astronomical observing in and around Altoona, PA (10 km NE of park). This chart shows conditions from 2 am Friday, August 5, 2011 through 8 pm Saturday, August 6, 2011. The first four rows pertain to sky conditions. The column(s) with the most and darkest blue blocks represent the best conditions for viewing the night sky (2 – 3 am Friday in the above example). The bottom three columns represent ground conditions.

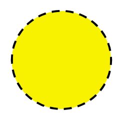
Table 15. Bortle Dark-Sky Scale for rating night skies.

BORTLE SCALE:		
Class	**Color Key**	**Description**
1		Zodiacal light, gegenshein, zodiacal band visible; M33 direct vision naked-eye object; Scorpius and Sagittarius regions of the Milky Way cast obvious shadows on the ground; airglow is readily visible; Jupiter and Venus affect dark adaptation; surroundings basically invisible.
2		Airglow weakly visible near horizon; M33 easily seen with naked eye; highly structured summer Milky Way; distinctly yellowish zodiacal light bright enough to cast shadows at dusk and dawn; clouds only visible as dark holes; surroundings still only barely visible silhouetted against the sky; many Messier globular clusters still distinct naked-eye objects.
3		Some light pollution evident at the horizon; clouds illuminated near horizon, dark overhead; Milky Way still appears complex; M15, M4, M5 and M22 distinct naked-eye objects; M33 easily visible with averted vision; zodiacal light striking in spring and autumn, color still visible; nearer surroundings vaguely visible.
4		Light pollution visible in various directions over the horizon; zodiacal light is still visible, but not even halfway extending to the zenith at dusk or dawn; Milky Way above the horizon still impressive, but lacks most of the finer details; M33 a difficult averted vision object, only visible when higher the 55 degrees; clouds illuminated in the directions of the light sources, but still dark overhead; surroundings clearly visible, even at a distance.
5		Only hints of zodiacal light are seen on the best nights in autumn and spring; Milky Way is very weak or invisible near the horizon and looks washed out overhead; light sources visible in most, if not all, directions; clouds are noticeably brighter than the sky.
6		Zodiacal light is invisible; Milky Way only visible near the zenith; sky within 35 degrees from the horizon glows grayish white; clouds anywhere in the sky appear fairly bright; surroundings easily visible; M33 is impossible to see without at least binoculars, M31 is modestly apparent to the unaided eye.
7		Entire sky has a grayish-white hue; strong light sources evident in all directions; Milky Way invisible; M31 and M44 may be glimpsed with the naked eye, but are very indistinct; clouds are brightly lit; even in moderate-sized telescopes the brightest Messier objects are only ghosts of their true selves. At full moon night the sky is not better than this rating even at the darkest locations with the difference that the sky appears more blue than orangish white at otherwise dark locations.
8		Sky glows white or orange--one can easily read; M31 and M44 are barely glimpsed by an experienced observer on good nights; even with telescope, only bright Messier objects can be detected; stars forming familiar constellation patterns may be weak or completely invisible.
9		Sky is brilliantly lit, with many stars forming constellations invisible and many weaker constellations invisible; aside from Pleiades, no Messier object is visilbe to the naked eye; only objects to provide fairly pleasant views are the Moon, the planets, and a few of the brightest star clusters.

Reference Condition
The Minimum Quality definition established by the International Dark Sky Association's Dark Sky Park Program can also be used to represent the threshold for attainment. Minimum Quality is obtained if the Milky Way is visible and sky conditions approximately correspond to the limiting magnitude 5.0 or Bortle Class 6.

Current Condition
Based on the map of artificial night sky brightness (Cinzano et al. 2001, Figure 36), ALPO lies within the orange area, which approximates areas where the Milky Way is invisible or quite difficult to see on clear nights. This would correspond to a 5 on the Bortle scale (Table 15). Thus, we rated the condition of dark skies for ALPO as warranting *moderate concern* (Table 16).

Table 16. ALPO condition assessment for dark night skies, using the Bortle Dark-Sky Scale.

Condition Category	Bortle Dark-Sky Scale	Current Condition	Condition Rating
Good	Class 1 - 3		
Moderate Concern	Class 4 - 6	Class 5	
Significant Concern	Class 7 - 9		

Data Gaps and Level of Confidence
Confidence in the assessment is *low* to *medium*, given the coarse level of interpretation using global maps and the lack of data for this indicator.

4.1.5 Soundscapes

Relevance and Context
Soundscapes are an often overlooked but extremely important natural resource in national parks. Natural sounds are a vital part of "the scenery and the natural and historic objects and the wild life" protected by the NPS Organic Act and represent an important component of resource conditions. The natural soundscape is composed of both physical (e.g., wind, flowing water) and biological (e.g., bird calls) sounds: the roar of spring melt waters rushing down Blair Gap Run; the sounds of birds singing in the fields and forests; the whirring of winds through the trees. The presence and abundance of these sounds set the stage for visitor interpretation of the natural system. Acoustic resources falling within park management include wildlife, water (flowing streams), wind, rain, historical, and cultural sounds (McCusker and Cahill 2009-2010).

Human-caused noise can be disruptive to both natural ecological process as well as visitor experience. Noise from highway traffic, aircraft, and other aspects of urbanization obscure sounds from the natural environment and disrupt the tranquility of historic settings in cultural areas. Although a certain level of noise is unavoidable, especially near visitor centers and other concentrated areas, soundscape preservation and noise management is necessary for preserving park resources. In addition, anthropogenic noise can also have detrimental effects on wildlife, especially through interference with breeding (e.g., mating calls), prey detection (e.g, bats), predator avoidance (e.g., mice or deer), and navigation (e.g., bats) (NPS 2006, Newman et al. 2009-2010).

Methods

No scientific data pertaining to soundscapes have been collected for ALPO. However, sound monitoring is essential for managing noise and can be a powerful tool to document patterns in both wildlife and visitor activity. Unfortunately the narrow, linear boundaries of the park parallel busy highways and roads, making it difficult for managers to protect or restore natural soundscapes from unacceptable impacts. However, managers can take steps to prevent or minimize these impacts through (1) monitoring of human activities that generate noise in and adjacent to the park and (2) development of action plans where possible to reduce the frequency, magnitude, and/or duration of these adverse activities. Managers can use audio recordings to chronicle wildlife behavior in response to visitor use and to identify and track sources of noise and document daily and seasonal patterns in ambient sound levels (Fristrup et al. 2009-2010). Although expensive monitoring assessments are probably not feasible at ALPO, Fristrup et al. (2009-2010) suggest low cost acoustic monitoring can be conducted within parks through basic sound monitoring using audibility loggers (e.g., palm PDA with sound logging software) and/or digital MP_3 recorders augmented with D batteries and weather-resistant housing. The former would require personnel to record the start and stop time of each sound; the latter would be capable of recording continuous audio over an approximate 6-day period.

Overall, soundscapes are a relatively new topic in natural resource management; therefore, desired conditions and appropriate indicators have not been developed for most national parks, including ALPO. McCusker and Cahill (2009-2010) provide some examples of desired condition, possible indicators and target values for soundscapes, which we've adapted for ALPO (Table 17).

Table 17. Possible condition metrics to use for soundscape monitoring at ALPO.

MANAGEMENT ZONE	DESIRED CONDITION	POSSIBLE INDICATOR	POSSIBLE TARGET VALUE/THRESHOLD
Natural Zone	Natural soundscapes intact; natural sounds occasionally mixed with human activity	Occurrence of non-natural sounds as expressed by percentage time audible per day	Non-natural sounds audible < 10% of day in no more than 25% of natural zone (adjust if possible)
Cultural Zone	Natural sounds audible and enhance visitor experience & presence of historically appropriate sounds. During low visitation and nighttime periods, natural soundscapes predominate.	Occurrence of non-natural sounds as expressed by percentage time audible per day. Occurrence of noise levels that interfere with general conversation	Non-natural sounds audible < 10% of day in no more than 25% of cultural zone during periods of low visitation/nighttime hours. Noise levels that interfere with general conversation occur < 5% of day in visitor service areas.

Sources of Expertise
Holly Salazer, Regional Air Resources Coordinator, Air Resources Division Northeast Region, National Park Service.

Beth Boyer, Associate Professor of Water Resources; Director, Pennsylvania Water Resources Research Center; Assistant Director, Penn State Institutes of Energy and Environment, Pennsylvania State University.

David Gay, Program Coordinator, National Deposition Program Office, Illinois State Water Survey, Champaign, IL.

National Atmospheric Deposition Program. 2012. Mercury Deposition Network. http://nadp.sws.uiuc.edu/MDN/

Drew Bingham, Air Resources Division, National Park Service

Air Resources Division, National Park Service; http://www.nature.nps.gov/air/planning/index.cfm

Eastern Rivers and Mountains Network, National Park Service; http://science.nature.nps.gov/im/units/ermn/

4.2 Weather and Climate

4.2.1 Precipitation and Temperature Trends

Relevance and Context
Weather and climate are important factors driving ecosystem change. Both extreme and gradual changes in precipitation and temperature patterns can potentially impact forest health (e.g., severe fires, introduction and persistence of pests), aquatic life (e.g., massive floods or prolonged droughts, temperature changes, lower water levels), species habitat ranges (e.g., local extinction as habitats move), and overall biodiversity (e.g., facilitation of invasive species). The I&M network acknowledges the importance of these factors and the potential impacts to both terrestrial and aquatic resources by recognizing weather and climate as high priority vital signs for inventory and monitoring of park natural resources and ecosystems (Marshall et al. 2012). The ERMN's primary goal/rationale for monitoring weather and climate is to 'obtain meteorological information that will be useful in interpreting and understanding changes in species composition and abundance, community structure, water flow and chemistry, and related landscape processes. In short, understanding the role of weather and climate as a driver of park ecosystems is key to understanding other vital signs monitored in the ERMN.' (Marshall et al. 2012).

Extreme weather and climate variability can affect ecosystems in multiple ways. Climate predictions for the New England and Mid-Atlantic states suggest warmer and possibly drier conditions (Meyer et al. 1999). Hayhoe et al. (2007) projected the Northeast United States will see increases in average annual surface temperatures of 2.9 – 5.3 °C by 2070 – 2099 compared to 1961-1990. This warming would lengthen the growing season length by 4-6 weeks, increasing the frequency of days that fall above high-temperature thresholds and decreasing the frequency of days that fall below cold-temperature thresholds (Dukes et al. 2009). This could substantially affect forest ecosystem function and structure, especially with regard to impacts from forest pathogens, insect pests, and invasive plant species. Populations of insect pests are often controlled by low winter temperatures; thus, warmer minimum temperatures may allow overwintering adult populations to increase. The hemlock wooly adelgid (*Adelges tsugae*), for example, is sensitive to cold and exhibits reduced survival at increasing lower temperatures, with a suggested mean winter temperature of -5 °C required to prevent population expansion (Parker et al. 1998, Paradis et al. 2008). This tolerance decreases as winter progresses, thus shorter winters may mean increased tolerance. Oriental bittersweet (*Celastrus orbiculatus*), an invasive and damaging vine, is also expected to respond favorably to warmer minimum temperatures (Dukes et al. 2009). As a group, invasive plant species are expected to benefit from climate change, especially given their tolerances of a wider range of environmental conditions than many native species (Goodwin et al. 1999). Conversely, the increasing fragmentation of natural ecosystems and isolation of populations lowers the adaptive capability and resilience of native terrestrial biota to weather extremes and climate variability.

Aquatic ecosystems will also likely experience effects from changing weather and climate patterns, including changes in habitat availability, especially during low flows, and changes in the magnitude and seasonality of runoff regimes. Increasing air temperatures will reduce habitat for cold-water fish species, while increasing habitat for warm-water species. Climatic variability can affect the rate of watershed recovery from declining acid deposition. For example, increases in dissolved organic carbon (DOC) concentrations during the winter months were found to be strongly correlated with minimum daily temperature, runoff, and snow pack depth (Park et al. 2005). These increases in DOC concentrations typically coincide with decreases in pH and increases in total aluminum concentrations in stream water and are expected to offset the increases in pH and ANC due to decreased acidic deposition (Driscoll et al. 2003).

The life history characteristics of many aquatic and terrestrial insects are closely tied to seasonal changes in temperature and precipitation patterns. As a result, extreme weather events can sometimes be catastrophic. For example, very low winter snowpacks in the California Sierra Nevada led to early synchronous adult emergences of the Edith's Checkerspot butterfly (*Euphydryas editha*). In one instance, flowers were not yet in bloom and most died from starvation. In another, the early emergence resulted in many deaths during a normal snowstorm the following month. Such infrequent and severe climatic events elicit short-term responses at the population level but also appear to drive gradual range shifts northward in the metapopulation (Parmesan et al. 2000).

Evaluating the effects of weather and climate requires distinguishing between the terms 'weather' and 'climate'. Essentially, weather refers to conditions that change over a relatively short time period (e.g., minutes to months), while climate refers to longer time periods (e.g., decades to centuries) (www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html). Weather is characterized by current conditions of temperature, precipitation, humidity, visibility, wind, atmospheric pressure, etc. Climate is expressed in terms of averages or other statistical descriptors over a defined period of record (e.g., average summer temperatures are warmer now than they were a hundred years ago).

There are many ways to summarize weather and climate but measures related to air temperature and precipitation tend to be the most relevant drivers of ecosystem processes. The ERMN has chosen 19 weather indicators to monitor temperature and precipitation patterns over time. These indicators (10 temperature, 9 precipitation) and their definitions consist of direct measurements or elements (e.g., air temperature, precipitation, snow depth, etc.), several derived elements (e.g., growing season length, number of extreme precipitation days, etc.), and an integrated element (drought) (Table 18) (Marshall et al. 2012).

Table 18. Summary of weather 'indicators' used to describe temperature and precipitation patterns.

Temperature Indicators	Definition
Average Annual Temperature	Mean of 365 average daily temperatures (calculated by taking the mean of the daily maximum and the daily minimum temperature
Average Annual Maximum Temperature	Mean of 365 maximum daily temperatures
Average Annual Minimum Temperature	Mean of 365 minimum daily temperatures
Maximum Temperature	Highest recorded temperature during the calendar year; typically recorded during summer (June through August)
Minimum Temperature	Lowest recorded temperature during the calendar year; typically recorded during winter (January through March)
Hot Days	Number of days during the calendar year when the maximum daily temperature equals 90° F (32°C) or above
Cold Days	Number of days during the calendar year when the maximum daily temperature equals 32° F (0°C) or below
Sub-freezing Days	Number of days during the calendar year when the minimum daily temperature equals 32° F (0°C) or below; typically happens at night
Sub-zero Days	Number of days during the calendar year when the minimum daily temperature equals 0° F (-17.8°C) or below; typically happens at night
Growing Season Length	Number of days between the last spring 'frost' (daily minimum temperature at or below 32°F (0°C) and the first fall 'frost'
Precipitation Indicators	**Definition**
Annual Precipitation	Cumulative yearly total liquid precipitation
Seasonal Precipitation	Cumulative seasonal (winter, spring, summer, autumn) total liquid precipitation
Heavy Precipitation Days	Number of days during the calendar year with ≥ 1.0 in (25 mm) liquid precipitation
Extreme Precipitation Days	Number of days during the calendar year with ≥ 2.0 in (51 mm) liquid precipitation
Micro-drought	Number of strings of seven or more consecutive days during the calendar year without a trace (<0.01 in / 0.3 cm) of liquid precipitation
Annual Snowfall	Cumulative yearly total snowfall
Measurable Snow Days	Number of days during the calendar year with measurable (≥ 0.1 in [0.3 cm]) snow
Moderate Snow Days	Number of days during the calendar year with ≥ 3.0 in (7.6 cm) of snow
Heavy Snow Days	Number of days during the calendar year with ≥ 5.0 in (12.7 cm) of snow

Methods

Weather indicators were calculated for the park using daily temperature and precipitation data collected at the nearby Ebensburg Sewage Treatment Plant (EB STP) (Figure 38). This station is part of the National Weather Service Cooperative Observer Program (COOP) and was selected as the best location with long-term data (February 1964 to present) that was most representative of park conditions (M. Marshall pers. comm.). The COOP network consists of volunteers who manually collect daily measurements of maximum and minimum temperatures, observation-time temperature, precipitation, snowfall, and snow depth. The quality of the data ranges from excellent to modest (Davey et al. 2006). Figure 38 shows the location of this station in relation to the park.
We used the weather indicators selected by Marshall et al. (2012) to describe temperature and precipitation patterns throughout the period of record, including seasonal summaries (Table 18). For consistency with previous Natural Resource Reports (e.g., Knight et al. 2011), we defined the seasons as follows: Winter (Jan-Feb-March), Spring (April-May-June), Summer (July-August-September), Autumn (October-November-December), Growing Season (days between last spring Tmin 32°F/0°C and first fall Tmin 32°F/0°C).

We also included the 30-year climatological normals corresponding to the period of record (1961 – 1990, 1971 – 2000, and 1981 – 2010). Every ten years the National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC) calculates the average value of a climate element over 30 years and defines this as the climatological normal (Marshall et al. 2012). Comparison of climatological normals helps differentiate between changing weather patterns and changing climate over the period of record. In addition, we calculated the weather indicators for the most recent full year of data to reflect current weather conditions and compare the status of the most recent temperature and precipitation indicators to the 30-year normal. We used 2010 because it was the last full year of data downloaded.

Since the purpose of monitoring weather and climate is not to determine the condition of various precipitation and temperature parameters but rather to recognize them as key drivers of ecosystem structure and function that affect the condition of other vital resources within the park, we did not include a condition assessment for this indicator. Instead we reported increasing or decreasing trends in the various weather indicators, determined from linear regression of the data for the EB STP weather station collected during the period of record. Note that, unlike other indicators in the NRCA, trend implies an increase or decrease in the parameter, not an increase or decrease in condition. Weather indicators with 30-year climatological normals showing a change of greater than 10% over the entire period of record were designated as exhibiting a trend of importance. This 10% change was defined as the difference between the earliest climatological normal (1965-2010) and the most recent climatological normal (1981-2010). In addition, the change had to be consistent across the entire period of record (a.k.a. the 1971-2000 climatological normal had to show the same direction of change). Although a change of only 10% may appear unimportant, small changes in temperature and precipitation may result in substantial impacts on park ecosystems. This designation method was selected because 30-year climatological normals are designed to account for annual variations in weather and provide a "typical climate condition" for a site. Changes in weather indicator values for 30-year normals greater than 10% were selected to highlight larger shifts in climate over the period of record and to avoid possibly misleading results from further statistical analysis given the small sample size (3) of climatological normals for the study site. It is for this reason, that we did not rely on statistical significance to ascertain trends across the period of record. For simplicity, we only reported numerical results for weather indicators on an annual basis and graphical results for select indicators showing trends over the period of record.

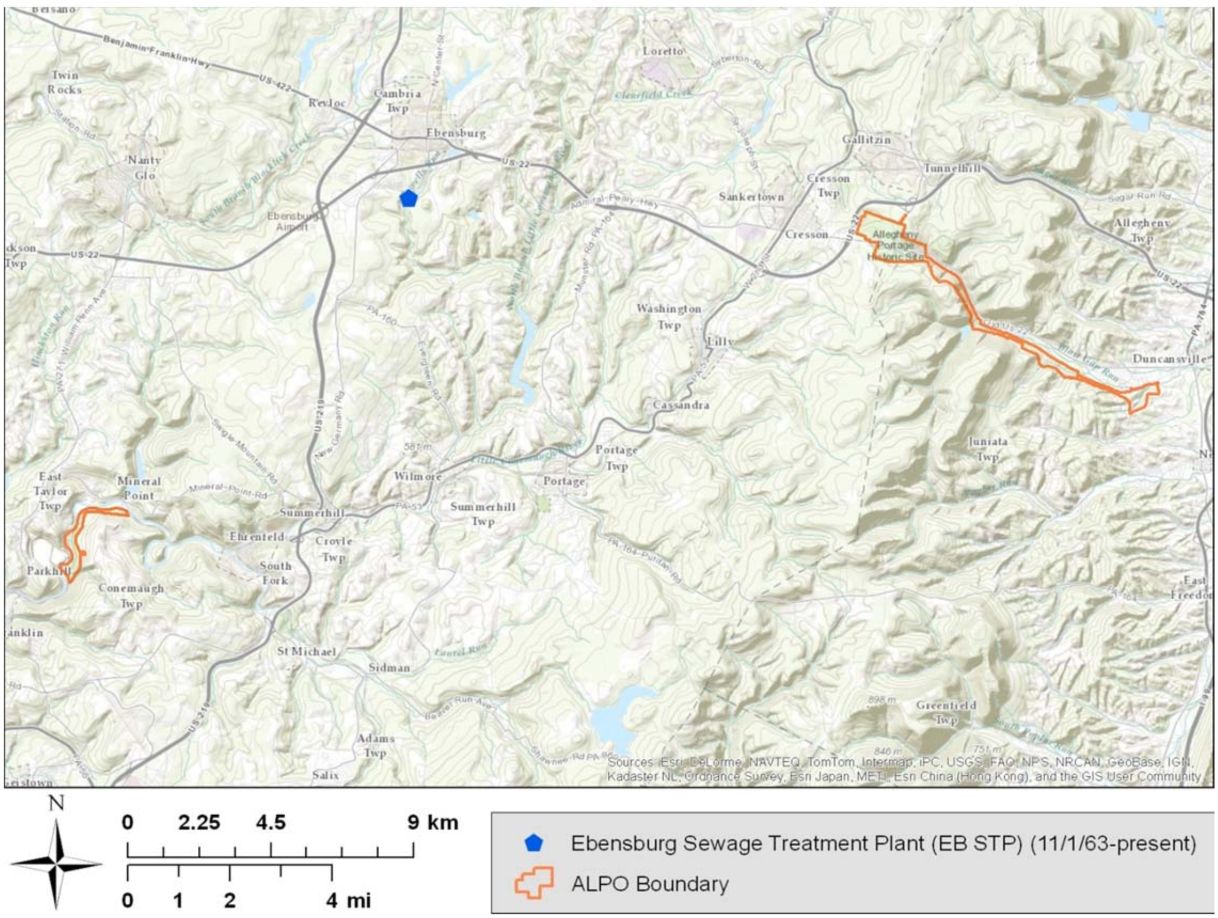


Figure 38. Location of the Ebensburg Sewage Treatment Plant (EB STP) in relation to ALPO's Main and Staple Bend Tunnel Units. Long-term precipitation and temperature data are available from this station from November, 1963 to present.

<u>Trends</u>

Table 19 displays the temperature and precipitation indicators for the period of record and each 30-year climatological normal during the period of record. Overall results from the analysis of weather indicators show little change in the Average Annual Temperature and Annual Precipitation for the park. Temperature indicators for the period of record suggest trends of importance (>10%) for increases in the Minimum Temperature and Growing Season Length, along with a decrease in the number of Sub-Zero Days. Precipitation indicators for the period of record show trends of importance for decreases in the Annual Snowfall, Measurable Snow Days, Moderate Snow Days, and

Heavy Snow Days. Six of these indicators showing a trend of importance are presented in further detail in Figure 39.

Table 19. Status of 2010 temperature and precipitation indicators compared to the entire period of record (1965-2010) and the 30-year normals (1965-1990, 1971-2000, 1981-2010) for the EB STP station. Arrows represent substantial increases or decreases (greater than 10% change) between climatological normals across the entire period of record and indicate the presence or absence of an important trend for the indicator over the entire period of record.

Weather Indicator	Current Weather	Period of Record	30-Year Climatological Normal			Trend
	2010	1965-2010	1965-1990	1971-2000	1981-2010	1964-2010
Average Annual Temperature	48.4	47.7	47.3	47.7	48.1	⇔
Average Annual Maximum Temperature	59.3	59.4	59.2	59.7	59.8	⇔
Average Annual Minimum Temperature	37.5	36.0	35.5	35.8	36.5	⇔
Maximum Temperature	91.0	90.0	90.5	90.1	89.6	⇔
Minimum Temperature	-9.0	-12.7	-15.3	-13.7	-11.5	⇧
Hot Days	2	3	3	3	3	⇔
Cold Days	59	38	38	35	36	⇔
Sub-Freezing Days	152	158	161	161	155	⇔
Sub-Zero Days	4	9	12	10	7	⇩
Growing Season Length	154	120	113	117	126	⇧
Annual Precipitation	48.0	48.4	49.5	49.7	47.4	⇔
Heavy Precipitation Days	12	9	8	9	9	⇔
Extreme Precipitation Days	2	1	1	1	1	⇔
Micro-Drought	6	5	5	5	5	⇔
Annual Snowfall	155.3	98.0	108.3	96.8	87.5	⇩
Measurable Snow Days	52	45	50	45	40	⇩
Moderate Snow Days	21	13	14	12	11	⇩
Heavy Snow Days	10	4	5	4	4	⇩

[1]1965 was the first full year of record (as opposed to 1961).

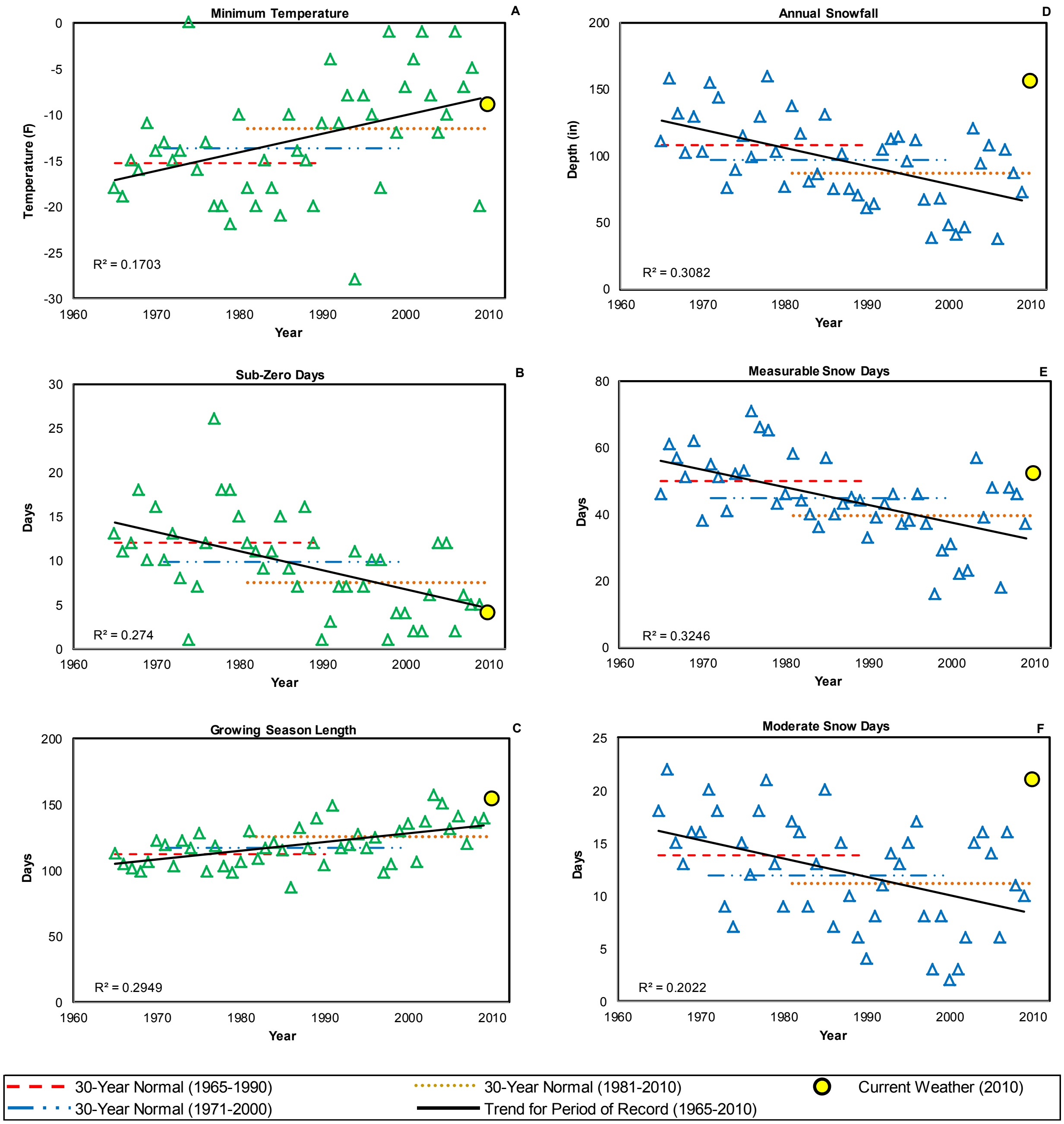


Figure 39. Graphs depicting changes in Minimum Temperature, Sub-Zero Days, Growing Season Length, Annual Snow Fall, Measurable Snow Days and Moderate Snow Days between the current year (2010), each 30-year normal period, and the entire period of record (1965-2010).

Climatological normals for 4 of the 5 indicators that directly measure changes in air temperature (Average Annual Temperature, Average Annual Maximum Temperature, Average Annual Minimum Temperature, and Minimum Temperature) increased for the park over the period of record. Maximum Temperature decreased (0.9 °F) during the period of record, equating to an overall change of this indicator of 1%. The increases observed in all indicators that describe low temperatures

(Average Annual Minimum Temperature, Minimum Temperature, Cold Days, Sub-Freezing Days, and Sub-Zero Days) all show a greater percent change than the indicators that describe high temperatures (Average Annual Maximum Temperature, and Hot Days). Although increases in low temperature indicators are larger than the Average Annual Temperature increase of the park, they may still result in a substantial impact on terrestrial and aquatic ecosystem structure and function as previously described. Although not designated with a trend of importance in Table 19, the 30-year normal for Micro-Drought increased throughout the period of record. Small increases in this indicator may not be as substantial as changes in other weather indicators, but increases in extended dry periods can impact the ecology of stream and wetland ecosystems dependent on precipitation or minimum stream flow.

The observed increase in weather indicators related to low temperatures for the park suggest a possible explanation for the observed decrease of weather indicators related to snowfall. Further analysis of weather indicators on a seasonal basis show the decreases in indicators measuring snowfall (Annual Snow Fall, Measureable Snow Days, Moderate Snow Days, and Heavy Snow Days) are likely driven by increased low temperature changes in the winter. Average Winter (January – March) Minimum Temperatures and Minimum Winter Temperatures increased more than Average Minimum Temperatures and Minimum Temperatures in Spring, Summer, or Autumn. This decreased snow coupled with near constant precipitation suggests a shift from frozen precipitation to rain in the region surrounding the park. Decreased snow and increasing low temperatures may impact the timing of plant and insect emergence in the spring. The shift from frozen to liquid precipitation may also impact the amount of water stored on the landscape, especially during a time when plant demand for water is low.

Another weather indicator that may be changing as a result of higher low temperatures is the Growing Season Length. Increases in 30-year climatological normals for this indicator during the period of record suggest the rate of change for this indicator is also increasing. The Growing Season Length increased 4 days between the 30-year normal from 1965-1990 (113 days) to the 30-year normal from 1971-2000 (117 days). The following 30-year normal (1981-2010) showed a 9-day increase (126 days), with the latest year on record (2010) having a Growing Season Length of 154 days. Increased Growing Season Length could impact plant community structure, as well as alter the timing and availability of important wildlife food sources throughout the park.

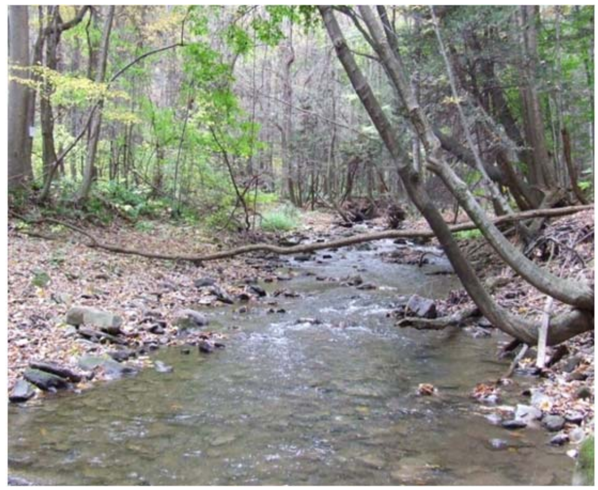
Data Gaps and Level of Confidence

Overall we have *high* confidence in the historical data and trend assessment for the following reasons. Daily temperature and precipitation data used to calculate 30-year normal weather indicators at the Ebensburg Sewage Treatment Plant contained only three data gaps over the 30-year (1981-2010) data collection window. The data gaps impacting the 30-year normal calculations are October 31, 1981, October 1-31, 1990, and November 1-30, 2000. These gaps were removed from indicator calculations and did not influence the time-dependent indicators including number of micro-droughts or growing season length.

Sources of Expertise
Matt Marshall, Eastern Rivers and Mountains Network Program Manager, National Park Service and Adjunct Assistant Professor of Wildlife Conservation, Pennsylvania State University.

4.3 Water Quality

The ERMN recognizes chemical, physical, and biological water quality as top priorities for vital signs monitoring in all parks within the network (www.science.nature.nps.gov/im/units/ermn/monitoring/Water.cfm). Freshwater quality is directly related to the health of other vital signs that rely on water for habitat and/or food (e.g., aquatic macroinvertebrates, fish, birds, and many threatened and endangered species) and is important for other state-defined aquatic life uses, as well (e.g., human consumption and recreation). Currently the ERMN includes water chemistry and aquatic macroinvertebrates as vital signs in its monitoring protocol (NPS-ERMN 2007).



Upstream view of Blair Gap Run near Incline 9 and the Muleshoe Bridge. Photo by S. Yetter

Watershed Characteristics

ALPO's Main Unit (Summit Area and Portage Trace Corridor) lies on a dividing ridge for the Ohio River and Chesapeake Bay watersheds. Blair Gap Run and Bradley Run are two headwater streams originating in or near the park at the Summit. Both are part of the Susquehanna River basin, albeit via different paths. Bradley Run and its tributaries flow north into the West Branch of the Susquehanna River, whereas Blair Gap Run flows toward the east and to the Juniata River basin.

Bradley Run
The Bradley Run watershed is located at the northwest corner of the Summit Unit with only a small extent flowing through park property. This area consists mainly of intermittent streams, springs and seeps. To our knowledge only one water quality study included this drainage with one monitoring station located on an unnamed tributary (UNT) to Bradley Run (Figure 40). Thus, we have very little information regarding the condition of this watershed and its effect on park lands, although it is expected to be minimal.

Blair Gap Run
The majority of the Summit Level and all of the Portage Trace Corridor lie within the Blair Gap Run watershed. The contributing watershed is ~45 km^2 with 7.8 stream km contained within the Main Unit. It originates as intermittent streams near the southern park boundary of the Summit Unit (Cambria County, elevation 725 m above mean sea level) and flows on and off of park land as it travels east into Duncansville (Blair County, elevation ~335 m above mean sea level). It eventually flows into the Beaverdam Branch of the Juniata River near Hollidaysburg. The Altoona water authority has two dams located directly on Blair Gap Run (the Blair Gap Reservoir and the Plane

Nine Reservoir); whereas the Hollidaysburg water authority also has a dam (Hollidaysburg or Muleshoe reservoir) located on Adams Run, just upstream of its confluence with Blair Gap Run. The upper reaches of Blair Gap Run from the headwaters to the Plane Nine reservoir are steep, and the stream flows at a fast velocity. From the Plane Nine Reservoir to the park boundary at Mill Road, the slope levels off and the stream becomes wider with a slower velocity. Along its length within the park, surface water flows and discharge of Blair Gap Run fluctuate due to seasonal variations and storm events.

Little Conemaugh River

ALPO's Staple Bend Tunnel Unit (SBTU) lies within the Ohio River basin and parallels the Little Conemaugh River for about 4 km from the town of Mineral Point southwest toward Johnstown. Although the contributing watershed is roughly 464 km^2 in size, park boundaries include less than one mile of river frontage. A railroad right-of-way adjoins or crosses through the park between the Portage Railroad trace and the river at the foot of the slope. West of the tunnel, a tributary to the Little Conemaugh River crosses the park.

Water Quality Threats and Designated Uses

Understanding the process of water quality monitoring requires a brief commentary on the legislation and regulatory actions behind it. The process of water quality management is jointly implemented by the U. S. Environmental Protection Agency (USEPA) and the individual states. States establish goals or water quality standards for all water bodies, which specify the appropriate uses to be achieved and protected (Copeland 2010). The Pennsylvania Department of Environmental Protection (PADEP) has designated uses for aquatic life, water supply, recreation and fish consumption, navigation, and special protection (PADEP 2009a). Both the PADEP and the USEPA define water quality standards and criteria to protect surface water bodies based on their designated use. The PADEP assesses the quality of surface waters throughout the state and identifies those not attaining designated and existing uses as 'impaired.' Water quality studies aimed at reporting the condition of a stream or other water body should take into account its designated use(s) and whether or not it is state-listed as impaired.

The upstream portion (above the Altoona Reservoir) of the Blair Gap Run watershed, as well as the tributaries to Bradley Run and the Little Conemaugh River are designated as Cold Water Fishes (CWF) for their aquatic life use. The downstream portions of Blair Gap Run and Millstone Run are designated as Trout Stocking Fisheries (TSF). Dry Run, a tributary to Blair Gap Run located downstream and off of park property is designated a Warm Water Fishery (WWF). None of the streams flowing through either the Main Unit or the SBTU are considered High Quality CWF and given special protection, although the results from two studies involving wild trout (Sheeder and Tzilkowski 2006, Tzilkowski and Sheeder 2006) recommended that PA DEP protected water use for Blair Gap Run downstream of the Plane Nine Reservoir and upstream of the reservoir be redesignated from Trout Stocking to Cold Water Fishes and from Cold Water Fishes to High Quality-Cold Water Fishes, respectively.

The Water Resources Division of NPS prepared a detailed analysis of water quality within and around ALPO (referred to as 'Horizon' reports) and concluded that surface waters within the area had been impacted by human activities, including mining and quarrying activities, municipal and industrial wastewater discharges, agricultural operations, oil and gas development, stormwater runoff, recreational use, and atmospheric deposition. Several small, acidic, abandoned mine discharges from former coal mines near the Summit Level and Incline 6 area of the Portage Trace drain into both watersheds. In the SBTU several mine drainages cross the park before discharging into the Little Conemaugh River. These drainages arise from abandoned mine openings and iron-mound seeps located both inside and outside of park boundaries. After crossing the park, these drainages form five streams that discharge through culverts under the railroad, into the Little Conemaugh River.

Water Quality Studies at ALPO

Concern for possible adverse impacts from acidic deposition, abandoned mine discharges, and other stressors prompted several water quality studies, primarily in the Blair Gap Run watershed, but also within the SBTU. In addition, the ERMN initiated long-term water quality monitoring in the Blair Gap Run watershed in 2008, which will provide consistent, reliable information for evaluating water quality condition and trends. The primary water quality studies conducted at ALPO are summarized below, including the abbreviations used in this report to identify each study, the time frame in which the data was collected, and a checklist of the measured parameters included in this NRCA (Table 20). Additional information regarding each study is available in Appendix A.

Table 20. Water quality studies used for the ALPO condition assessment, including time period of data collection and parameters measured. NRCA ID is the abbreviated name used in the ALPO Natural Resource Condition Assessment (NRCA) to refer to each study.

STUDY	NRCA ID	TIME PERIOD	DATA COLLECTED[1]				
			pH	DO	TEMP	SC	BMI
Arnold et al. 1997	Arnold	Spring 1996 - Spring 1997	x			x	x
Park Monitoring Data	PMD	May 1999 - March 2003	x	x	x	x	
Senior Ranger Program	EASI	October 2002 - June 2007	x	x	x	x	x
Sheeder and Tzilkowski 2006	Level 1 WQ	April 2004 - January 2005	x	x	x	x	x
Tzilkowski and Sheeder 2006	Wild Trout	April 2006	x	x	x	x	
Laubscher et al. 2007	Laubscher	June 2004	x	x	x	x	x
Tzilkowski et al. 2011a, 2011b	ERMN	October/November 2008 - 2010/2012	x	x	x	x	x
Kaktins and Carney 2002	K&C	May 2000 - April 2001	x	x	x	x	
Cravotta 2005	Cravotta	April 2004	x	x	x	x	

[1] List includes only parameters selected as indicators (i.e., not comprehensive). DO = dissolved oxygen; TEMP = temperature; SC = specific conductivity; BMI = benthic macroinvertebrates

Discussions with NPS personnel revealed the utilization of this data would be most helpful if results for each parameter were first presented as statistical summaries by study to compare results between studies. Doing so also helped to ascertain the level of confidence in the data and allowed us to choose only those data with medium to high confidence for use in the condition assessment. Several of the studies utilized existing or nearby monitoring sites, resulting in overlapping locations between studies (e.g., the PMD study initially used most of the locations established in the Arnold study). Site names were often different, however, making it difficult to compare results from the same locations. To simplify interpretation of results, we combined overlapping or nearby monitoring sites into one primary location and assigned the station names reported in Sheeder and Tzilkowski (2006) before summarizing the results (Table 21, Figure 40).

Table 21. ALPO water quality monitoring locations for the Blair Gap Run watershed (Main Unit). The Site ID is the general name assigned to each location. NRCA ID is the abbreviated name assigned to each study for this condition assessment (Table 20). The Study Site ID corresponds to the name assigned to that location from each separate study.

SITE ID	NRCA ID	STUDY SITE ID	LOCATION DESCRIPTION
ALPO 1	Arnold PMD PMD Level 1 WQ	Site 2 Site 2 New Site 2 ALPO 1	Blair Gap Run below the Skew Arch Bridge, Incline 6 Area of Portage Trace Corridor
ALPO 2	Arnold PMD PMD EASI Level 1 WQ	Site 3 Site 3 Site 3A Site 3A ALPO 2	Blair Gap Run below Muleshoe Bridge, above the confluence with Blair Run, Incline 8 Area of Portage Trace Corridor
ALPO 3	Arnold PMD PMD EASI Level 1 WQ	Site 4 Old Site 4 Site 3B Site 3B ALPO 3	Blair Run below the confluence of Adams Run and the Hollidaysburg Reservoir, Incline 8 Area of Portage Trace Corridor
ALPO 4	PMD EASI Level 1 WQ ERMN	New Site 4 Site 4 ALPO 4 ALPO 1003	Blair Gap Run below the confluence with Blair Run
ALPO 5	Arnold PMD Level 1 WQ ERMN	Site 6 Site 6 ALPO 5 ALPO 1001	Tributary (Millstone Run) near Level 10 of the Portage Trace Corridor
ALPO 6	EASI Level 1 WQ ERMN	Foot of Ten ALPO 6 ALPO 2001	Blair Gap Run at Foot of Ten, Incline 10 of the Portage Trace Corridor
ALPO 1A	Arnold PMD PMD	Site 1 Site 1 Site 1A	Blair Gap Run at Summit Area of Main Unit across from Lemon House
ALPO 1B	PMD	Site 1B	UNT to Blair Gap Run, upstream of Skew Arch Bridge
ALPO 5A	Arnold PMD	Site 5 Site 5	UNT tributary to Blair Gap Run at Incline 10 near the east park boundary.

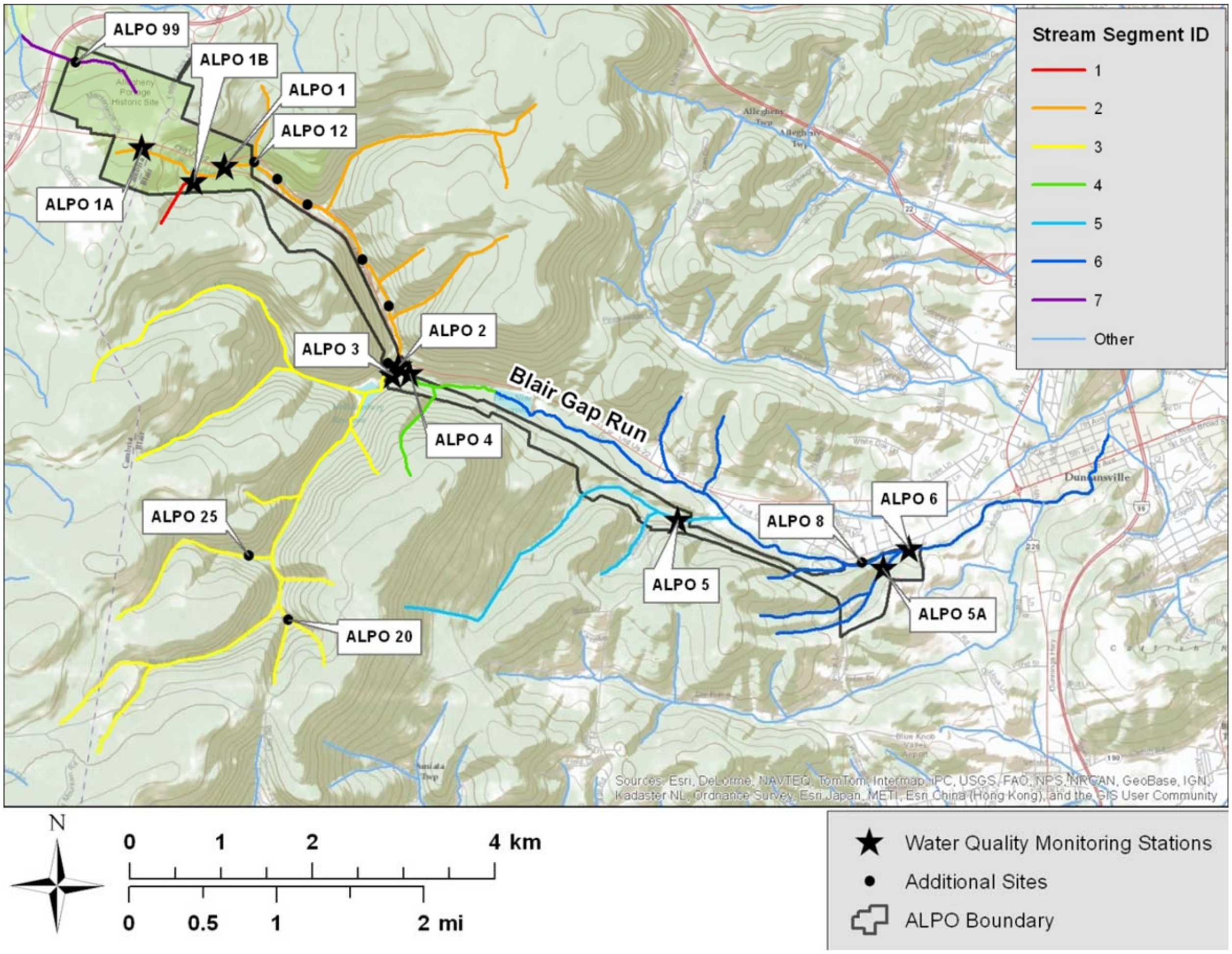


Figure 40. Water quality monitoring stations in the Blair Gap Run and Bradley Run (ALPO 99 only) watersheds surrounding the Main Unit and the Portage Trace of ALPO. Stars indicate primary monitoring sites with multiple measurements, which are summarized in Appendix A. Additional sites consisted of discrete (grab) samples, which were incorporated into the condition assessment. Results for the condition assessment are summarized by stream segment (i.e. monitoring sites along the same stream segment were combined), each of which is assigned a Stream Segment ID: Segment 1=UNT to Blair Gap Run; Segment 2=Upper reaches of Blair Gap Run; Segment 3=Blair Run and tributaries; Segment 4=Blair Gap Run below confluence with Blair Gap Run and Hollidaysburg Reservoir; Segment 5=Millstone Run; Segment 5A=UNT to Blair Gap Run; Segment 6=Blair Gap Run from the Altoona Reservoir downstream; and Segment 7=UNT Bradley Run. Segments 1 through 4 and Segment 7 are designated Cold Water Fisheries; Segments 5 and 6 are designated Trout Stocking Fisheries.

Table 22. ALPO water quality monitoring locations for the Little Conemaugh watershed (SBTU). The Site ID is the name assigned to the monitoring locations. NRCA ID is the abbreviated name assigned to each study for this condition assessment (Table 20).

SITE ID	NRCA ID	LOCATION DESCRIPTION
ALPO 7	Arnold	Stream at West of Staple Bend Tunnel
1U	K & C Cravotta	~100 ft upstream from culvert 18 at the head of a pool produced by a weir
1	K & C Cravotta	Downstream of culvert 18 (~40 ft above the ditch next to the railroad tracks)
1Fe	K & C Cravotta	Iron-bearing spring located ~300 ft north of site 1, just within park property next to Conrail tracks
2	K & C Cravotta	Discharge of culvert under the railroad receiving flow from sites 1, 1Fe, Fe, and the iron mound Outflow of a pipe collecting AMD from sites 1Fe, Fe, and seepage from the iron mound
2Fe	K & C Cravotta	Ground water samples from 3-ft deep well below the road near culvert 21
3	K & C Cravotta	Stream arising from several acid seeps and crossing trail at culvert 21
3A 3B	K & C Cravotta	Two sampling points located above the trail on stream crossing the trail at culvert 22. 3A is ~180 upstream of the trail below confluence of a seep from a small iron mound; 3B is ~75 ft upstream of culvert 22
4 5	K & C Cravotta	Both were sited on stream arising from several collapsed mine seeps and crossing the trail at culvert 23. Site 4 is a small pond draining into the stream. Site 5 is located just above trail at culvert 23.
6	K & C Cravotta	Discharge from a mine opening on east side of trail between culverts 26 and 27
7	K & C Cravotta	Just above culvert 28 on stream arising from a mine off of park property and crossing trail at culvert 28
8	Cravotta	Discharge site just north of Pond 1.
POND 1	Cravotta	Downstream of AMD discharge sites near the southern limit of the SBTU park boundary.
POND 2	Cravotta	Downstream of AMD discharge sites near the southern limit of the SBTU park boundary.

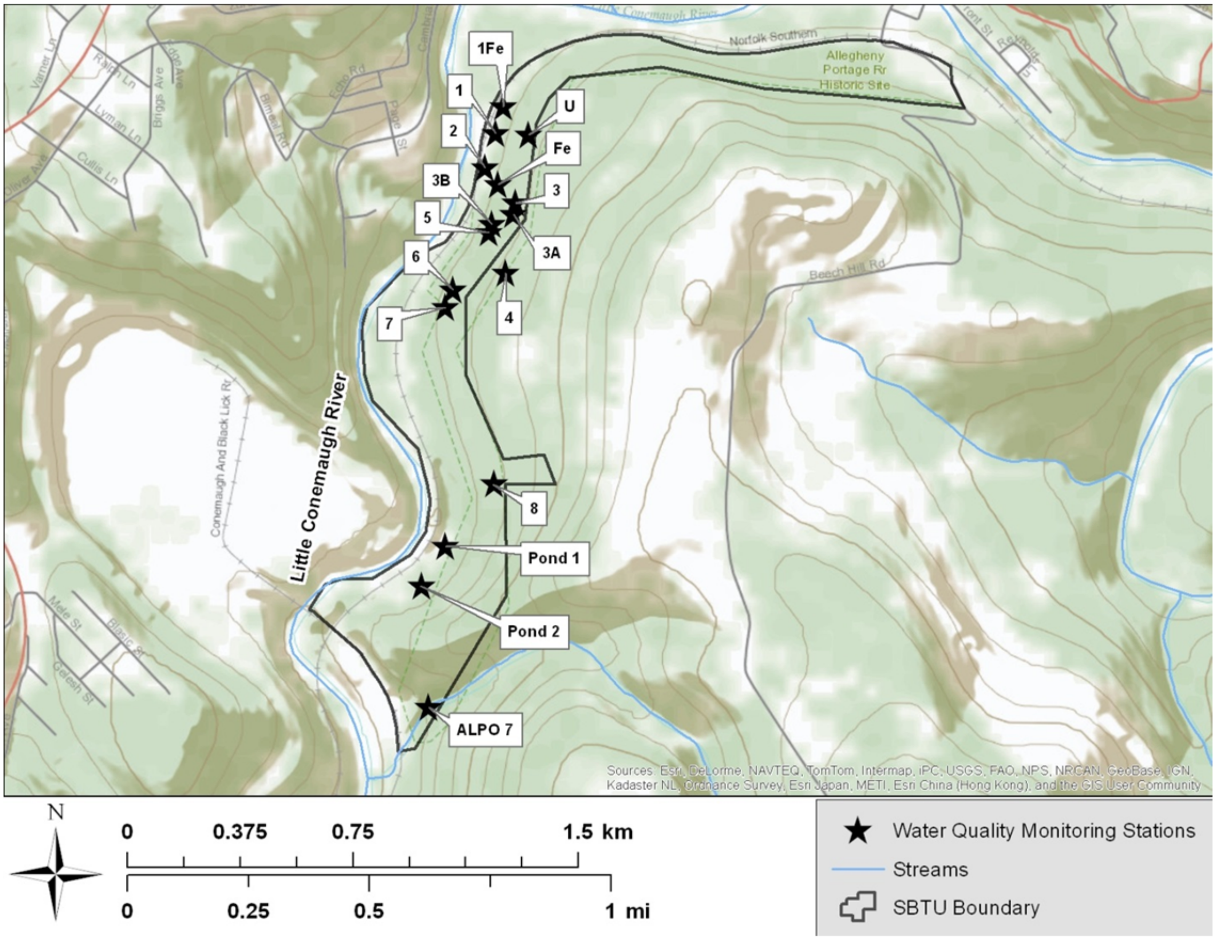


Figure 41. Water quality monitoring stations at the SBTU (Little Conemaugh Watershed). ALPO 7 was part of the Arnold et al. (1997) water quality study. All other locations were part of Kaktins and Carney (2002) (K & C in Table 20) and/or Cravotta 2005. Refer to Table 22 for descriptions of each monitoring site.

We provide condition assessments for two vital sign indicators: core water chemistry (pH, dissolved oxygen, specific conductivity, and temperature) and macroinvertebrates. Each assessment consists of two main parts: 1) statistical summaries of the core water quality parameters measured at each of the primary (a.k.a. multiple field measurements per parameter) water quality monitoring locations; and 2) condition assessments for each parameter by stream segment. We did not conduct condition assessments regarding any expanded water chemistry parameters, primarily due to the lack of any long-term monitoring data and the absence of these parameters in the ERMN monitoring reports. Fish are not considered a high priority vital sign in the network, although Eastern brook trout (*Salvelinus fontinalus*) is a species of management concern at the park (see section 4.5.1). Only two studies contained information regarding the overall fish community, both species inventories. Such a small dataset made it difficult to apply a biotic index or other type of assessment, thus, we did not use the fish community as an indicator of condition.

4.3.1 Water Chemistry

Relevance and Context

Water chemistry exerts an important influence on aquatic life through many pathways, including altering the toxicity of specific pollutants. Four water quality parameters are considered to be vitally important to aquatic organisms: pH, temperature, dissolved oxygen, and conductivity. Water pH is a measure of its acid or alkaline nature and is one of the most important environmental factors limiting distribution of species in aquatic habitats. Specifically, it is an expression of the hydrogen ion activity of the solution and is expressed as the negative logarithm of the hydrogen ion concentration (US EPA 1983). Water pH of most natural freshwaters in the U.S. is between 6 and 9 (slightly acidic to alkaline) and is regulated primarily by the carbonate buffer system. The pH range 6.5 – 9.0 is considered to be generally protective for fish. Although pH can vary temporally due to biological activities such as photosynthesis or respiration, extreme pH values or variations in pH are often caused by pollution such as acid mine drainage. The importance of these extreme changes in pH to aquatic organisms resides primarily in the effects on other environmental factors, effects which seem to intensify as the pH deviates from the optimum.

Temperature exerts an important influence on the chemical and biological processes of the aquatic environment and its resident biota. It determines the distribution of aquatic species; controls spawning and hatching; regulates biological activity; and stimulates or suppresses growth and development. Cold blooded animals, such as fish, have not evolved mechanisms for controlling body temperature. Consequently, their metabolism increases as the water warms and decreases as it cools. If the water temperature shifts too far from a species' optimum, the organism suffers.

Conductivity is the ability of a substance to conduct an electrical current over 1 cm of water having a cross-sectional area of 1 cm^2 at a specified temperature (Hem 1982). Conductivity increases with increasing amount and mobility of ions. However, increased temperatures result in increased ion movement; therefore, conductivity measures must be corrected for temperature (hence the term 'specific' conductivity. Most conductivity meters make this correction before displaying the readings, typically converting values to what they would be at room temperature (25 °C). Conductivity most likely affects aquatic organisms through changes in community composition rather than toxicity due to ionic strength, although the latter is possible if ionic strength disrupts osmotic regulation and bioavailability of essential elements or toxic metals. Generally, as conductivity increases, organisms with high acute lethal salinity tolerances relative to other taxa (e.g., macrocrustaceans) also increase while those with lower tolerances decrease (e.g., Ephemeroptera; Black et al. 2004, Pond 2004). Conductivity can vary due to natural factors (e.g., geologic formation and soil type). For example, acidic water flowing over calcareous shale has higher conductivity levels than more resistant rock (e.g., sandstone) due to calcium (Ca^{2+}) and carbonate (CO_3^{2-}) ions dissolving in the water. Most freshwater lakes and streams have specific conductivities ranging from 50 to 100 µS/cm, but values as low as 2 µS/cm are not uncommon. Wetlands and bogs can range from 50 to 50,000 µS/cm (USEPA 2012a). Despite these natural variations, specific conductivity serves as an indirect measure of dissolved solids and an important indicator of water quality, primarily because ionic strength is influenced by many types of human activities and increases with increasing anthropogenic effects.

Perhaps the most critical element in the aquatic environment is dissolved oxygen (DO). Fish and other aquatic organisms must rely on oxygen dissolved in water, which enters the aquatic system via photosynthesis and by transfer from the atmosphere (e.g., aeration of water as it moves over falls and rapids). The solubility of DO is a function of temperature; cold water can hold more DO than warm water. Consideration of the relationship of temperature and availability of dissolved oxygen is important in water quality monitoring and requires knowledge of both seasonal and diurnal variations in DO, as well as the needs and preferences of particular species.

Methods

Due to differences in methods and level of confidence in the data collected, we reported the mean values for the four core water quality parameters (pH, conductivity, temperature, and dissolved oxygen) separately for these studies. These averages were provided primarily to compare parameters between sites and data sets. Data from each study was evaluated for outliers or unrealistic entries. Monitoring locations with only one-time water chemistry measurements were not included in the statistical summaries but were used in the condition assessment, primarily because several of these measurements represented the only water quality data collected in the Bradley Run watershed and in smaller tributaries of the Blair Gap Run watershed. For the condition assessment, we divided the watersheds at the Main Unit into stream segments (Figure 40) and compiled the water quality monitoring data for each segment. At the SBTU, we combined all monitoring data. We then reported condition based on either the percentage of measurements in each condition category (i.e. pH, dissolved oxygen, and specific conductivity) or the percent attainment of water quality standards.

Water quality data were collected from 1996 to present, however given the previous comments regarding the use of different methods and limitations of field chemistry measurements, we did not attempt to ascertain trends in any of the parameters.

An important distinction should be made regarding water chemistry measurements. The datasets for ALPO consisted of measurements collected in the field with meters. Field chemistry has limitations for aquatic life use attainment decisions, due primarily to the fact that a one-time measurement cannot adequately reflect conditions throughout the year (PADEP 2009). Consequently, discrete core water chemistry results are typically interpreted as supplemental information to any biological results (Barbour et al. 1999). However, field chemistry measurements are important for general characterizations of water quality conditions. It is primarily within this context that we conducted the condition assessment, even though the data is presented as percent attainment of water quality standards.

Reference Condition

Surface water quality was assessed using standards and criteria established by the Pennsylvania Department of Environmental Protection (PADEP 2009a) and the United States Environmental Protection Agency (US EPA 2012a, 1976). These regulatory criteria or thresholds vary depending on the type of water body, its protected use, and in some cases the time of year. Standards for pH, dissolved oxygen, and specific conductivity are listed in Table 23.

A rating of *good* condition was assigned to pH values falling within the state water quality standard (6.0 – 9.0). A pH range of 5 to 6 is unlikely to be harmful to fish species unless either the concentration of free CO_2 is greater than 20 ppm or the water contains iron salts which are precipitated as ferric hydroxide (US EPA 1976). Thus, we assigned the condition category of *moderate concern* to pH values within the 5-6 range. Because high pH ranges can also be harmful, we also assigned *moderate concern* to pH values greater than 9.0, as well. Water pH less than 5.0 was considered *significant concern*.

Dissolved oxygen criteria are defined by the minimum level (5 or 4 mg/L depending on the protected use; PADEP 2009). We defined *good* condition as no production impairment for salmonid waters or >8 mg/L. Note that embryo and larval stages require water column concentrations 3 mg/L higher due to lower DO concentrations in trout redds (US EPA 1986). A condition of *moderate concern* was assigned to DO values between 8 mg/L and the minimum value. DO measurements below the minimum levels were considered as warranting *significant concern*.

Currently, there are no water quality standards or criteria set for specific conductance in fresh water. The US EPA defines a range of 150 – 500 µS/cm as supporting good mixed fisheries (US EPA 2012). However, since many headwater streams generally have conductivity levels ranging between 2 to 100 µS/cm and can range as high as 1500 µS/cm, we assigned values between 2 and 500 µS/cm to the *good* condition category and 500 and 1500 µS/cm to the *moderate concern* category. Values above 1500 µS/cm were considered to be of *significant concern*.

For water pH, dissolved oxygen, and specific conductivity, the overall condition rating for the segment (and park unit) was assigned the condition category with the highest percentage (e.g., 48% good, 51% moderate, and 1% significant concern equates to an overall condition rating of *moderate concern*).

Reference condition for temperature data depends on the time of year and designated use (e.g., temperatures in cold water fisheries cannot exceed 18.9 °C during July and August). Refer to Table 24 for more information. Many water quality programs allow for exceedance of the maximum temperature threshold when the air temperature of a given day is extremely high, and Pennsylvania water quality criteria specifies that heated waste sources may not result in a change by more than 2 °F during a 1-hour period (PADEP 2009). Temperature measurements below the maximum threshold criteria were defined as attaining water quality standards, whereas temperature measurements above the maximum threshold criteria (by 1°C or more) exceeded water quality standards. The overall condition rating for the segment was based on the proportion of measurements below the maximum threshold (% attainment) and was assigned as follows: >67% attainment = *good*; 33 – 67% attainment = *moderate concern*; <33% attainment = *significant concern*.

Table 23. Reference criteria for core water chemistry parameters. Water pH, dissolved oxygen, and temperature criteria are based on designations for the protection of cold water fishes (CWF), trout stocking (TSF), and warm water fishes (WWF) aquatic life uses. Specific conductivity does not have established criteria for designated uses.

Water Quality Parameter	Threshold Criteria	Condition	Distinctions	Source
pH	6 - 9 inclusive	Good	CWF, WWF, TSF, MF	1, 2
	5 - 6	Moderate Concern		
	< 5	Significant Concern		
Dissolved Oxygen (DO) (mg/L)	> 8	Good	CWF (Minimum)	1, 3
	5 - 8	Moderate Concern		
	< 5	Significant Concern		
	< 5 (2/15 to 7/31) < 4 (Rest of year)	Significant Concern	TSF (Minimum)	
	< 4	Significant Concern	WWF (Minimum)	
Specific Conductance (μS/cm)[2]	2 < S.C.< 500	Good	Inland freshwaters	4
	500- 1500	Moderate Concern		
	> 1500	Significant Concern		
Temperature (°C)	Below maximum (Table 5)	Good	See Table 24	1
	Above maximum	Moderate Concern		

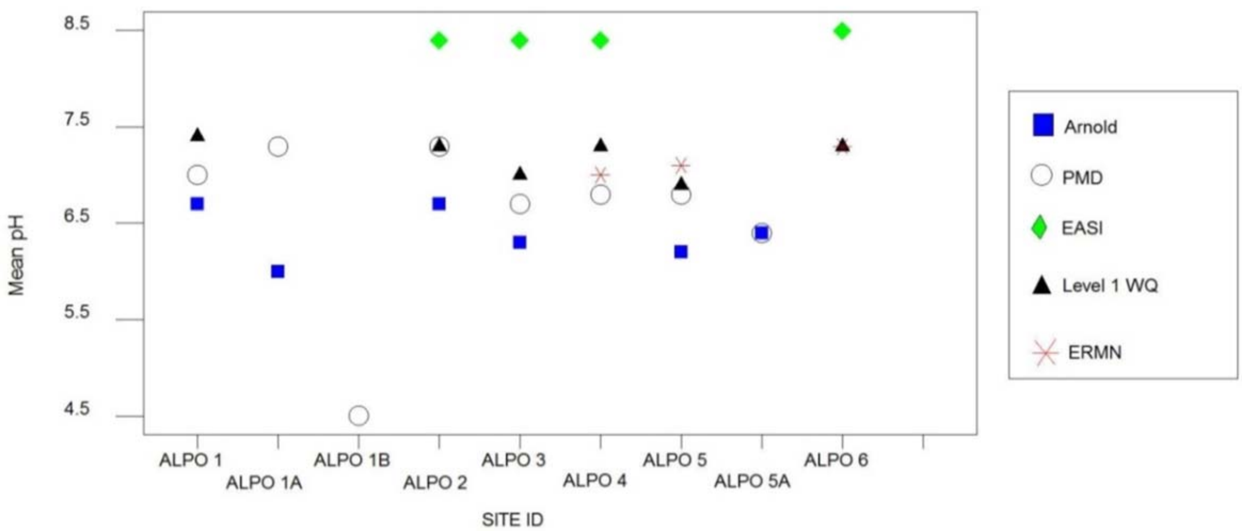
[1]PA DEP (2009a); [2]US EPA (1976); [3]US EPA (1986); [4]US EPA (2012a)

Table 24. Pennsylvania temperature criteria for the protection of aquatic life (PADEP 2009a). Time period and maximum temperature criteria for CWF, TSF, and WWF designated life uses are presented.

	Temperature (°C)		
Time Period	**CWF**	**TSF**	**WWF**
January	3.3	4.4	4.4
February	3.3	4.4	4.4
March	5.6	7.8	7.8
April 1-15	8.9	11.1	11.1
April 16-30	11.1	14.4	14.4
May 1-15	12.2	17.8	17.8
May 16-31	14.4	20.0	22.2
June 1-15	15.6	21.1	26.7
June 16-30	17.8	22.2	28.9
July	18.9	23.3	30.6
August 1-15	18.9	26.7	28.9
August 16-31	18.9	30.6	30.6
September 1-15	17.8	28.9	28.9
September 16-30	15.6	25.6	25.6
October 1-15	12.2	22.2	22.2
October 16-31	10.0	18.9	18.9
November 1-15	7.8	14.4	14.4
November 16-30	5.6	10.0	10.0
December	4.4	5.6	5.6

Current Condition and Trends

Data from the Senior Ranger program (EASI) was often questionable. Comparing the means from this dataset to the means from the other study datasets allowed us to determine if our confidence in the EASI data was sufficient to include it in the condition assessment. Water pH values at all sites were typically higher in the EASI dataset than the other studies, sometimes ranging between 9 and 10, which is highly unlikely for a high-elevation forested headwater stream in this region. For this reason, the entire water pH EASI dataset was deleted from the condition assessment.



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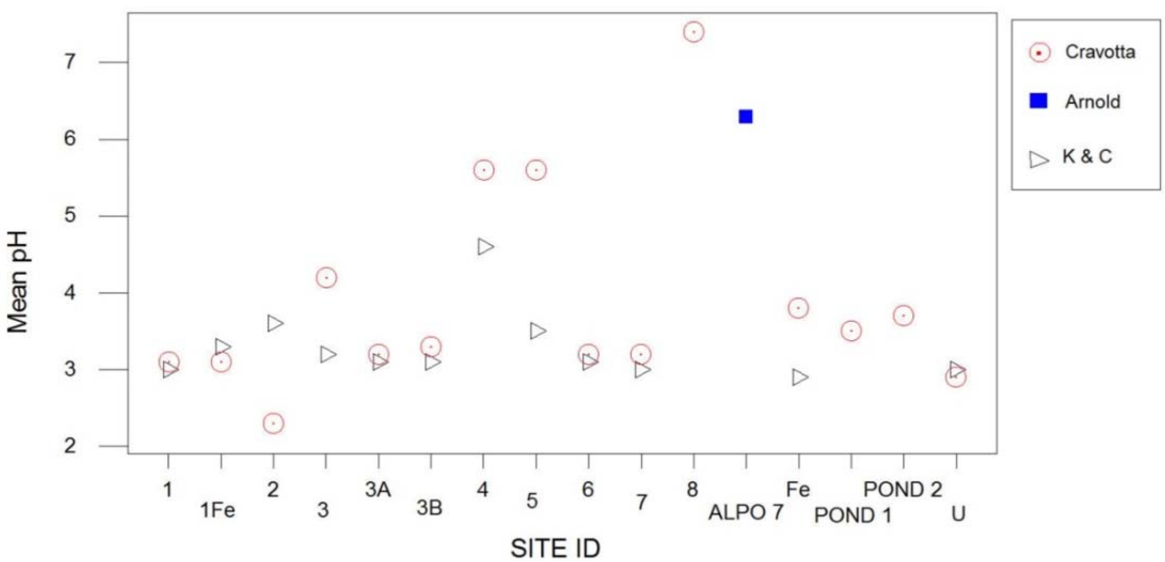
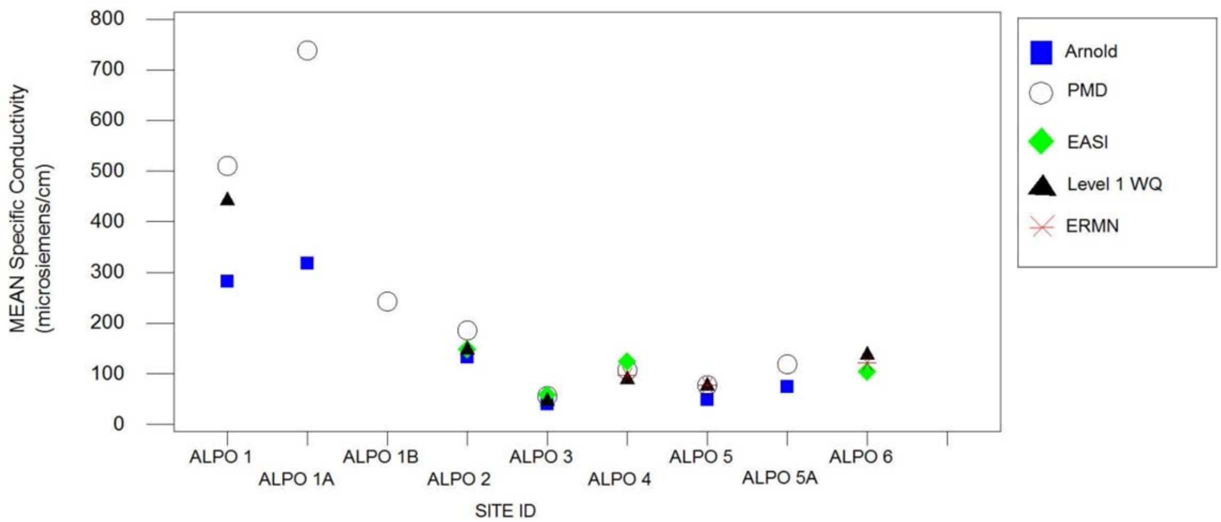


b.)

Figure 42. Mean water pH measured at the primary water quality monitoring locations in a) the Main Unit (Blair Gap Run and Bradley Run watersheds) and b) the SBTU (Little Conemaugh watershed). Means are reported separately for each study. Refer to Tables 21 and 22 for study information.

We were also skeptical of exceedingly high specific conductivity measurements in the EASI dataset at all stations collected from 11/26/2006 to 6/27/2007. This was confirmed by the natural resource manager that measurements from October 2006 to June 2007 included a math error; thus all EASI conductivity measures collected during the above time frame were deleted before computing statistics or performing the condition assessment.



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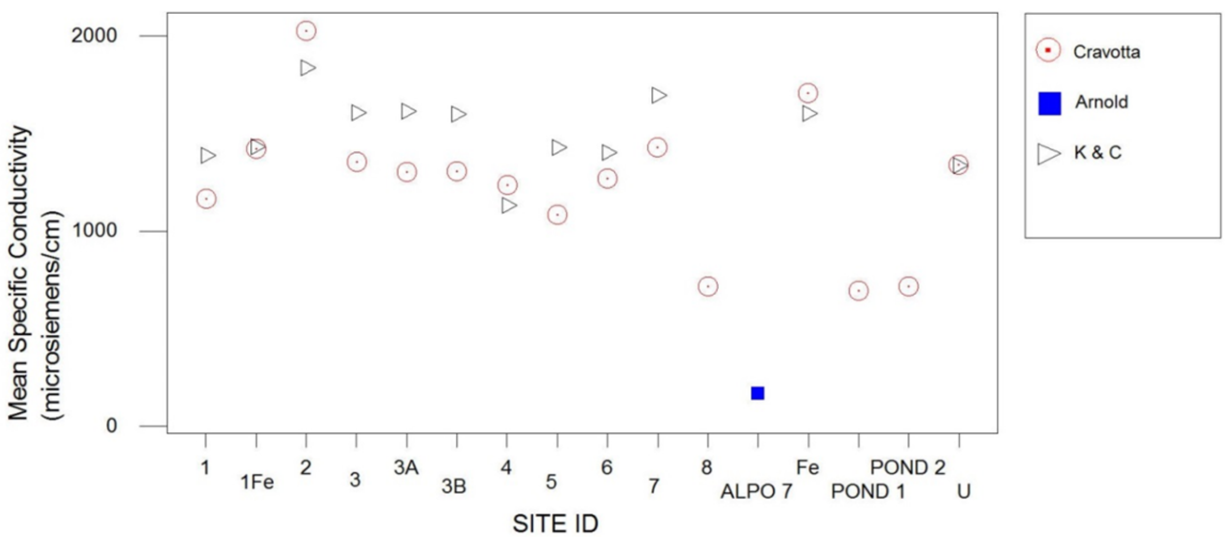
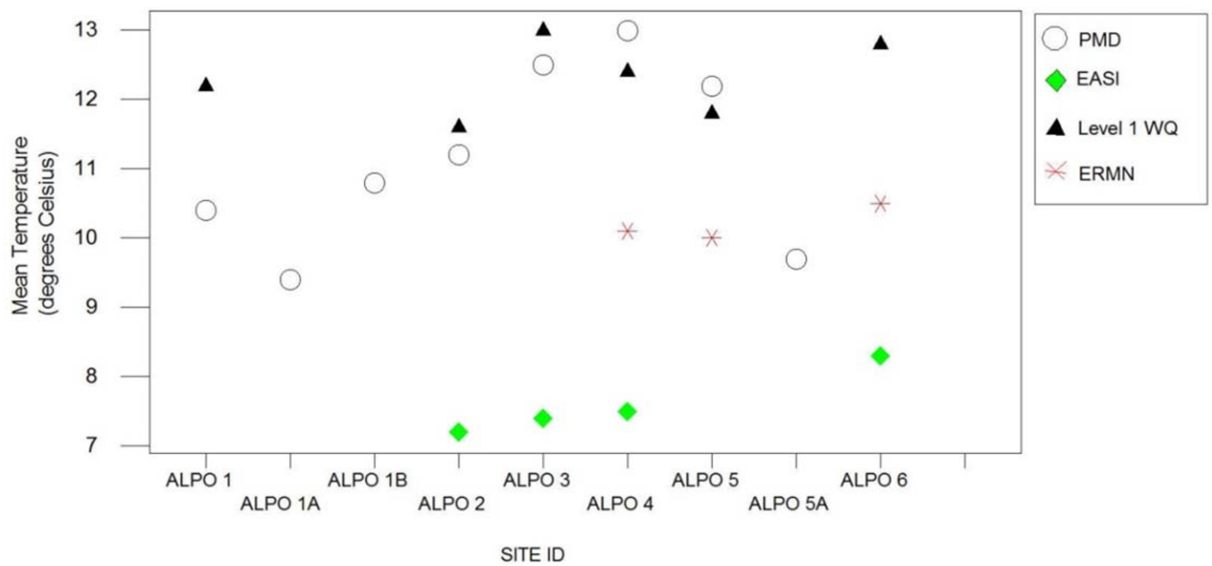


b.)

Figure 43. Mean specific conductivity measured at the primary water quality monitoring locations in a) the Main Unit (Blair Gap Run and Bradley Run watersheds) and b) the SBTU (Little Conemaugh watershed). Means are reported separately for each study. Refer to Tables 21 and 22 for study information.

Temperature data was also questionable from the EASI dataset, with some measurements surprisingly low even for the cold winter months (e.g., -10° C). As a result, we deleted the EASI temperature dataset from the condition assessment due to low confidence.



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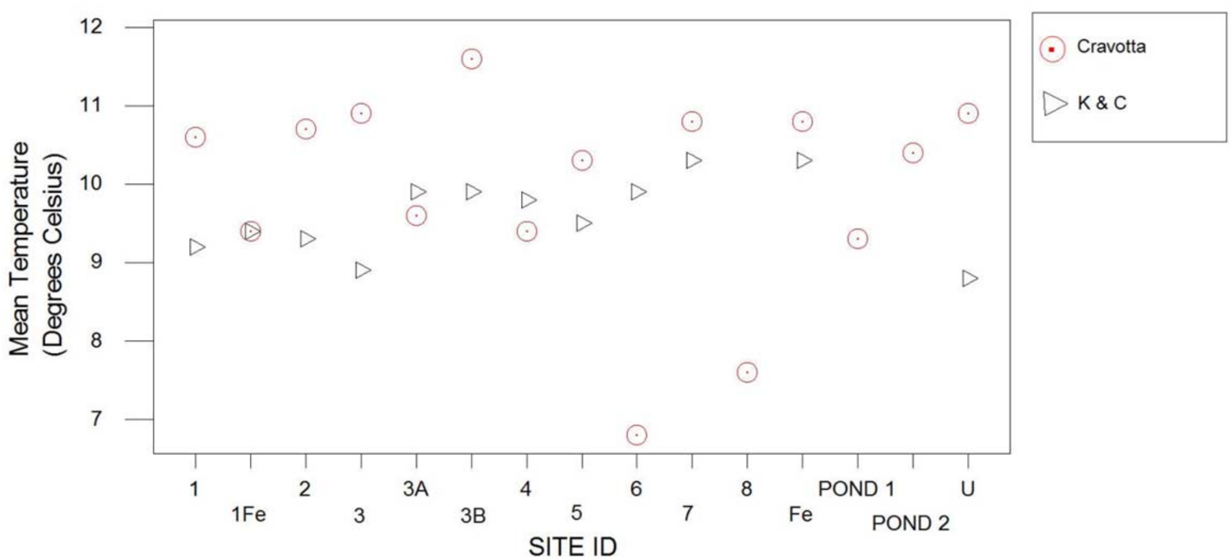
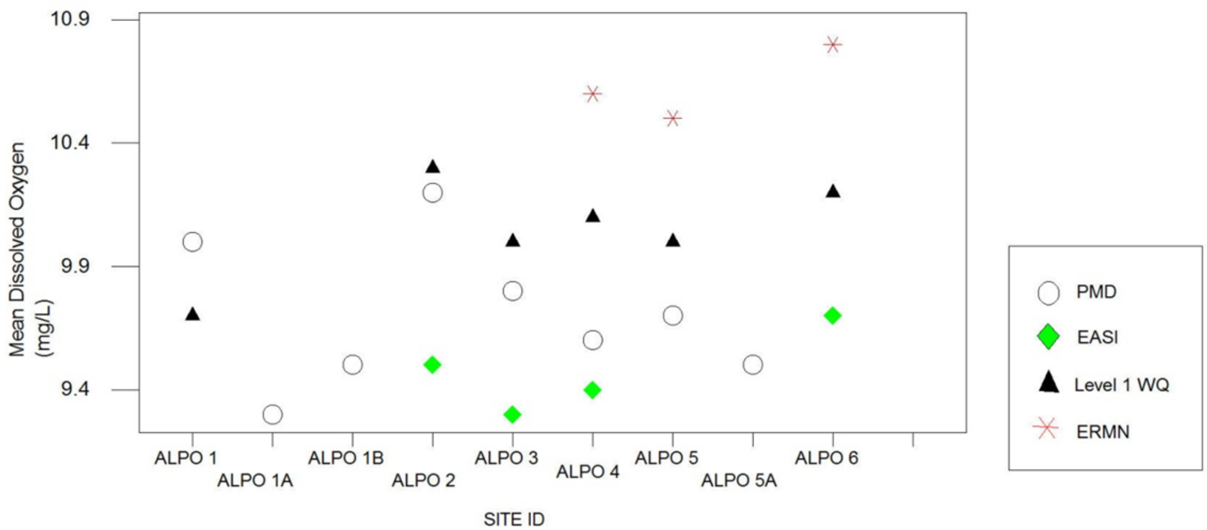
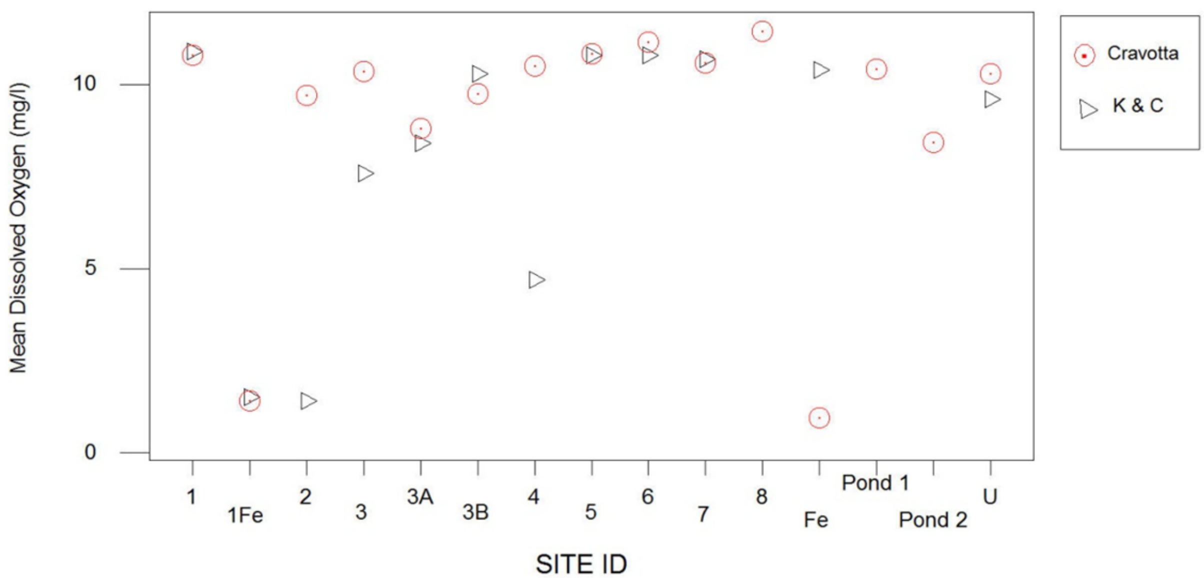


b.)

Figure 44. Mean temperature measured at the primary water quality monitoring locations in a) the Main Unit (Blair Gap Run and Bradley Run watersheds) and b) the SBTU (Little Conemaugh watershed). Means are reported separately for each study. Refer to Tables 21 and 22 for study information.



a.)



b.)

Figure 45. Mean dissolved oxygen measured at the primary water quality monitoring locations in a) the Main Unit (Blair Gap Run and Bradley Run watersheds) and b) the SBTU (Little Conemaugh watershed). Means are reported separately for each study. Refer to Tables 21 and 22 for study information.

Table 25. ALPO water quality condition assessment for pH, specific conductivity, and dissolved oxygen showing (number) and percentage of samples in each condition category. Overall condition rating [good (🟢); moderate concern (🟡); or significant concern (🔴)] is based on the condition category with the highest percentage of samples. Trends were not assessed due to lack of long-term monitoring data with consistent, standardized collection procedures.

CORE PARAMETER	STREAM SEGMENT	PROTECTED USE	N	% GOOD CONDITION)	% MODERATE CONCERN	% SIGNIFICANT CONCERN	CONDITION RATING
pH	Segment 1	CWF	20	(2) 10.0%	(2) 10.0%	(16) 80.0%	🔴
	Segment 2	CWF	127	(119) 93.7%	(7) 5.5%	(1) 0.8%	🟢
	Segment 3	CWF	45	(36) 80.0%	(8) 17.8%	(1) 2.2%	🟢
	Segment 4	CWF	28	(28) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	Segment 5	TSF	47	(45) 95.7%	(2) 4.3%	(0) 0.0%	🟢
	Segment 6	TSF	36	(34) 94.4%	(2) 5.6%	(0) 0.0%	🟢
	Segment 7	CWF	1	(0) 0.0%	(0) 0.0%	(1) 100.0%	🔴
	MAIN UNIT		304	(264) 86.8%	(21) 6.9%	(19) 6.3%	🟢
	SBTU	CWF	337	(11) 3.3%	(4) 1.2%	(322) 95.5%	🔴
Specific Conductivity	Segment 1	CWF	20	(20) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	Segment 2	CWF	177	(126) 71.2%	(51) 28.8%	(0) 0.0%	🟢
	Segment 3	CWF	89	(89) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	Segment 4	CWF	75	(75) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	Segment 5	TSF	46	(46) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	Segment 6	TSF	75	(75) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	Segment 7	CWF	1	(1) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	MAIN UNIT		483	(432) 89.4%	(51) 10.6%	(59) 12.2%	🟢
	SBTU	CWF	332	(4) 1.2%	(179) 53.9%	(149) 44.9%	🟡
Dissolved Oxygen	Segment 1	CWF	20	(15) 75.0%	(5) 25.0%	(0) 0.0%	🟢
	Segment 2	CWF	172	(149) 86.6%	(20) 11.6%	(3) 1.7%	🟢
	Segment 3	CWF	95	(74) 77.9%	(21) 22.1%	(0) 0.0%	🟢
	Segment 4	CWF	83	(67) 80.7%	(15) 18.1%	(1) 1.2%	🟢
	Segment 5	TSF	44	(41) 93.2%	(3) 6.8%	(0) 0.0%	🟢
	Segment 6	TSF	82	(76) 92.7%	(6) 7.3%	(0) 0.0%	🟢
	Segment 7	CWF	1	(0) 0.0%	(1) 100.0%	(0) 0.0%	🟡
	MAIN UNIT		497	(422) 84.9%	(71) 14.3%	(4) 0.8%	🟢
	SBTU	CWF	334	(222) 66.5%	(41) 12.3%	(71) 21.2%	🟡

At the Main Unit, 86.8% of pH measurements, as well as mean pH values at each monitoring location (Figure 42a) were within regulatory standards and considered in good condition (Table 25). The exceptions were the unnamed tributary upstream of the Skew Arch Bridge (Segment 1; n=20) and the unnamed tributary to Bradley Run (Segment 7; n=1). Along Segment 1, 80.0% of pH measurements were below 5, indicating significant concern. Segment 7 also had low pH and rated similarly to Segment 1, but it is important to note that only one discrete measurement was conducted at Segment 7 (Table 25). Although this shouldn't discount these results, we recommend consideration of the biological results as confirmation of low pH conditions. The majority of monitoring sites at the SBTU had mean pH values below regulatory standards (Figure 42b). Over 95% of the pH measurements taken at the SBTU in the Little Conemaugh watershed rated as significant concern (Table 25). Given the known presence of abandoned mine discharge in and around the SBTU, this condition rating is not surprising.

Means for specific conductivity were similar between studies for most monitoring locations, although park monitoring (PMD) results were somewhat higher than means from other studies for ALPO 1 and ALPO 1A (Figure 43a). All stream segments in the Main Unit (Blair Gap Run and Bradley Run watersheds) were considered to be in good condition regarding specific conductivity (Table 25). Segment 2 had some slightly elevated measurements (between 500 and 1100 µS/cm), all of which were collected at ALPO 1A and ALPO 1 monitoring locations (Figure 40). Measures of specific conductivity were often elevated at the SBTU (Figure 43b), again most likely due to abandoned mine drainage, resulting in only 3.3% of specific conductivity measures in the good condition category, 53.9% warranting moderate concern, and 44.9% warranting significant concern (Table 25).

Table 26. ALPO water quality condition assessment for temperature showing (number) and percentage of samples attaining or exceeding water quality standards. Condition rating is based on the percentage of samples meeting attainment with >67% = good (green circle); 33-67% = moderate concern (yellow circle); <33% = significant concern (red circle).

CORE PARAMETER	STREAM SEGMENT	PROTECTED USE	N	% ATTAINMENT (Good Condition)	% EXCEEDANCE	CONDITION RATING
Temperature	Segment 1	CWF	19	(14) 73.7%	(5) 26.3%	green
	Segment 2	CWF	88	(78) 88.6%	(10) 11.4%	green
	Segment 3	CWF	42	(30) 71.4%	(12) 28.6%	green
	Segment 4	CWF	29	(19) 65.5%	(10) 34.5%	yellow
	Segment 5	TSF	45	(43) 95.6%	(2) 4.4%	green
	Segment 6	TSF	34	(33) 97.1%	(1) 2.9%	green
	Segment 7	CWF	1	(1) 100%	(0) 0%	green
	MAIN UNIT		258	(218) 84.5%)	(40) 15.5%	green
	SBTU	CWF	335	(237) 70.7%	(98) 29.3%	green

Means for dissolved oxygen, as well as most of the specific measurements (84.9% and 66.5% of measurements greater than 8 mg/L at the Main Unit and SBTU, respectively), all indicated good condition for this parameter (Figure 45, Table 25). Similarly, stream temperatures also indicated good condition at both park units (Main Unit = 84.5% attainment; SBTU = 70.7% attainment), although 34.5% of temperature measurements at Segment 4 exceeded maximum temperature criteria (Table 25).

Data Gaps and Level of Confidence

Overall confidence in the core water chemistry assessment is medium (specific conductivity > pH > temperature/dissolved oxygen), due primarily to temporal variability and sparse datasets that often did not fully describe the methods in detail and consisting of discrete grab samples that cannot capture diurnal variability. In addition, other factors (e.g., seasonal cycles, storm flows, snow melt, etc.) affect field water chemistry measurements and, thus, likely affected these results. Again, more weight should be placed on the biological results (next section) when assessing water quality.

Sources of Expertise

Caleb Tzilkowski, Aquatic Ecologist, Eastern Rivers and Mountains Network, National Park Service.

4.3.2 Aquatic Macroinvertebrates

Relevance and Context

Unlike chemical measurements, which can only measure ecological condition indirectly, biological assemblages often serve as direct measures of the physical, chemical, and biological stressors affecting the aquatic environment in which they reside. The health of an organism often reflects the suite of environmental conditions present throughout the year, making point-in-time (one-time) measurements more indicative of true ecological condition.

The USEPA defines biological assessments as “an evaluation of the condition of a waterbody using biological surveys and other direct measurements of the resident biota in surface waters” (Barbour et al. 1999). Aquatic macroinvertebrates (e.g., insects, mollusks, macrocrustaceans, etc.) are excellent assemblages for use in biological monitoring. Defined as ‘bottom –living’ organisms lacking backbones and large enough to be retained by mesh sizes of ~200 – 500 mm, macroinvertebrates are extremely diverse, occupy a wide variety of habitats, are relatively long-lived (some may live for several years as aquatic larvae), and display a wide range of tolerances to pollution (Rosenberg and Resh 1993). As such, many states and federal agencies use macroinvertebrate assemblages in biological assessments.

Trichoptera (caddisflies) can be quite diverse in forested headwaters. Photo by S. Yetter

Macroinvertebrate data can be complex and difficult to interpret, but this complexity is derived from the fact that different organisms have different habitat preferences and pollution tolerances, thus creating an effective assessment of condition. Biotic indices summarize these differences in community responses into categories (i.e. metrics) of taxonomic richness, taxonomic composition, functional feeding groups, habit, and degree of tolerance to produce a single number that characterizes this complexity, provides a measure of ecosystem health, and relates to a wide range of physical, chemical, and biological stressors. One such biotic index is the Macroinvertebrate Biotic Integrity Index (MBII) developed by the USEPA's Environmental Monitoring and Assessment Program (EMAP) for riffle-dominated upland and lowland streams in the Mid-Atlantic Highlands Region (Klemm et al. 2003) and later regionalized for streams across the contiguous United States and referred to as the Multimetric Index of Biotic Integrity (MIBI), (Herlihy et al. 2008). For consistency, this condition assessment will refer to the index as the MBII after the original name given by Klemm et al. (2003). The MBII uses seven metrics to characterize the macroinvertebrate community and its response to anthropogenic disturbance (Table 27). Refer to Klemm et al. (2003) for more information regarding calculating metrics and MBII calculation.

Table 27. Macroinvertebrate Biotic Integrity Index metric descriptions and directions of response to increasing human disturbance (Klemm et al. 2003).

Metric	Description	Response
Ephemeroptera richness	Number of Ephemeroptera (mayfly) taxa	Decrease
Plecoptera richness	Number of Plecoptera (stonefly) taxa	Decrease
Trichoptera richness	Number of Trichoptera (caddisfly) taxa	Decrease
Collector-filterer richness	Number of taxa with a collecting or filtering-feeding strategy	Decrease
Percent non-insect individuals	Percentage of individuals that are not insects	Increase
Macroinvertebrate Tolerance Index	Σipiti where pi is the proportion of individuals in taxon I and ti is the pollution tolerance value (PTV) for general pollution	Increase
Percent five dominant taxa	Percentage of individuals in the five numerically dominant taxa	Increase

Chironomidae (far left) and other Diptera. Photo by S. Yetter

The ERMN lists benthic macroinvertebrates (BMI) as an important vital sign and began collecting macroinvertebrate data within the Blair Gap Run watershed using the Wadeable Streams Monitoring Protocol in 2008 (Tzilkowski et al. 2009, 2010, 2011a, b). Four studies at the park contained BMI data: Arnold, Level 1 WQ, Laubscher, and the ERMN monitoring data (Table 20).

Methods

We used the MBII to report condition of BMI communities at ALPO (Main Unit only). Metrics and MBII scores were already available for the Level 1 WQ and ERMN monitoring data but needed to be computed for the earlier datasets (Arnold and Laubscher), which required reconciling the datasets. Like the core water chemistry, each study used different methods of collecting and processing BMI data (Table 28). Macroinvertebrate assessment results can be influenced by such factors as season, type of field equipment used, sample effort (both in the field and in the laboratory), and taxonomic resolution. Sampling apparatuses used in ALPO's water quality monitoring studies included modified surber samplers, d-frame kick nets, and slack samplers (Table 28). These differences do not appear to affect results as strongly as sampling effort and taxonomic resolution. Cao et al. (2005) compared data collected using kicknet and surber samplers and concluded that samples were comparable if standardized to a fixed count. Likewise, Peterson and Zumberge (2006) compared two riffle-based sampling protocols (National Water-Quality Assessment and EMAP) and concluded that collection methods did not affect metrics if: 1) samples were standardized to a fixed count (e.g., 300-count equivalent); 2) differences in taxonomic identifications between datasets were reconciled; 3) Oligochaetes and water mites (i.e., Prostigmata taxa) were counted at that taxonomic level; and 4) Ostracoda were not considered in the analysis. We followed these recommendations before computing the MBII scores for the Arnold and Laubscher datasets (e.g., ostracods were deleted and Chironomidae were compiled to family-level for the Arnold dataset).

The effect of sampling season on water quality results differs between indices and metrics (Lenz 1997, Johnson et al. 2012). Diversity metrics often score highest in spring and late fall, although the differences do not necessarily affect the discriminatory power of the index in separating reference from impaired sites; whereas functional feeding and habitat metrics (e.g., % clingers) based on abundances or proportions of individuals are typically the most sensitive to seasonal changes (Lenz 1997, Johnson et al. 2012). The EMAP samples used to create the MBII were collected during the spring base-flow period from late April to June (Klemm et al. 2003). This time frame coincides with two of the studies at ALPO (Table 28). However, we could not find any specific references regarding the susceptibility of the MBII to seasonal variation. Most likely, any seasonal differences would result in slightly elevated or decreased MBII scores, but it is doubtful that these differences would affect the results to the extent of placing a site in the wrong condition category. Consequently, we included all the studies (Table 28) and compared the MBII scores between studies with the understanding that subtle differences between scores may be due to seasonal variation.

Table 28. Summary of macroinvertebrate sample methods, including time of year and sampling apparatus, used in the benthic studies conducted at ALPO's Main Unit (Blair Gap Run and Bradley Run watersheds).

Study	NRCA ID	Collection Month/Year	Sample Methods
Arnold et al. 1997	Arnold	May 1997	5 samples per site using a modified surber (250 µm mesh)
Laubscher et al. 2007	Laubscher	June 2004	4 samples per site (each sample 2-kick composite equalling 8 kicks per site) using a D-frame kick net (500 µm mesh)
Sheeder and Tzilkowski 2005	Level 1 WQ	January 2005	9 kicks per site using a D-frame kick net (250 µm mesh)
Tzilkowski et al. 2011a, 2011b	ERMN	October 2008 October 2009 October 2010	5 composited samples per site using a slack sampler (500 µm mesh)

In addition to seasonal variation, macroinvertebrate relative abundances and community metrics experience cyclic fluctuations; therefore, it is important to establish the range of natural variation within a community before attempting to evaluate long-term trends. This can take several years. Due to the lack of long-term BMI data that were collected with a consistent method from a single study, we did not attempt to assess trends. However, one objective of the ERMN stream monitoring program is to determine status and long-term trends in BMI abundance and assemblage composition. Therefore, future analysis of trends in BMI condition for ALPO is forthcoming following additional years of ERMN monitoring data.

Reference Condition

Standardized MBII scores range from 0 to 100 with 0 representing most impaired condition and 100 representing least impairment (Klemm et al. 2003). Impaired and reference streams for the MBII were identified by Klemm et al. (2003) from the dataset of 574 wadeable stream reaches using water chemistry, qualitative habitat, and minimum organism count criteria to define impaired and reference condition. Herlihy et al. (2008) included this dataset along with other sources of macroinvertebrate reference-site data used in the US EPA's Wadeable Streams Assessment (N = 1655), to establish reference criteria for nine defined large ecoregions across the United States. MBII scores were assigned to condition classes by comparing the scores to percentiles of the distribution of scores observed at reference sites. Sites at which the indicator score was < 5^{th} percentile of the distribution of reference-site scores (MBII = 49) were classified as in poor condition, a site at which the indicator score was > 5^{th} and < 25^{th} percentile was classified as fair, and a site at which the indicator score was >25^{th} percentile (MBII = 63) was classified as in good condition (Klemm et al. 2003). This coincides with the condition categories defined for the ALPO NRCA (Table 29).

Table 29. MBII scoring criteria and condition categories used for the ALPO benthic macroinvertebrate condition assessment.

MBII Score	Condition Category	Condition Symbol
> 63	*Good*	
49 - 63	*Moderate Concern*	
< 49	*Significant Concern*	

<u>Current Condition</u>

Benthic macroinvertebrate data were not available for Segment 1. MBII scores from all studies and monitoring locations in the upstream portions of Segment 2 (headwaters of Blair Gap Run near the Summit Area) were low and rated as significant concern (Table 30). This segment includes ALPO 1 (along with ALPO 12) and ALPO 1B (Figures 40 and 46). Ephemeroptera and Trichoptera richness were low and the communities were dominated by two acid-tolerant stoneflies (*Leuctra* and *Amphinemura*) and Chironomidae. These results suggested impairment in these upper reaches from acidification. Their ridgetop location places these sites/reaches at greater risk for acid deposition, especially from high sulfate and nitrogen concentrations in precipitation. In addition, historical mining activities may also be affecting these streams.

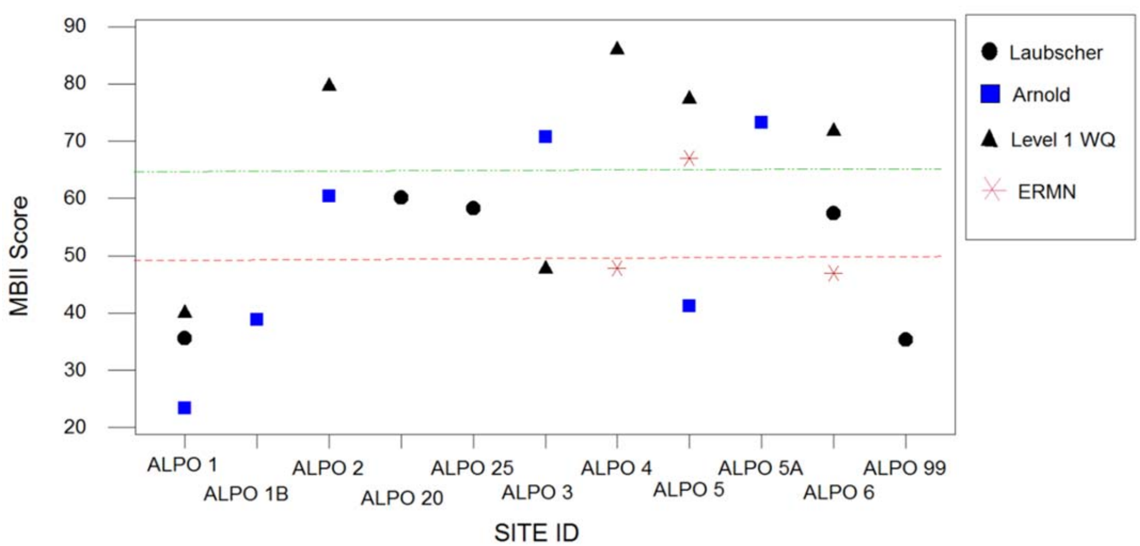


Figure 46. MBII scores (3-yr mean scores for ERMN) from various studies at each of the water quality monitoring stations for ALPO's Main Unit (Blair Gap Run and Bradley Run watersheds). Dashed lines represent minimum value for good condition (green) and maximum value for significant concern (red). Refer to Figure 40 for corresponding stream segments for each station.

Table 30. Water quality condition assessment results for ALPO stream segments in the Blair Gap Run and Bradley Run watersheds using the Macroinvertebrate Biotic Integrity Index (MBII). Condition ratings for each sample location are based on the MIBI score compared to the percent distribution of reference sites (MBII >63 = *good* condition; MBII 49-63 = *moderate concern*; MBII <49 = *significant concern*). Segment condition rating represents the average of the samples for each segment. Refer to Figure 40 for stream segment information.

Stream Seg.	Study	Sample Location	E	P	T	CF	% NI	% 5 dom	MTI	MBII Score	Condition Rating	Segment Condition Rating
2	Laubscher	ALPO 12	3	5	3	2	0.50	85.00	3.75	35.59	Significant Concern	
2	Arnold	SITE 1	5	7	5	4	0.80	91.20	4.65	38.84	Significant Concern	
2	Arnold	SITE 2	3	6	2	1	0.40	95.20	5.23	23.34	Significant Concern	🔴
2	Arnold	SITE 3	7	8	10	7	0.00	71.60	4.52	60.48	Moderate Concern	
2	Level 1	ALPO 1	2	3	5	5	3.10	75.40	3.57	39.92	Significant Concern	
2	Level 1	ALPO 2	7	10	7	10	0.00	67.00	3.50	79.63	Good	
3	Laubscher	ALPO 20	7	7	9	4	0.20	65.20	3.74	60.23	Moderate Concern	
3	Laubscher	ALPO 25	8	6	8	3	0.40	60.70	4.01	58.27	Moderate Concern	🟡
3	Arnold	SITE 4	14	11	8	8	0.60	76.30	4.91	70.80	Good	
3	Level 1	ALPO 3	5	3	6	7	0.00	78.30	3.83	47.70	Significant Concern	
4	Level 1	ALPO 4	8	10	8	13	2.80	63.70	3.73	86.04	Good	
4	ERMN	Muleshoe 2008	7	4	7	6	28.44	59.38	4.41	39.91	Significant Concern	🟡
4	ERMN	Muleshoe 2009	7	5	8	6	12.34	56.17	4.10	50.57	Moderate Concern	
4	ERMN	Muleshoe 2010	5	5	7	6	5.11	67.41	3.63	53.00	Moderate Concern	
5	Arnold	SITE 6	6	6	3	2	0.80	87.20	2.93	41.19	Significant Concern	
5	Level 1	ALPO 5	8	8	8	12	0.30	69.00	3.57	77.39	Good	
5	ERMN	Millstone 2008	9	6	5	4	1.88	53.69	3.23	59.79	Moderate Concern	🟢
5	ERMN	Millstone 2009	7	8	8	4	0.52	54.38	3.25	67.34	Good	
5	ERMN	Millstone 2010	11	6	8	5	1.21	43.51	3.51	74.01	Good	
6	Laubscher	ALPO 8	9	5	9	7	2.00	72.10	4.15	57.40	Moderate Concern	
6	Level 1	ALPO 6	7	6	8	14	1.60	64.30	3.49	71.81	Good	
6	ERMN	Foot of Ten 2008	5	3	7	7	10.90	62.70	4.23	44.06	Significant Concern	🟡
6	ERMN	Foot of Ten 2009	4	2	9	8	5.45	74.28	3.97	47.19	Significant Concern	
6	ERMN	Foot of Ten 2010	6	3	8	7	1.79	81.50	3.80	49.65	Moderate Concern	
6	Arnold	SITE 5	9	11	8	7	0.90	62.80	4.07	73.27	Good	
7	Laubscher	ALPO 99	1	3	5	2	3.50	87.40	3.43	35.30	Significant Concern	🔴

The downstream-most sites along Segment 2 appeared to be in better condition with MBII scores indicating *moderate concern* and *good* condition (Figure 46, Table 30). Sites located along Blair Run and its tributaries (Segment 3) varied in condition. Upstream sites in Segment 3 were rated as *moderate concern*, while the downstream site was considered to be in *good* condition from the Arnold study data and *significant concern* from the Level 1 WQ data.

The MBII scores for Segment 4 along Blair Gap Run upstream of the Altoona Reservoir differed among studies (Figure 46, Table 30). Three of the datasets represent different collection years of the ERMN monitoring. Future monitoring data will be necessary to properly interpret the results for this segment. Segment 5 (Millstone Run tributary) was rated as significant concern by the 1996 monitoring data but MBII scores were greater in the more recent datasets; consequently, we rated this segment as being in *good* condition. Segment 6 was rated as *moderate concern* and represented different monitoring sites located near the Foot of Ten area of Blair Gap Run. This segment is near the town of Duncansville and was likely impacted by human activities. The overall condition rating of *moderate concern* for this segment supports this conclusion. Segment 7, the only site sampled in the Bradley Run watershed is also located on the ridgetop near the Summit Area and had a low MBII score and rated as *significant concern* (Figure 46, Table 30). Similarly to the other sites near the Summit Area, these results are most likely due to acid deposition and/or past mining activities.

<u>Data Gaps and Level of Confidence</u>

This assessment was lacking data for the SBTU. Confidence in this assessment is *medium* to *high*. Reference criteria are based on an expansive regional dataset and statistically valid methods. None of the datasets were from questionable sources and, although methods differed, we are confident that appropriate steps were taken with the raw data to produce comparable MBII scores. The assessment did not receive a high rating primarily due to seasonal differences in collection dates, which may have affected the comparisons between MBII scores. For the most part, community metrics seem to be unaffected if samples are collected during an index period of October through May (PADEP 2009).

<u>Sources of Expertise</u>

Caleb Tzilkowski, Aquatic Ecologist, Eastern Rivers and Mountains Network, National Park Service.

4.4 Ecosystem Integrity

4.4.1 Forest/Wood/Shrubland

<u>Relevance and Context</u>

ALPO is predominately forested with over one-half of the park characterized as Allegheny Hardwood Forest (52%) and an additional 17 % as Northern Hardwood Forest (Perles et al. 2007). These associations commonly occur in higher elevations of the Allegheny Plateau and are dominated by sugar maple (*Acer saccharum*), yellow birch (*Betula allegheniensis*), and black cherry (*Prunus serotina*). Important associate species include white oak (*Quercus alba*), red oak (*Quercus rubra*), sweet birch (*Betula lenta*), bitternut hickory (*Carya cordiformis*), shag-bark hickory (*Carya ovata*), American beech (*Fagus grandifolia*), tuliptree (*Liriodendron tulipifera*) and red maple (*Acer rubrum*). Areas characterized by a mixture of hemlock (*Tsuga canadensis*) and hardwood species make up the balance of natural forested areas within the park. The remaining natural areas are comprised of floodplain forest, alder shrubland, grassland, and open meadow habitats associated with rivers, streams, and other smaller drainages. Interspersed with these natural areas are conifer plantations, old fields and successional forests, the result of previous disturbances that removed the forested land cover. Most of the park's invasive species are found in these areas.

Over the past 25 years, there have been six vegetation surveys within ALPO. Four of these surveys have studied and classified forested habitats: Melton (1981 and 1982a, b), Western Pennsylvania Conservancy (2003), Perles et al. (2007), and Perles et al. (2010). From 1980-1982, Melton mapped vegetation types within the park and provided a qualitative assessment of their abundance. He described five tree cover composition types and recorded density, size class, and stand quality. He also recorded observations on tree mortality, insect infestation and disease. Quality was expressed in terms of merchantable timber. The 2001-2002 Western Pennsylvania Conservancy survey identified 15 distinct forest communities (Western Pennsylvania Conservancy 2003) providing a qualitative description of each type and comprehensive species list. The report also provides management recommendation for invasive species control in forested areas of the park. In 2005, Perles et al. (2007) collected data from 77 plots located within different habitat types and identified 10 forest associations. Detailed information is provided for each association including distribution within the park, environmental characteristics, and species composition. They also recommend forest management plans for the three most highly disturbed forest types: Conifer Plantation, Modified Successional Forest, and Successional Old Field. In a Vital Signs monitoring study from 2007-2009 (Perles et al. 2010) collected data on forest stand structure; tree health, growth, and mortality; tree regeneration; coarse woody debris; shrubs; groundstory diversity; invasive species; and soil in eight forest associations within the park. This study has been carried forward annually with the most recent data available from the 2011 sampling season.

This condition assessment relies heavily on the information obtained in the above vegetation surveys. In addition, we obtained historical information on surveyed tree species to augment the assessment and characterize historical reference condition. We did this primarily to capture the shift in forest composition from the historical period just prior to the region's industrial advancement to present day. The objective is to provide managers with the proper context for interpreting and managing for desired forest composition and condition by understanding both past, present, and future directions of change and the causal factors responsible. The ALPO assessment contains three parts: 1) a comparison of historical and current forest composition; 2) an estimate of current forest community condition; and 3) a prediction of future shifts in ALPO's forest composition. Our objectives were not only to rate the condition of this important resource but also to document past, present, and future shifts in forest composition that have resulted from prior activities and subsequent landscape changes.

Methods

Comparison of historical and current forest composition

Witness trees were used as boundary markers on warrant maps, which were required for all first purchases of land in the Commonwealth. These maps and associated land records are housed in the State Archives and are available online through the Pennsylvania Historical & Museum Commission web page (www.portal.state.pa.us/portal/server.pt/community/land_records/3184). Witness trees from land surveys in the 1790s in and surrounding ALPO were compiled and the topographic characteristics at each witness tree location were extracted from a Digital Elevation Model using a GIS. A total of 328 witness trees were used to estimate forest tree species composition at the time of settlement (Figure 47).

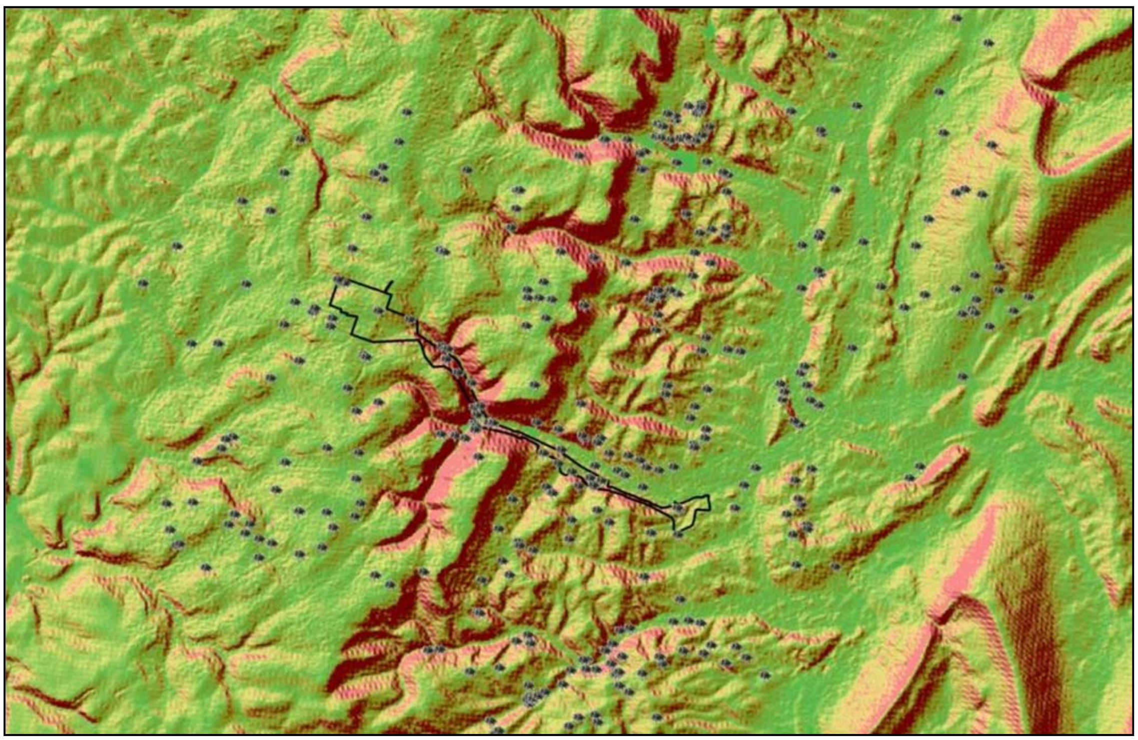


Figure 47. Map showing witness tree locations (n = 328) in and near ALPO used to estimate forest composition at the time of Euro-American settlement. Witness tree locations are displayed over a shaded relief map to distinguish witness trees on the Allegheny Plateau, the Allegheny Front, and the Ridge and Valley.

Second, we compared tree species composition in plots measured by Perles et al. (2007) and Perles et al. (2010) (n=96) with forest composition at the time of settlement based on witness trees. To assess change in tree species composition from reference we compiled the witness tree and vegetation plot data by topographic position (plateau, side slope, and valley) and compared the abundance of tree species for the two time periods for each site type. We then assigned the percent change from the reference for each tree species to one of three categories: minimal change (±100%); moderate change (± 200%); and extreme change (±300% or more).

Estimate of current forest community condition
We used FQA which is an assessment method that uses the floristic characteristics of a plant community to estimate condition (Swink and Wilhelm 1979, 1994). For this assessment, only vascular plants are considered which includes species of forbs, graminoids, shrubs, and trees. The premise of FQA is that individual species have varying tolerances to disturbance, and they also exhibit varying degrees of fidelity to specific habitat types. This tolerance is expressed quantitatively as a coefficient of conservatism – a number between 0 and 10 that is subjectively assigned to the flora of a region. In 2009, coefficient values were assigned to the flora of the Mid-Atlantic Region (Chamberlain and Ingram 2012). These values were used to calculate the floristic quality of forested habitats within ALPO.

The primary FQA metric is the Floristic Quality Index (FQI). The FQI is a metric that uses the mean coefficient value of a plant community to weight species richness. Originally developed to assess the nativity of natural habitats, we used a modified version of the formula that takes into account non-native species, and thus can be used to assess condition (Miller and Wardrop 2006):

$$I' = \left(\frac{\overline{C} \times}{10 \times} \frac{\sqrt{N}}{\sqrt{N + A}} \right) \times 100$$

where $\overline{C}$ is the average coefficient of conservatism for native species, N is native species richness and A is the number of non-native species (Miller and Wardrop 2006).

To estimate condition, we used the ERMN Monitoring data set (Perles et al. 2010 plus additional unpublished data). This data set includes 24 plots sampled in forested areas of the park. The data set was first divided into the seven forest vegetation types categorized by Perles et al. (2007). For each vegetation type, the adjusted FQI score, mean coefficient value and percent non-native species were calculated. To determine condition, we trisected the FQI score and mean coefficient value into three condition categories (Tables 31 and 32):

Table 31. Condition categories for Floristic Quality Index scores. The data was trisected to determine condition thresholds.

Adjusted Floristic Quality Assessment Score	Condition	Symbol
> 35	Good	(green circle)
18-35	Moderate Concern	(yellow circle)
< 18	Significant Concern	(red circle)

Table 32. Condition categories for mean Coefficient of Conservatism. The data was trisected to determine condition thresholds.

Mean Coefficient of Conservatism	Condition	Symbol
> 3.6	Good	
1.9-3.6	Moderate Concern (Caution)	
< 1.9	Significant Concern	

Prediction of future shifts in forest composition

We also evaluated future trends in tree species composition using the plot data. The trend analysis is based on a comparison of the relative abundance (cover) of tree species in different size-classes: 1) seedlings/sapling (S); 2) small trees (10-30 cm dbh) (U); 3) intermediate trees (30-50 cm dbh) (I); and 4) large trees (> 50 cm dbh) (C). The trend analysis was conducted for the forest cover types identified by Perles et al. (2007). Only forest types with at least three plots were included in the analysis: 1) Allegheny Hardwood Forest (AHF); 2) Dry Eastern Hemlock-Oak (EHO); 3) Eastern Hemlock-Northern Hardwoods (EHNH; 4) Modified Successional Forest (MFS); 5) Northern Hardwood Forest (NHF); and 6) Northern Red Oak-Northern Hardwood Forest (NON). We represented future trends by ordinating the relative abundance of each tree species in each size-class for each forest type using nonmetric multidimensional scaling (NMDS) (McCune and Grace 2002). This approach assumes that the differences in the composition and abundance of smaller-younger vs. larger-older stems represent a shift in regeneration patterns that will lead to species replacement. Compositional differences were displayed in NMDS species' space by joining larger to smaller size classes with a vector.

Given the differences in (e.g., qualitative vs. quantitative) and limitations of (e.g., small datasets) the data, we considered a trend analysis to be unfeasible and inappropriate. The addition of future ERMN monitoring data to the Perles et al. (2010) dataset, which was used to calculate the FQA metrics should allow for an analysis of trends in forest/wood/shrubland condition at a later date.

<u>Reference Condition</u>

There are no detailed data on Pre Euro-American settlement forest conditions that can be used as a reference. However, reference conditions for forest tree species composition that are representative of the general location can be inferred from witness tree studies and we used this approach for ALPO. Similar assessments of change in tree species composition since Euro-American settlement have been conducted in other parts of the Ridge and Valley (Abrams and McCay 1996; Abrams and Ruffner 1995) and Allegheny Plateau (Abrams and McCay 1995; Abrams and Ruffner 1995; Black et al. 2006; Thomas-Van Gundy and Strager 2011). Changes in tree species composition from the reference in ALPO are generally similar to changes identified by these other studies. This rather broad reference criterion was not used to estimate condition but rather to help ascertain the extent of changes in community composition since the onset of Euro-American settlement to the present.

Land survey data do not include lists of plants species at each survey point so no historic reference condition could be identified for the FQA condition assessment. Thus, the reference condition for the FQA condition assessment (and the reference criteria used to estimate forest/wood/shrubland condition) was based on the floristic list in the ERMN monitoring plots (n=24) (Perles et al. 2010) and the coefficient of conservatism assigned to vascular plants in the flora of the Mid-Atlantic Region (Chamberlain and Ingram 2012).

Current Condition

Comparison of historical and current forest composition

Frequencies of the various witness trees recorded from historical land maps suggested forests at the time of the land surveys in ~1794 were a mixture of both hardwoods and conifers but the composition varied with physiographic position (i.e. plateau, slope, or valley) (Table 33). Based on the frequency of witness trees (n=328), the most common tree species on the Allegheny plateau were American chestnut, oak (white, red, chestnut), spruce (hemlock), eastern white pine, sugar maple, birch and American beech. Oaks and American chestnut were predominant on more well drained side slopes along with lesser amounts of sugar maple and American beech. In more mesic valleys, oak (white, blackjack, pin, chestnut), hickory, American basswood, and black walnut were the most frequent witness trees.

Forest composition in ALPO has changed dramatically since the time of the land surveys. For example American chestnut was abundant in the reference forest and was not recorded in the vegetation plots though remnants sprouts are probably present but they cannot develop into trees because of chestnut blight (Table 34). Oaks, hickories, and eastern white pine were also abundant in the reference forest and they are much less abundant in the contemporary forest. On the other hand, tulip tree, and especially red maple, cherry (*Prunus* sp.) and black locust are much more abundant today than at the time of settlement. For ALPO, overall, the comparison of historical and current forest tree species composition indicates that twenty-two tree species have undergone minimal change, four have experience moderate change (all oaks considered together are moderate), and thirteen tree species have demonstrated extreme changes in their relative proportion of the forest community (Table 34). Eastern hemlock appears to have undergone minimal change in its representative proportion of the community. While most oak species experienced extreme declines from historical times to present (e.g., % frequency on the slope of white oak from witness tree surveys = 20.2% declined to an average cover of 0.1%), northern red oak showed the opposite change (% frequency on the slope from witness tree surveys = 2.5% increased to 18.4% of average cover currently). The overall decline in oak and pine and increase in red maple is a regional pattern and is related to extensive 19th century logging, post logging fires, and a century of stand development with little fire and other disturbances (Abrams 1992, 2001). In contrast, the increase in cherry, black locust, and tulip tree are related to the logging disturbance.

Table 33. Frequency of witness trees in each physiographic location at the time of land surveys (~1794) in and near ALPO. Values for the witness trees are relative frequency; n = number of witness trees.

Latin Name	Common name	Frequency (%) Plateau (n=103)	Frequency (%) Slope (n=163)	Frequency (%) Valley (n=62)	Frequency (%) Any location
Quercus all species	Oaks	15.5	50.9	62.9	43.1
Quercus alba	White oak	5.8	20.2	32.3	19.4
Castenea dentata	American chestnut	16.5	12.3	0.0	14.4
Quercus prinus	Chestnut oak	2.9	16.0	8.1	9.0
Carya	Hickory	4.9	4.9	12.9	7.6
Acer saccharum	Sugar maple	8.7	8.6	3.2	6.9
Fagus grandifolia	American beech	6.8	6.1	0.0	6.5
Juglans nigra	Black walnut	0.0	0.0	6.5	6.5
Tsuga canadensis (includes Picea)	Eastern hemlock	11.7	1.2	0.0	6.4
Pinus strobus (includes Pinus)	Eastern white pine	9.7	1.8	0.0	5.8
Acer rubrum	Red maple	0.0	0.0	0.0	4.4
Betula (lenta + alleghensis)	Birch	7.8	0.6	0.0	4.2
Quercus palustris	Swamp oak	1.0	4.3	6.5	3.9
Tilia americana	American linden	1.9	1.8	4.8	2.9
Cornus	Dogwood	0.0	2.5	0.0	2.5
Quercus rubra	Red oak	4.9	2.5	0.0	2.4
Robinia pseudoacacia	Black locust	1.0	3.7	0.0	2.3
Populus grandentata	Bigtooth poplar	3.9	0.6	0.0	2.2
Prunus (pennsylvanica & serotina)	Cherry	1.9	0.0	0.0	1.9
Fraxinus americana	White ash	0.0	0.0	0.0	0.0
Fraxinus sp.	Ash	1.9	0.0	1.6	1.8
Fraxinus all		1.9	0.0	1.6	1.8
Juglans cinerea	Butternut	0.0	0.0	1.6	1.6
Nyssa sylvatica	Black gum	0.0	0.0	1.6	1.6

Table 33. (continued) Frequency of witness trees in each physiographic location at the time of land surveys (~1794) in and near ALPO. Values for the witness trees are relative frequency; n = number of witness trees.

Latin Name	Common name	Frequency (%) Plateau (n=103)	Frequency (%) Slope (n=163)	Frequency (%) Valley (n=62)	Frequency (%) Any location
Carpinus carolina	Ironwood	0.0	1.2	0.0	1.2
Rhus	Black Shittem	1.0	0.0	0.0	1.0
Platanus occidentalis	Sycamore	0.0	0.0	1.6	0.8
Magnolia acuminata	Cucumber tree	1.0	0.6	0.0	0.8
Acer negundo	Box elder	0.0	0.4	0.0	0.4
Malus sp.	Crabapple	0.0	0.0	0.2	0.2
Amelanchier arborea	Serviceberry	0.0	0.0	0.0	0.0
Aralia spinosa	Devils' walking stick	0.0	0.0	0.0	0.0
Malus pumila	Crabapple	0.0	0.0	0.0	0.0
Ostrya virginiana	Hophornbeam	0.0	0.0	0.0	0.0
Pyrus sp.	Pear	0.0	0.0	0.0	0.0
Ulmus americana	American elm	0.0	0.0	0.0	0.0
Acer pennsylvanica	Striped maple	0.0	0.0	0.0	0.0
Alnus rugosa	Speckled alder	0.0	0.0	0.0	0.0
Crategus	Hawthorne	0.0	0.0	0.0	0.0
Liriodendron tulipifera	Tulip tree	0.0	0.0	0.0	0.0

Table 34. Tree species composition at the time of settlement (witness trees) and in contemporary forests in ALPO. The values for the witness trees are relative frequency and the values for the contemporary forest are average cover in plots. The degree of the relative proportion of each tree species from historical to present time is indicated in one of three categories: Minimal Change = (±100% ↔); Moderate Change = (± 200% ↑ ↓); and Extreme Change = (±300% or more ↑ ↓).

	Frequency (%)	Witness tree	Contemporary plots	Condition	Witness tree	Contemporary plots	Condition	Witness tree	Contemporary forest	Condition
		Frequency (%)	Cover (%)		Frequency (%	Cover (%)		Frequency (%)	Cover (%)	
Latin Name	Common name	Plateau (n=103)	Plateau (n=29)		Slope (n=163)	Slope (n=37)		Any location	Any location	
Quercus all species	Oaks	15.5	8.5	↔	50.9	22.3	↓	43.1	15.4	↓
Quercus alba	White oak	5.8	0.0	↓	20.2	0.1	↓	19.4	0.1	↓
Castenea dentata	American chestnut	16.5	0.0	↓	12.3	0.0	↓	14.4	0.0	↓
Quercus prinus	Chestnut oak	2.9	0.5	↓	16.0	3.8	↓	9.0	2.2	↓
Carya	Hickory	4.9	0.9	↓	4.9	1.4	↓	7.6	1.2	↓
Acer saccharum	Sugar maple	8.7	8.5	↔	8.6	15.8	↔	6.9	12.2	↔
Fagus grandifolia	American beech	6.8	8.0	↔	6.1	3.3	↔	6.5	5.6	↔
Juglans nigra	Black walnut	0.0	0.0	↔	0.0	1.0	↔	6.5	0.5	↓
Tsuga canadensis (includes Picea)	Eastern hemlock	11.7	16.0	↔	1.2	6.2	↑	6.4	11.1	↔
Pinus strobus (includes Pinus)	Eastern white pine	9.7	0.4	↓	1.8	0.0	↓	5.8	0.4	↓
Acer rubrum	Red maple	0.0	22.9	↑	0.0	9.8	↑	4.4	16.4	↑
Betula (lenta + alleghensis)	Birch	7.8	5.9	↔	0.6	2.2	↑	4.2	4.0	↔
Quercus palustris	Spanish oak	1.0	0.0	↔	4.3	0.0	↓	3.9	0.0	↓
Tilia americana	American linder	1.9	0.6	↓	1.8	0.4	↓	2.9	0.5	↓
Cornus	Dogwood	0.0	0.0	↔	2.5	0.0	↓	2.5	0.0	↓
Quercus rubra	Red oak	4.9	8.0	↔	2.5	18.4	↑	2.4	13.2	↑
Robinia pseudoacacia	Black locust	1.0	5.2	↑	3.7	6.5	↔	2.3	5.9	↑
Populus grandentata	Bigtooth poplar	3.9	0.0	↓	0.6	0.0	↔	2.2	0.0	↔
Prunus (pennsylvanica and serotina)	Cherry	1.9	16.9	↑	0.0	18.3	↑	1.9	17.6	↑
Fraxinus americana	White ash	0.0	2.2	↑	0.0	3.7	↑	0.0	3.0	↑
Fraxinus sp.	Ash	1.9	0.0	↓	0.0	0.9	↔	1.8	0.9	↔
Fraxinus all		1.9	2.2	↔	0.0	4.6	↑	1.8	3.4	↔
Juglans cinerea	Butternut	0.0	0.0	↔	0.0	0.0	↔	1.6	0.0	↓
Nyssa sylvatica	Black gum	0.0	0.0	↔	0.0	1.1	↔	1.6	1.1	↔
Carpinus carolina	Ironwood	0.0	0.0	↔	1.2	0.1	↓	1.2	0.1	↓
Rhus	Black Shittem	1.0	0.0	↔	0.0	0.5	↔	1.0	0.5	↔
Platanus occidentalis	Sycamore	0.0	0.0	↔	0.0	0.0	↔	0.8	0.0	↔
Magnolia acuminata	Cucumber tree	1.0	1.2	↔	0.6	0.0	↔	0.8	1.2	↔
Acer negundo	Box elder	0.0	0.0	↔	0.4	0.0	↔	0.4	0.0	↔
Malus sp.	Crabapple	0.0	0.0	↔	0.0	0.3	↔	0.2	0.3	↔
Amelanchier arborea	Serviceberry	0.0	0.0	↔	0.0	0.2	↔	0.0	0.1	↔
Aralia spinosa	Devils' walking stick	0.0	0.0	↔	0.0	0.1	↔	0.0	0.1	↔
Malus pumila	Crabapple	0.0	0.1	↔	0.0	0.1	↔	0.0	0.1	↔
Ostrya virginiana	Hophornbeam	0.0	0.0	↔	0.0	0.2	↔	0.0	0.2	↔
Pyrus sp.	Pear	0.0	0.0	↔	0.0	0.2	↔	0.0	0.2	↔
Ulmus americana	American elm	0.0	0.0	↔	0.0	0.9	↔	0.0	0.9	↔
Acer pennsylvanica	Stripped maple	0.0	0.2	↔	0.0	0.2	↔	0.0	0.2	↔
Alnus rugosa	Speckled alder	0.0	0.0	↔	0.0	0.0	↔	0.0	0.0	↔
Crategus	Hawthorne	0.0	0.1	↔	0.0	0.2	↔	0.0	0.2	↔
Liriodendron tulipifera	Tulip tree	0.0	2.8	↑	0.0	4.1	↑	0.0	3.5	↑

Estimate of current forest community condition

FQI scores for forest associations within ALPO Main Unit ranged from 24-52 (Table 35), while forest associations in the SBTU ranged from 45-47 (Table 36). Mean C values ranged from 3-5 for ALPO Main Unit forest associations. Both forest associations in SBTU scored 5. Forest associations in the ALPO Main Unit had a higher percentage of non-native species present on average than the SBTU.

Table 35. Floristic Quality Metrics for Forest/Wood/Shrubland associations within the ALPO Main Unit based on data from Perles et al. (2010). The number of sample plots is given for each association. Mean C is the average coefficient of conservatism for each association.

ALPO Main Unit Floristic Metrics	Allegheny Hardwood Forest (n=4)	Dry Eastern Hemlock-Oak Forest (n=1)	Eastern Hemlock-Northern Hardwood Forest (n=3)	Modified Successional Forest (n=2)	Northern Hardwood Forest (n=7)	Northern Red Oak - Northern Hardwood Forest (n=2)	Successional Old Field (n=2)
Adjusted FQI	48	49	52	32	37	24	31
Mean C	5	5	5	3	4	3	4
% Non-Native Spp.	3	0	5	12	15	26	22

Table 36. Floristic Quality Metrics for Forest/Wood/Shrubland associations within the SBTU based on data from Perles et al. (2010). The number of sample plots is given for each association. Mean C is the average coefficient of conservatism for each association.

SBTU Metrics	Allegheny Hardwood Forest (n=2)	Tulip Tree Beech Maple Forest (n=1)
Adjusted FQI	47	45
Mean C	5	5
% Non-Native Spp.	2	7

Tables 37 and 38 summarize the results of the condition assessment using the FQA results in Tables 35 and 36. Most forest associations in the main portion of ALPO scored *good* for floristic quality (Table 37) and floristic metrics ranked associations in a similar manner. These forests contain many elements associated with intact natural forests of the Allegheny Plateau including a variety of oak (Quercus) and hickory (*Carya*) species, American beech (Fagus grandifolia), tuliptree (*Liriodendron tuilipifera*), eastern hemlock (*Tsuga canadensis*), black cherry (*Prunus serotina*), and black gum (*Nyssa sylvatica*). They also contain many highly conservative understory woody and herbaceous plants such as common serviceberry (*Amelanchier arborea*), mountain holly (*Ilex montana*), whorled wood aster (*Oclemena acuminata*), Indian cucumber root (*Medeola virginiana*), starflower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadense*), partridgeberry (*Mitchella repens*), painted trillium (*Trillium undulatum*), red trillium (*Trillium erectum*) and sessileleaf bellwort (*Uvularia sessilifolia*).

While in good condition, these associations, particularly the Dry Eastern Hemlock – Oak, Allegheny Hardwood, and Eastern Hemlock – Northern Hardwood Forest associations, while in good condition, all contain known or suspected non-native, invasive species that can diminish floristic quality by outcompeting native species.

Table 37. Condition Assessment Metrics for ALPO Main Forest Associations. Condition category breakpoints are indicated in Tables 31 and 32.

ALPO Main Unit Floristic Metrics	Allegheny Hardwood Forest (n=4)	Dry Eastern Hemlock-Oak Forest (n=1)	Eastern Hemlock-Northern Hardwood Forest (n=3)	Modified Successional Forest (n=2)	Northern Hardwood Forest (n=7)	Northern Red Oak - Northern Hardwood Forest (n=2)	Successional Old Field (n=2)
Adjusted FQI	● (green)	● (green)	● (green)	● (yellow)	● (green)	● (yellow)	● (yellow)
Mean C	● (green)	● (green)	● (green)	● (yellow)	● (green)	● (yellow)	● (yellow)

The Eastern Hemlock – Northern Hardwood Forest association supports Japanese stiltgrass, (*Microstegium vimineum*) an aggressive invader that can take over large areas of forest. Like most invasives, Japanese stiltgrass is opportunistic. While slow to invade densely vegetated sites, it readily colonizes areas where the substrate has been disturbed and vegetative cover removed (Barden 1987). Without adequate control measures in place for this species, it is likely this association will continue to decrease in condition.

The Allegheny Hardwood Forest association supports Oriental ladysthumb (*Polygonum cespitosum*) a potentially invasive species. The Northern Hardwood Forest association, while containing many examples of high-quality forest endemics, also has the largest number of non-native species, including seven of the eight target invasives for the park. (see Section 4.5.7 Non-native Invasive Plants for additional information on target species).

Modified Successional Forest and Successional Old Field associations ranked *moderate concern* for floristic quality, while the Northern Red Oak – Northern Hardwood Forest association scored *moderate to significant concern*. All three of these associations support large numbers of non-native and invasive species, as well as weedy, native species, such as black locust (*Robinia pseudoacacia*), common gypsyweed (*Veronica officinalis*), common cinquefoil (*Potentilla simplex*), hayscented fern (*Dennstaedtia punctilobula*), and the invasive reed canary grass (*Phalaris arundinacea*).

The two forest associations within the SBTU scored good for floristic quality (Table 38). These associations share many of the same high quality species found in the ALPO Main Unit. However, both associations support seven of the eight target invasive species identified by the park, as well as several other non-target invasive and weedy species that could potentially become problematic.

Prediction of future shifts in forest composition
The ordination of size-classes in each forest type suggests that forests are continuing to shift in composition away from the current and reference composition (Figure 48).

Table 38. Condition Assessment Metrics for the SBTU Forest Associations

SBTU Floristic Metrics	Tulip Tree - Beech - Maple Forest (n=2)	Allegheny Hardwood Forest (n=1)
Adjusted FQI	●	●
Mean C	●	●

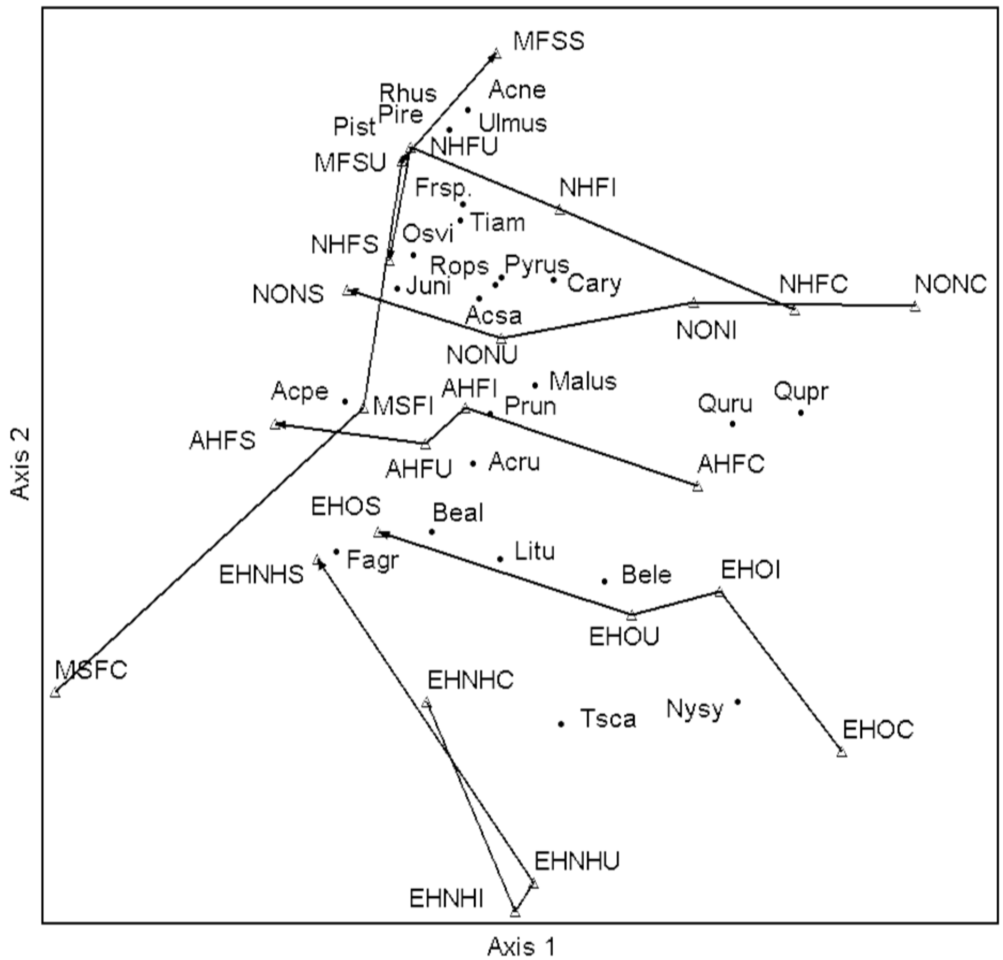


Figure 48. Compositional differences in the cover of the 25 most abundant tree species in six forest types identified by Perles et al. 2007: 1) Allegheny Hardwood Forest (AHF); 2) Dry Eastern Hemlock-Oak (EHO) ; 3) Eastern Hemlock-Northern Hardwoods (EHNH; 4) Modified Successional Forest (MFS); 5) Northern Hardwood Forest (NHF); 6) Northern Red Oak-Northern Hardwood Forest (NON). Fourth letter denotes the size class (C=canopy, I = intermediate, U = understory, S=seedling). Vectors show the direction and magnitude of compositional difference between the four size-classes for each forest type in NMDS species space. For example, in AHF forests, oaks that are dominant in the canopy (AHFC) are being replaced by more shade-tolerant and fire-intolerant maples which are abundant in understory (AHFU) and seedling (AHFS) layers. Species acronyms are a combination of the first two letters of the genus and species and full Latin names can be found in Table 34.

Forest types with canopy layers dominated by various mixtures of oak, hemlock, American beech, sugar maple, cherry, and red maple have a regeneration layer dominated by striped maple and red maple. Thus, hickory, oak, American linden, and eastern white pine which showed large declines in cover in the reference and contemporary data set are likely to continue to decline and be replaced by more shade-tolerant and acid-tolerant maples.

Overall, the general story of the forested landscape in and around ALPO follows that of the region. During European settlement, land clearing, extensive logging and burning was followed by the chestnut blight, fire suppression and intensive deer browsing. White oak was one of the species most negatively impacted by these activities, while red oak experienced a temporary expansion (Abrams 2006). As disturbances lessened and burning of fossil fuels increased, later successional hardwoods that are more tolerant to shade and acidic soils, such as red maple, black cherry, and striped maple, have been aggressively replacing the once dominant oaks and hickories. This replacement is likely to continue, unless management actions intervene.

<u>Data Gaps and Level of Confidence</u>
The confidence in this condition assessment is *low* to *medium*. Condition was assessed from a quantitative set of data collected using standard, peer-reviewed sampling methods. In addition, by using a single data set (Perles ERMN Vital Signs monitoring data) to determine condition (Perles et al. 2010 and additional unpublished data), we eliminated many of the obvious problems associated with different sampling methods including varying sample sizes and the use of both qualitative and quantitative measures. However, the use of a single set of data presented additional challenges including small sample sizes and a limited ability to analyze trends due to a lack of sufficient time series data. Nonetheless, we were able to document the current condition with some level of confidence, as well as provide baseline data for meaningful comparisons in the future.

<u>Sources of Expertise</u>
Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

Stephanie Perles, Plant Ecologist, Eastern Rivers and Mountains Network, National Park Service.

Alan Taylor, Professor Physical Geography, Director of Vegetation Dynamics Lab, Department of Geography, Pennsylvania State University

4.4.2 Grasslands

<u>Relevance and Context</u>
The historical evolution of temperate northeastern grasslands can be largely attributed to changing land use practices (Askins et al. 2007). Prior to European settlement, grasslands were created through natural disturbances (e.g., fire, wind, flooding, beaver activity, disease and insect damage) and periodic burning by Native Americans. In the 18^{th} and 19^{th} centuries, farmlands dominated the landscape and many grassland birds depended on habitats in agricultural fields (Norment 2002). Many of these areas were either abandoned and transformed by forest succession or transformed by

human development in the 20th century. Such was the case in the area surrounding ALPO. In 1939 much of the land in and around Foot of Ten was in agricultural use (Figure 49a). By 2006, most of this area had been converted to suburban land (Figure 49b). During this time period agricultural land use within a 1-km buffer surrounding and including the park decreased from ~1542 acres (19% of total land area in Figure 49a) to less than 19 acres (<5% of total land area in Figure 49b), while developed areas increased from ~223 acres to ~842 acres or from less than two percent to over ten percent of total land area (Figure 49). The cumulative impacts of these types of land use changes, along with fire suppression and more intensive agricultural practices have substantially reduced suitable habitat throughout the region and resulted in population declines in grassland birds (Askins et al. 2007). Recently, however, reclaimed surface mines have provided a new type of grassland habitat in the northeast, with ~35,000 ha in Western Pennsylvania supporting high densities of Grassland Sparrows (Askins et al. 2007, Stauffer et al. 2011).

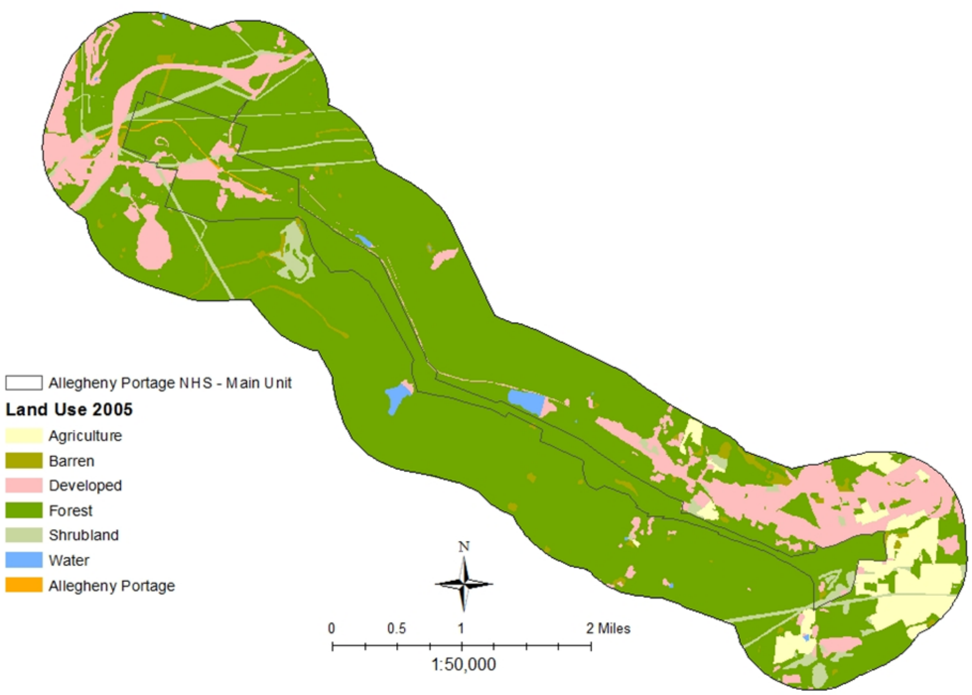
Currently, grasslands at ALPO represent ~36 ha (89 ac) or 8.7% of land within the Main Unit and less than 1 ha (2 ac) or 1% of land at the SBTU. Most of these areas are primarily in the form of narrow, linear strips. The largest patches are located in the Summit Area of the Main Unit, which contains 17.9 ha (44 ac) of grassland.

The heightened need for grassland bird conservation prompted NPS to explore the potential for cultural parks to support breeding grassland bird communities. Management of historical sites for cultural significance often requires the maintenance of open landscapes, which can also be maintained to benefit breeding grassland birds (Peterjohn 2006). Peterjohn (2006) listed the following obligate grassland bird species as being the most widespread in the Mid-Atlantic Region along with their frequency of occurrence in Pennsylvania:

- Horned Lark (*Eremophila alpestris*)—FC
- Vesper Sparrow (*Pooecetes gramineus*)—FC
- Savannah Sparrow (*Passerculus sandwichensis*)—FC
- Grasshopper Sparrow (*Ammodramus savannarum*)—FC
- Henslow’s Sparrow (*A. henslowii*)—U
- Bobolink (*Dolichonyx oryzivorus*)—FC
- Eastern Meadowlark (*Sturnella magna*)—FC

FC (Fairly Common): Regularly encountered in appropriate habitats; U (Uncommon): Observed only in small numbers and frequently absent from suitable habitats.

a.)



b.)

Figure 49. Land use classifications within the Main Unit of ALPO and a 1-km surrounding buffer area in (a) 1939 and (b) 2006. Land use was determined through aerial photo interpretation. Grasslands could potentially occur in the agricultural and barren areas and also developed areas maintained as grassland in the park.

In the past, periodic disturbances, such as grazing and fire, in native grasslands created a patchwork of habitat types ranging from disturbed agricultural fields (preferred by Horned Larks, Vesper Sparrows, and Savannah Sparrows) to habitats with sparse litter layers interspersed with bare ground (preferred by Grasshopper Sparrows and Eastern Meadowlarks) to mature habitats devoid of disturbances for at least three to five years where tall dense vegetation and thick litter layers developed (preferred by Henslow's Sparrows and Bobolinks). Managing grasslands to support entire communities requires maintenance of these multiple habitats. However, spotty distributions of grassland birds across the Mid-Atlantic Region combined with limitations placed on parks to provide the full range of grassland habitats can render such a management goal unfeasible. Instead, Peterjohn (2006) recommends that management activities should be directed to benefit those species most likely to occur within each park.

Grasshopper Sparrow (Ammodramus savannarum). Photo by J. Hill

Bird studies specifically focused on grassland species have not been conducted at ALPO, most likely because park lands are predominantly forested. Yahner and Keller (2000) conducted bird surveys using the 50-m, fixed width transect protocol (Emlen 1971) during the spring migratory and breeding seasons in 1997. In both seasons, grass/forb habitats contained higher abundances of permanent residents (mostly open-field and edge species) compared to hardwood habitats. The authors recommended developing mowed lawns into unmowed grasslands, especially around the Visitors Center and Lemon House. They also noted management opportunities in the area of ALPO no. 9 for grass/forb habitat. Since then, mowing frequency was reduced at Summit area fields and some of those fields have been overseeded to establish wildflower meadows. At the foot of Incline 9, mowing frequency was more recently reduced at one field and the other wet meadow will be left unmowed (Kathy Penrod, ALPO Natural Resource Manager, pers. comm.). Point count surveys were also conducted during the spring-migratory, breeding, fall-migratory, and winter seasons (Yahner et al. 2001). Most species characteristic of open habitats were not present at the park because of the relatively small amount of herbaceous or grassland habitat.

Henslow's Sparrow (Ammodramus henslowii)

This apparent lack of grassland bird occurrence throughout ALPO is not surprising, considering the park provides only small patches of mostly disturbed grassland habitats. Consequently, evaluating grassland habitat in the park from the perspective of supporting the entire suite of obligate grassland bird species is not a practical endeavor. However, these areas may potentially support Vesper, Savannah, and possibly Grasshopper Sparrows (J. Hill and G. Stauffer, pers. comm.). Therefore, our focus here is primarily to evaluate the condition of ALPO's potential grasslands for providing habitat for these three species of grassland birds.

An evaluation of suitable grassland habitat involves the following:

- Size of contiguous habitat (i.e. patch size)
- Degree of fragmentation, edge and isolation effects
- Cool-season vs. warm-season grasses
- Maintenance through mowing and/or prescribed burning.

Contiguous 40-100 ha (100-250ac) tracts are necessary to support entire grassland bird communities (Herkert 1994; Winter and Faaborg 1999). However, creation and maintenance of such large tracts is not always possible, especially in small forested parks like ALPO, and small patches with minimal edge habitat can serve as important areas for grassland bird conservation (Davis 2004). Other researchers suggest the following: fields <5 ha (12 ac) are avoided by grassland birds; 5-10 ha (12-25 ac) fields are occupied by some species within landscapes where grasslands are extensive; and field sizes must be 10-20 ha (25-50 ac) before they are consistently occupied by some species (Peterjohn 2006). Wilson and Brittingham (2012) reported that at least 10 ha (24.7 ac) is necessary to sustain grassland bird populations and that smaller patches potentially serve as population sinks. However, these small patches may be supported through immigration, rather than internal recruitment, suggesting that maintenance of small patches requires the existence of other grassland habitats nearby and emphasizing the need to evaluate grassland habitats within a landscape context (i.e., small grassland patches may be able to sustain bird populations is they occur within an agricultural or other open landscape) (Bakker et al. 2002, Hill 2012). Several studies found area-sensitivity and actual size requirements of various grassland bird species vary from region to region (Herkert 1994, Vickery et al. 1999, Helzer and Jelinksi 1999, Johnson and Igl 2001, Bakker et al. 2002, Davis 2004, Winter et al. 2006). Savannah Sparrows are a good example. Peterjohn (2006) lists the average territory size for this species as 1.0 – 1.25 ha with the caveat that areas vary widely by region. Vesper Sparrows require a mean territory size of 2 – 3.5 ha; grasshopper sparrow territories average approximately 0.8 – 1.4 ha, although some as small as 0.2 – 0.3 ha have been reported from Pennsylvania (Peterjohn 2006).

It is also important to define 'contiguous' habitat with respect to perceived barriers for the three passerine species noted for ALPO's grasslands. Solid treelines and narrow wooded fencerows represent habitat boundaries for Vesper, Savannah, and Grasshopper Sparrows, whereas minimum-maintenance roads with grassy borders do not (Bakker et al. 2002). These barriers must be taken into consideration when determining areas of contiguous grassland habitats.

Although size is important, in many cases the shape of the patch, particularly the ratio of edge to interior habitat, is a better predictor of area sensitivity than patch size (Johnson and Igl 2001, Davis 2004). Simple shapes (e.g., circles) contain more interior habitat, whereas small, narrow patches contain more edge habitat where predation and nest parasitism are more likely to occur. Isolation of these patches from similar habitats inhibits dispersal (Johnson and Igl 2001). These can have serious effects on the reproductive success and survival of particular species. In addition, local vegetation structure and landscape attributes (e.g., agricultural matrix vs. forested matrix) can also affect habitat selection and suitability (Bakker et al. 2002, Winter et al. 2006, Ribic et al. 2009).

Warm-season grasses provide some advantages over cool-season grasses, including (1) primarily native species in Mid-Atlantic Region, whereas cool-season grasses are primarily nonnative species; (2) preferred timing of hay removal does not interfere with initial nesting attempts; and (3) provide greater habitat complexity (Peterjohn 2006). However, certain species of grassland birds either do no exhibit a preference or are significantly more abundant in cool-season grass habitats (Walk and Warner 2000, Scott and Lima 2004). Managing for both grassland types may provide the greatest habitat diversity for grassland birds; however, this applies to extensive grasslands. Contiguous habitats less than 100 ha should manage for only one habitat type and a subset of grassland birds (Vickery et al. 1999, Peterjohn 2006).

Periodic management through mowing and/or fire is necessary to eliminate the growth of woody vegetation and maintain grassland cover; however, mowing during the breeding season renders a habitat unsuitable for nesting (Wilson and Brittingham 2012). Mowing can have disastrous effects on grassland bird species that typically have not evolved avoidance strategies but rather simply stay still and end up getting mowed over. In fact, repeated mowing and mowing during breeding season are among the most important factors contributing to the decline of grassland birds in recent decades (Peterjohn 2006). Reduced nesting success results in overall population declines with some species disappearing completely from regularly mowed fields (Helzer and Jelinski 1999, Askins et al. 2007). Recommendations for mowing management regimes include (1) $\leq$ 1 mowing per year after the breeding season (2-4 years ideally); and (2) haying to prevent the buildup of litter in disturbed and immature grassland habitats.

Methods

We developed an ecological model from Peterjohn (2006) to summarize the evaluation of ALPO's grassland habitats (Figure 50). This model incorporates two different components, each operating at a different scale. The first represents the local or habitat scale and evaluates the suitability of the habitat with respect to site-specific factors controlled through management activities. The second represents the landscape scale and evaluates the suitability of the habitat with respect to the surrounding landscape or matrix within which the habitat patch is located, and, thus, allows one to ascertain the value of managing the patch as grassland.

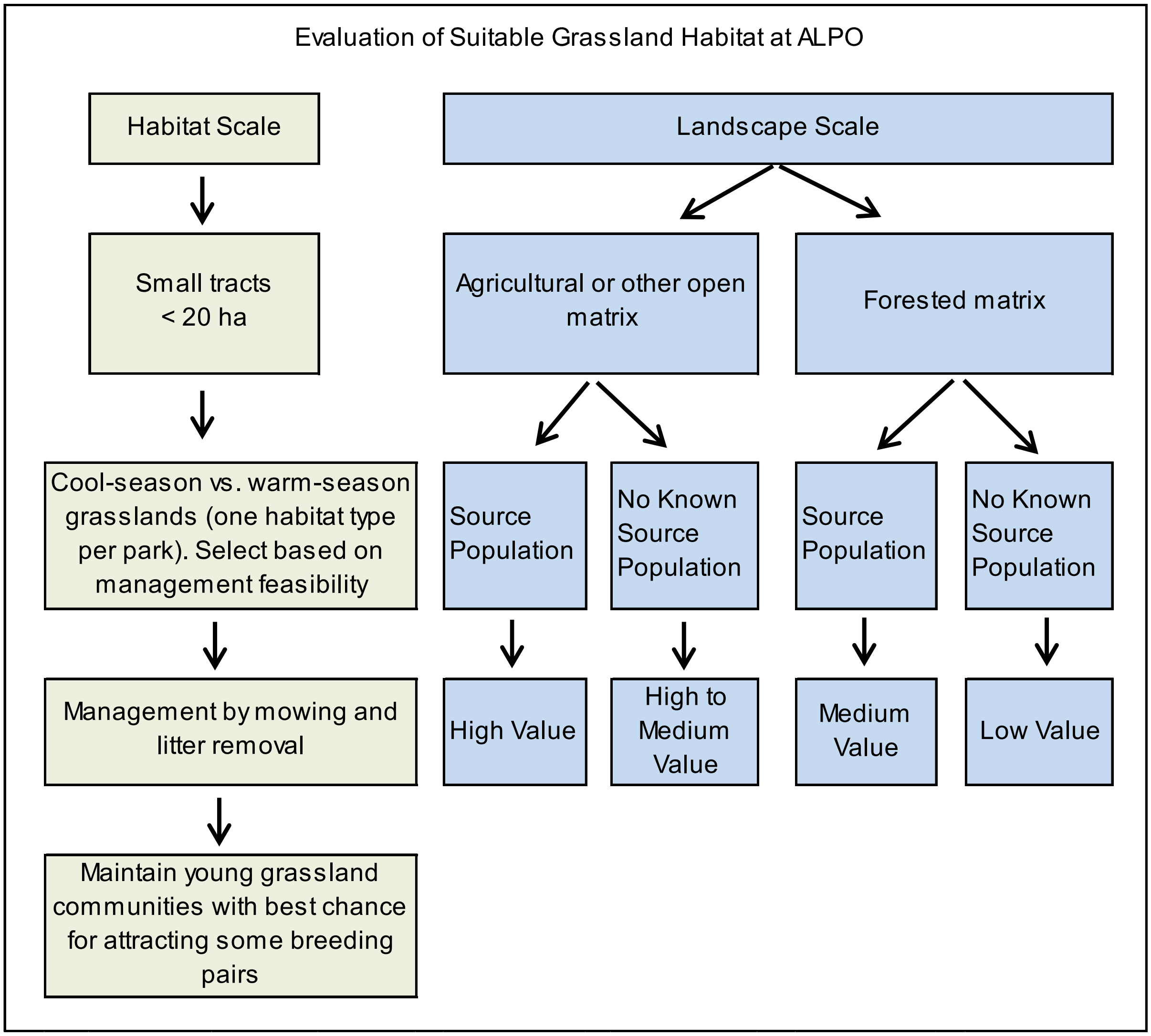


Figure 50. Ecological model for evaluating suitable grassland habitat at ALPO (adapted from Peterjohn 2006).

ALPO has small tracts (<20ha), which lie within a forested matrix. The nearest known occurrences of grassland bird species (state game lands 184 north of the park and agricultural fields surrounding Martinsburg, PA located southeast of the park) are both ~18 miles away. This suggests ALPO's grasslands would have limited potential for supporting breeding grassland bird populations. However, proper management could provide habitat for potential sink or pseudo-sink populations capable of supporting a few breeding pairs. The small patch size necessitates managing for one habitat type (cool-season or warm-season grasses), and management activities to maintain young grassland habitat should include infrequent mowing and litter removal (Figure 50). We did not have sufficient information to conduct a trend analysis.

We used the ALPO vegetation map from Perles et al. (2007) to identify grassland polygons. This geospatial database provides local park-specific names for vegetation types, as well as crosswalks to the National Vegetation Classification System (NVCS), including association, alliance and formation level attributes. We considered polygons assigned the formation name of ‘medium-tall sod temperate or subpolar grassland’ to be grassland patches. Mosaics of this formation were also mapped, as well as wetland areas; however neither was considered as grassland habitat. Wetland areas falling within grassland areas were not used in determining patch boundaries but were subtracted before calculating patch areas. To determine potential grassland habitat among the selected polygons, we considered several criteria (Table 39). These criteria originated from discussions with ALPO’s Natural Resource Manager and from Hill (2012) and were determined from a combination of geospatial data calculations and confirmed with aerial photographs.

Table 39. Criteria used to select areas of potential grassland habitat at ALPO.

Criteria for inclusion as potential grassland habitat (must meet all five)	
1.	Formation classified as medium-tall sod temperate or subpolar grassland (No mosaics)
2.	$\geq$5 ha or two or more adjacent polygons whose sum is $\geq$ 5 ha.
3.	No exclusive pipeline corridors (these do not provide grassland habitat); patches with linear pipelines running through them may be ok.
4.	Small perimeter to area ratio (< 0.141)
5.	< 14.67 woody plants in 400 m^2 area.

Of the total area in the park classified as grassland formation, only 17.2 ha (44.3 ac) qualified as potential grassland habitat. This represents only 3.4% of the total land area of the park (Main Unit + SBTU). This entire habitat was located within the Main Unit’s Summit Area and was represented by four contiguous patches (Figure 51). Patches A and B occur within mowed areas of the Summit Historical Core and are separated by a tree line along the railroad trace; Patches C and D occur on the other side of Rt. 22 and are separated by a small stream. While patches C and D do not appear to provide habitat for grassland birds, they met the criteria established in Table 39 (it is unclear whether or not the small stream channel represents a barrier between these habitat patches). Therefore, we included these patches in the condition assessment with the understanding that, given appropriate management actions, they could potentially offer grassland habitat in the future.

Reference Condition

Park data were compiled for patch size, complexity, and mowplans. From this information we computed metrics for minimum field size, perimeter:area ratio (P:A), and mowplans. We do not have vegetation data for these grassland plots; therefore, we could not use the floristic quality assessment (FQA) as a metric. Because of recommendation by Peterjohn (2006) to manage for only one habitat type and because of documented difficulties in converting certain grassland areas into warm-season grasses (Kathy Penrod, pers. comm.), we did not include the warm-season grasses as a metric for this particular park. Table 40 lists the metrics used for determining grassland condition, their scoring criteria, condition categories, and a brief description of how each was calculated. Perimeter:area ratio (P:A) is a simple measure of shape complexity. Reference P:A was calculated as the P:A of a circle of the same area as the polygon. One problem with this metric is that it varies with the size of the patch (i.e., a larger patch will have a decrease in the P:A than a smaller patch of the same shape). However, since the area was kept constant when comparing reference to observed patch perimeters, this should not be an issue with this metric. With respect to management for grassland maintenance, we considered reference condition to be mowplan 1 (low frequency mowing in September/October) in conjunction with haying to prevent the buildup of plant biomass. We did not consider prescribed burning, because burning for ALPO, because the grasslands are predominately cool season grasses. The preferred management technique for warm season grasses is prescribed burning and the preferred management technique for cool season grasses is haying or mowing. While conversion of cool season grasses to warm season grasses is possible at ALPO, it would likely require plowing and planting to achieve success. No-till seed drills have been used to overseed some fields at ALPO with warm season grasses and wildflowers but those attempts met with limited success. Cultural landscape management places some constraints on the natural resource management of grasslands at ALPO. Because some grasslands are archaeological sites, plowing is discouraged. Additionally, the park's cultural landscape evaluation calls for contrasting fields, to give the appearance of hayfields and wildflower meadows and re-create the historic scene of the mid-1800's.

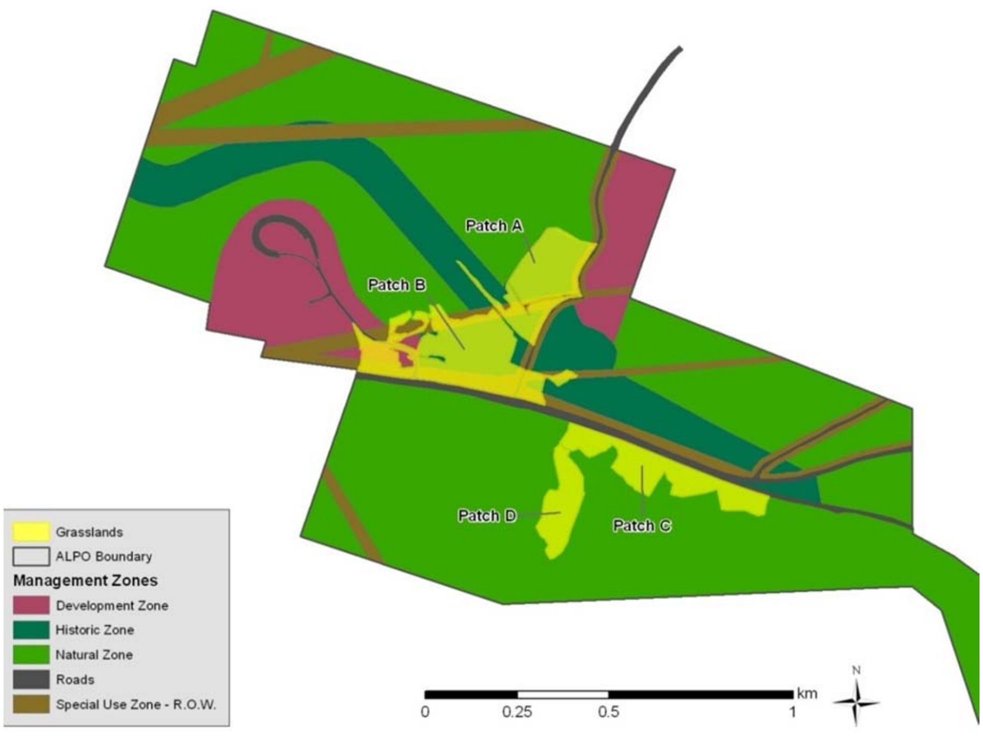


Figure 51. Location of potential grassland areas (yellow) at ALPO's Summit Unit. Note that the majority of grassland habitat is located in the historic management zone.

Table 40. Descriptions of metrics and scoring criteria used to determine the condition of ALPO's grasslands.

Metric	Scoring Criteria	Condition Category	Description
Minimum Field Size	> 10 ha	Good Condition	Calculated as size of contiguous habitat
	4.9 - 10 ha	Moderate Concern	
	> 4.9 ha	Significant Concern	
Perimter:Area Ratio	>66	Good Condition	Calculated as the ratio of (Reference P:A /Actual P:A)*100
	33 - 66	Moderate Concern	
	< 33	Significant Concern	
Mowplans	(1) Mow Sept/Oct	Good Condition	Rate as % of potential grassland habitats in each of these categories
	(2) Mow before July 4 & in Sept/Oct	Moderate Concern	
	(3) Mow before June 19, July 17, Aug 21, & Sept 18 Or No Management Plan	Significant Concern	
FQI Score	35 - 52	Good Condition	
	18 - 34	Moderate Concern	
	0 - 17	Significant Concern	

Current Condition and Trends

Seventy-five percent of the potential grassland area evaluated (three of four patches) was rated as 'significant concern' for the minimum field size metric (Table 41). Only Patch B was greater than 5 ha, although Patch A was close (4.29 ha). Patches C and D were very small and were only considered as potential grassland patches due to their proximity to one another and the fact that their combined area was greater than 5 ha. Although small field size appears to be a major limiting factor for ALPO grassland habitats, the P:A metric for these patches scored higher (3 patches = caution; 1 patch = good condition) (Table 42). The majority of ALPO's potential grassland habitat (60%) is currently being managed under mowplan 1 and was considered to be in good condition (Table 43). The 1939 land use map suggests that Patches C and D historically offered better habitat for grassland birds, either as farmland or some other type of open field habitat (Figure 49a). Current aerial views show woody vegetation is encroaching and becoming established within these patches, both of which are classified as 'no management'. These combined areas represent 33% of the potential grassland area and have been assigned a condition category of 'significant concern' (Table 43). It is up to park staff to determine whether or not Patches C and D could or should be managed as potential grassland habitat.

Table 41. Minimum field size metric results and condition categories for ALPO potential grassland habitats.

MINIMUM FIELD SIZE			
PATCH ID	Field Size (ha)	Condition Category	Condition Symbol
A	4.29	Significant Concern	
B	7.72	Moderate Concern	
C	3.85	Significant Concern	
D	2.09	Significant Concern	
Summit	25%	Moderate Concern	
	75%	Significant Concern	

Table 42. Perimeter:Area metric results and condition categories for ALPO potential grassland habitats.

PERIMETER:AREA RATIO			
PATCH ID	Condition Score (0-100 scale)	Condition Category	Condition Symbol
A	56.5	Moderate Concern	
B	49.1	Moderate Concern	
C	45.5	Moderate Concern	
D	68.0	Good	
Summit	52.8	Moderate Concern	

Table 43. Mowplan metric results and condition categories for ALPO potential grassland habitats.

MOWPLANS			
% Potential Grassland Area	60% Mowplan 1	Good Condition	
	7% Mowplan 2	Moderate Concern	
	33% No Management	Significant Concern	

Data Gaps and Level of Confidence

Confidence in this assessment is *medium*, primarily due to the lack of breeding grassland bird studies in and around ALPO. However, considerable research has been conducted with respect to minimum field size requirements, area sensitivity, and mowing impacts on specific grassland species, including Vesper, Savannah, and Grasshopper Sparrows. Thus, we rated our confidence in this assessment as *medium*.

Source of Expertise

Matt Marshall, Eastern Rivers and Mountains Network Program Manager, National Park Service and Adjunct Assistant Professor of Wildlife Conservation, Pennsylvania State University.

Kathy Penrod, Natural Resource Manager, Allegheny Portage Railroad National Historic Site

Jason Hill, Post-Doctoral Researcher, PA Cooperative Fish and Wildlife Research Unit

Glenn Stauffer, Post-Doctoral Researcher, PA Cooperative Fish and Wildlife Research Unit

4.4.3 Wetlands

Relevance and Context

Non-tidal wetlands are common along rivers and streams (e.g., floodplains and riparian seeps), in isolated depressions surrounded by dry land (e.g., vernal ponds), along the margins of lakes and ponds, and in other low-lying areas where either shallow groundwater or surface water sufficiently saturate the soil long enough to support specially adapted plants and develop hydric soil (USEPA 2012b). While overlooked by many, wetlands provide many ecosystem services, ranging from flood protection during storm surges, stream and river channel stabilization, carbon sequestration, endangered species habitat, and maintenance of biodiversity. In 1977, President Carter issued Executive Order 11990: "Protection of Wetlands" (42 Federal Register 26961) to avoid, to the greatest extent possible adverse impacts to wetland habitats within NPS managed lands. In addition to this executive order any NPS activities that involve the discharge of dredged or fill material into wetlands or other "waters of the United States" must also comply with Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act (33 CFR 320-331). Thus, management of wetlands is important from both an ecological and regulatory standpoint.

ALPO is predominately forested with over one-half of the park characterized as Allegheny Hardwood Forest (52%) and an additional 17% as Northern Hardwood Forest (Perles et al. 2007). Interspersed with these natural areas are conifer plantations, old fields and successional forests - the result of previous disturbances that removed the forested land cover. Wetlands are found predominantly in these remaining natural areas and include floodplain forest, alder shrubland, grassland and open meadow habitats associated with rivers, streams, and other smaller drainages. Comprehensive, park-wide wetland studies are lacking for ALPO; however, we were able to compile information on the park's wetlands from vegetation surveys, monitoring data, and wetland inventory maps and delineations. These are briefly described below. The vegetation surveys described wetland types as associations, while the wetland delineations use the Cowardin classification (Cowardin et al. 1979).

Over the past 25 years, there have been six vegetation surveys within the Allegheny Portage Railroad National Historic site. Three of these surveys have studied and classified wetlands as a component of a broader vegetation survey/classification study: Grund and Bier (2000), Western Pennsylvania Conservancy (2003), and Perles et al. (2007). Grund and Bier (2000) provide a brief description of wetlands within the park, as well as an inventory of species observed in these areas during their survey of species of special concern. The 2003 Western Pennsylvania Conservancy survey identified two distinct wetland communities, Bluejoint-Reed Canary Grass Marsh and Wet Meadow providing a qualitative description of each type, its distribution within the park, and a species list.

In 2005, Perles et al. (2007) collected plot data and devised 16 vegetation associations including five wetland associations. Detailed information was provided for each association including distribution within the park, environmental characteristics, and species composition. The five wetland types classified by Perles et al. (2007) are: Alder River Shrubland, Japanese of or Giant Knotweed Herbaceous Vegetation, Reed Canary Grass Riverland Riverine Grassland, Sugar Maple Floodplain Forest, and Wet Meadow. Alder River Shrubland and Knotweed Herbaceous Vegetation associations are found within the Staple Bend Tunnel Unit, while the remainder is found within ALPO Main Unit. These associations are described briefly below. Additional information on each association can be found in Perles et al. (2007).

Alder River Shrublands form dense stands on sand and gravel bars adjacent to or within active stream channels. Dominated by European alder (*Alnus glutinosa*), these areas also support silky dogwood (*Cornus amomum*) and spiraea (*Spiraea* spp.). The herbaceous Wetland herbaceous species are also prevalent including jewelweed (*Impatiens capensis*), shallow sedge (*Carex lurida*), reed canary grass (*Phalaris arundinacea*), common boneset (*Eupatorium perfoliatum*), mannagrasses (*Glyceria* spp.), Virginia water horehound (*Lycopus virginicus*), sensitive fern (*Onoclea sensibilis*), and roundleaf goldenrod (*Solidago patula*). Japanese knotweed (*Polygonum cuspidatum*) and Japanese stilt grass (*Microstegium vimineum*), both highly invasive, non-native species can be abundant in this association.

Japanese or Giant Knotweed Herbaceous Vegetation association is found along the shoreline of the Little Conemaugh River and also along embankments, ditches or rights-of-way adjacent to highways, roads, or railroads within the Staple Bend Tunnel Unit. The association is dominated by the invasive species Japanese knotweed (*Polygonum cuspidatum*), giant knotweed (*Polygonum sachalinense*), or a hybrid of the two. It may also support staghorn sumac (*Rhus hirta*), wingstem (*Verbesina alternifolia*), white snakeroot (*Ageratina altissima* var. *altissima*), wrinkleleaf goldenrod (*Solidago rugosa*), jewelweed (*Impatiens* spp.), trumpetweed (*Eupatorium fistulosum*), and other knotweeds (*Polygonum* spp.). Invasive species are also present in this association including tree of heaven (*Ailanthus altissima*), Morrow's honeysuckle (*Lonicera morrowii*), garlic mustard (*Alliaria petiolata*), spotted knapweed (*Centaurea biebersteinii*), and Japanese stilt grass (*Microstegium vimineum*).

Reed Canary Grass Riverland Riverine Grasslands occur in poorly-drained creeks and drainageways with flooded to saturated soils. These areas are dominated by reed canary grass, but also support a mix of other herbaceous and graminoid species including knotweeds (*Polygonum* spp.), jewelweed, thoroughworts (*Eupatorium* spp.), cutgrasses (*Leersia* spp.), Canadian clearweed (*Pilea pumila*), smallspike false nettle (*Boehmeria cylindrica*), and wingstem. Willows (*Salix* spp.) or dogwoods (*Cornus* spp.) are also scattered throughout this association.

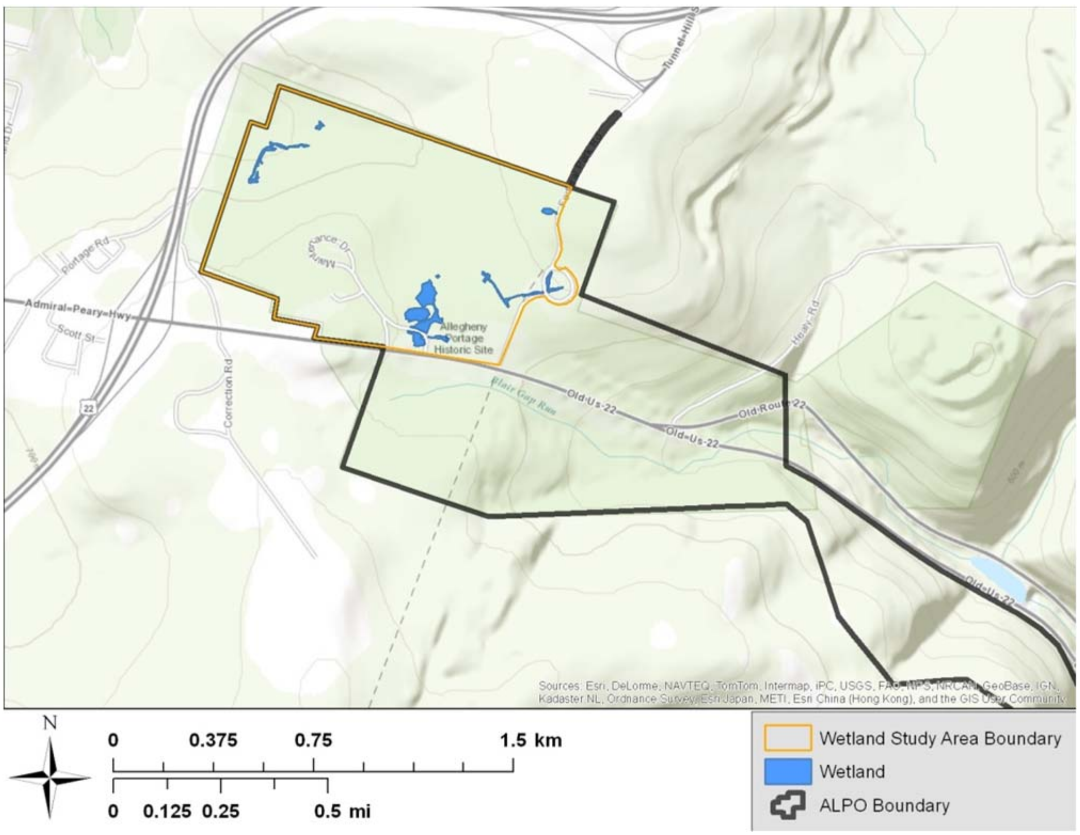
Sugar Maple Floodplain Forests are found along creeks and drainages within ALPO and are subject to periodic, brief overbank flooding. Dominated by sugar maple (*Acer saccharum*), these areas also support red maple (*Acer rubrum*), black cherry (*Prunus serotina*) and blackgum (*Nyssa sylvatica*) as common canopy associates. The subcanopy is comprised of smaller trees and shrubs including American hornbeam (*Carpinus caroliniana*), American witch-hazel (*Hamamelis virginiana*), eastern hop-hornbeam (*Ostrya virginiana*), northern spicebush (*Lindera benzoin*), striped maple (*Acer pensylvanicum*), and seedlings of white ash (*Fraxinus americana*). Japanese barberry (*Berberis thunbergii*) and multiflora rose, both invasive non-native shrubs are often present in this association. The herbaceous layer is generally sparse and populated with typical forest species including white wood aster (*Eurybia divaricata*), New York fern (*Thelypteris noveboracensis*), sessileleaf bellwort (*Uvularia sessilifolia*), and violets (*Viola blanda, Viola cucullata*).

The ***Wet Meadow*** association occurs in swales and along streams and drainages in the main portion of ALPO. Although dry for much of the year, these areas typically flood early in the growing season and may remain saturated to near the surface for extended periods of time. Wet Meadows support a mixture of predominantly graminoid species including rice cutgrass (*Leersia oryzoides*), broom sedge (*Carex scoparia*), shallow sedge (*Carex lurida*), reed canary grass, redtop (*Agrostis gigantea*), jewelweed (*Impatiens capensis*), common rush (*Juncus effusus*), sensitive fern (*Onoclea sensibilis*), arrowleaf tearthumb (*Polygonum sagittatum*), halberdleaf tearthumb (*Polygonum arifolium*), spikerush (*Eleocharis* sp.), rushes (*Juncus* spp.) and fowl mannagrass (*Glyceria striata*). Sphagnum (*Sphagnum* sp.) may also be abundant in this association.

Where flooding is less frequent or soils less saturated, old field species predominate including bentgrasses (*Agrostis* spp.), goldenrods (*Solidago* spp.), flat-top goldentop (*Euthamia graminifolia*), and sweet vernalgrass (*Anthoxanthum odoratum*). These areas also support dogwood (*Cornus* sp.), bristly dewberry (*Rubus hispidus*), and the invasive species multiflora rose.

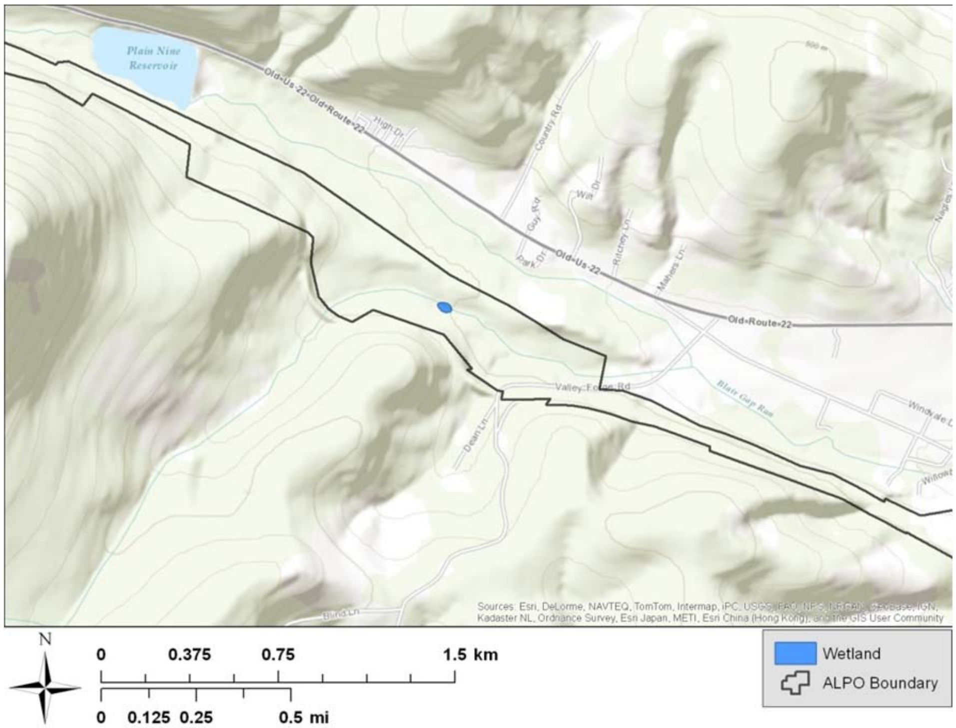
Wetland inventory sources included the National Wetlands Inventory (USFWS-NWI) and a wetland delineation conducted at the Summit area in 2012 (Sharpe et al. 2012). This latter study delineated seven wetlands and five groundwater seeps encompassing 4.43 acres within the Summit Area of ALPO's Main Unit. They provided detailed information on hydrology, soils, and plants within each wetland, as well as mapped wetland boundaries. Wetlands 1 through 4 were located in the eastern portion near the Visitors Center and the Lemon House. All were classified as either PEM1B (palustrine, emergent, persistent, saturated community) or PEM1C (palustrine, emergent, persistent, seasonally flooded community). Wetland 5 was located north of the Visitors Center and of apparent anthropogenic origin and was classified as PFO1C (palustrine forested, broad-leaved deciduous, seasonally flooded community). Wetlands 6 and 7 were located in a powerline right-of-way and classified as PEM1J (palustrine, emergent, persistent, intermittently flooded community). Five groundwater seeps and their associated waterways were also observed and mapped; all occurred near and contribute to wetland 6. Wetlands 1, 3, 4, 6, and 7 all displayed direct surface water connectivity to unnamed tributaries to Bradley Run (Sharpe et al. 2012).

Figure 52 (a–c) shows wetland habitats in ALPO's Main Unit and Staple Bend Tunnel Unit (SBTU). For the Summit portion of the ALPO Main Unit, we used data from 2012 wetland delineation (Sharpe et al. 2012); for all other areas of the park, we used mapped polygons from National Wetlands Inventory (USFWS-NWI).



a.)

Figure 52. Maps depicting known wetland habitats at ALPO's Summit area (a), Incline 9 (b), and SBTU (c). Wetlands within the yellow border are field delineated while any other wetland polygon shown are generated from USFWS-NWI data.



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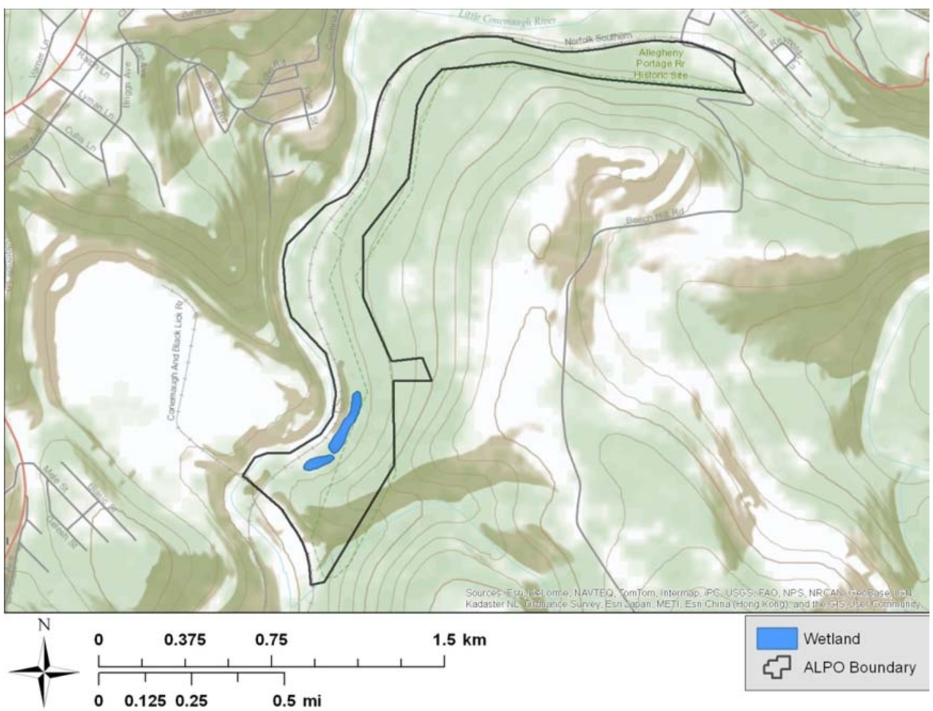


c.)

Figure 52 (cont'd). Maps depicting known wetland habitats at ALPO's Summit area (a), Incline 9 (b), and SBTU (c). Wetlands within the yellow border are field delineated while any other wetland polygon shown are generated from USFWS-NWI data.

Methods

The condition of wetland habitats is primarily reflected through hydrology, soils, and vegetation. In addition, the influence of the surrounding landscape must be considered (i.e., wetland condition must be evaluated within a landscape context). Numerous studies have demonstrated a clear link between a wetland's condition and the condition of the landscape surrounding that wetland, particularly the land use in the hydrologic contributing area to that wetland. The measure most readily impacted by these landscape effects is the vegetation community. Hence, FQA is one of the best measures of describing wetland condition using data collected in the field.

For computational ease, and to include both land cover effects from the contributing area and the surrounding landscape outside that contributing area, landscape analysis is often conducted in a circular plot around the wetland's center point. Brooks et al. (2004) computed landscape condition based on 1 km-radius circles around multiple wetlands in watersheds that varied in land cover in Pennsylvania. Wardrop et al. (2007a, 2007b) related this same landscape approach to condition ranking based on the presence of multiple stressors in wetlands and in a 100-m buffer around each wetland. Moon and Wardrop (2013) describe the method and the relationship between wetland condition and the surrounding landscape in more detail using a case study. The pattern is clear; surrounding land use coupled with observed stressors in and around a wetland are strongly determinant of wetland condition, and the vegetation is a highly responsive parameter to assess.

We evaluated wetland condition by first considering the type of vegetative cover within the wetland and then by considering landscape factors influencing the wetland. Wetland habitats were assessed using FQA; landscape context was assessed with the following metrics: (1) landscape connectivity; (2) buffer index; and (3) surrounding land use index. Because wetland habitats were not sampled during the 2007-2009 ERMN Monitoring survey (Perles et al. 2010), we used the 2005 vegetation classification data (Perles et al. 2007) to calculate floristic quality metrics (Table 48). We used the NWI data to calculate landscape metrics, while condition categories were adapted from Faber-Langendoen (2009) (Table 47). A recent study compared the accuracy of NWI remote sensing estimates of wetland distribution to those of USGS/NPS vegetation mapping (e.g., Perles et al. 2007) for three northeast region national parks, each of which represented three principal NWI wetland mapping scales (1:40,000, 1:58,000, and 1:80,000) (P. Sharpe, pers. communication). Results suggested no significant differences between NWI and vegetation maps at the 1:80,000 scale and NWI as the better source for the other scales. We used NWI mapping rather than the vegetation map from Perles et al. (2007) to calculate the landscape metrics, primarily because we found it easier to focus on the wetland in the NWI map (as opposed to teasing out the wetland vegetation types from the terrestrial vegetation types in the vegetation map).

Wetland Habitat

We used Floristic Quality Assessment (FQA) to assess wetland habitats within ALPO's Main and Staple Bend Tunnel Units. FQA is an assessment method that uses characteristics of the plant community to provide an estimate of condition (Swink and Wilhelm 1979, 1994). The premise of FQA is that individual species have varying tolerances to disturbance, as well as exhibit varying degrees of fidelity to specific habitat types. This tolerance is expressed quantitatively as a *coefficient of conservatism* – a number between 0 and 10 that is subjectively assigned to the flora of a region. In 2009, coefficient values were assigned to the flora of the Mid-Atlantic Region (Chamberlain and Ingram 2012). These values were used to calculate the floristic quality of forested habitats within ALPO

The primary Floristic Quality Assessment metric is the Floristic Quality Index (FQI). The FQI is a metric that uses the mean coefficient value of a plant community to weight species richness. It was originally developed to assess the nativity of natural habitats. We used a modified version of the formula that takes into account non-native species, and thus can be used to assess condition (Miller and Wardrop 2006):

$$I' = \left(\frac{\overline{C} \times}{10 \times} \frac{\sqrt{N}}{\sqrt{N + A}} \right) \times 100$$

where $\overline{C}$ is the average coefficient of conservatism for native species, *N* is native species richness and *A* is the number of non-native species (Miller and Wardrop 2006).

Landscape Context
We did not have site-level data to assess either the buffer or the level and type of stressors surrounding the wetland. Thus, we relied on geospatial information to determine certain metrics (e.g., average buffer width). Landscape connectivity was defined as a measure of the unfragmented landscape and defined by classifying land use types into non-anthropogenic and anthropogenic influences (Faber-Langendoen 2009). We assessed riverine and nonriverine wetlands differently, since the former represent more open systems. For riverine wetlands, the length of the segments upstream and downstream (i.e. the riverine corridor) of the wetland that are adjacent to non-buffer (anthropogenic land cover classification) was summed and used to score the riverine wetlands according to the categories in Table 44. Nonriverine wetlands were scored similarly but for landcover within a 500-m buffer area surrounding the wetland.

Table 44. Classification of natural systems (based on Anderson Level 1 classifications) used to score landscape connectivity metrics for both riverine and nonriverine wetlands.

Non-Anthropogenic	Anthropogenic Influence
10. Water	20. Developed
40. Forest	30. Barren Land
50. Shrubland	60. Non-native Woody
	80. Agriculture

To determine the buffer index, the width of the natural buffer was estimated for each wetland from observations in GIS and then averaged for the group of wetlands in the Main Unit and SBTU, respectively. The surrounding land use index incorporated the rankings shown in Table 45, and the proportion of each land cover class found within entire contributing watershed for both the Main Unit and the SBTU (HUC-8 watershed boundary).

Table 45. Landcover ranking (based on Anderson Level 2 classifications).

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

Reference Condition/Threshold Values Utilized

Wetland Habitat

To determine condition, we used the FQI score and mean C value ($\bar{C}$) calculated for each Wetland Association within the Park. For FQI score, we trisected the data into three condition categories (Table 46a). Condition categories for $\bar{C}$ value were based on the thresholds developed by Faber-Langendoen (2009). For the purpose of this report, the good (3.5-4.5) and excellent (> 4.5) categories of Faber-Langendoen (2009) were combined into a single *good* category (Table 46b).

Table 46. Condition categories for Wetland Associations based on FQI score (a.) and based on $\overline{C}$ value (b.).

FQI Score	Condition	Symbol
30 - 41	*Good*	
15 - 29	*Moderate Concern*	
0 - 14	*Significant Concern*	

a.)

$\overline{C}$	Condition	Symbol
> 3.5	*Good*	
3.0 - 3.5	*Moderate Concern*	
< 3.0	*Significant Concern*	

b.)

Landscape Context

Table 47. Condition categories for landscape context metrics (adapted from Faber-Langendoen 2009).

METRIC	**CONDITION RATING**		
	Good	**Caution**	**Significant Concern**
Landscape Connectivity			
Riverine	Combined length of all non-buffer segments is between 00m and 800m for '2-sided' sites; between 0 m and 400 m for '1-sided' sites.	Combined length of all non-buffer segments is between 800 and 1800 m for '2-sided' sites; between 400 and 900 m for '1-sided' sites.	Combined length of all non-buffer segments is > 1800 m for '2-sided' sites; > 900 m for '1-sided' sites.
Non-riverine	Embedded in 60-100% natural habitat	Embedded in 20-60% natural habitat	Embedded in < 20% natural habitat
Buffer Index			
Length	Buffer is >50 - 100% of occurrence perimeter	Buffer is 25 - 49% of occurrence perimeter	Buffer is < 25% occurrence perimeter
Width	Average buffer width of occurrence is > 100 m, after adjusting for slope	Average buffer width is 50 - 99m, after adjusting for slope	Average buffer width (m) is, after adjusting for slope. D:10-49; E: <10m
Surrounding Land Use Index	Average Land Use Score = 0.80 - 1.0	Average Land Use Score = 0.4 - 0.80	Average Land Use Score < 0.4

Condition and Trends

Wetland Habitat

Adjusted FQI scores and mean C scores were highest in the Sugar Maple Floodplain Forest community (Table 48). Percent non-natives were highest in the Japanese or Giant Knotweed Herbaceous Vegetation communities (Table 48).

Table 48. Floristic Quality Metrics for wetland associations within ALPO Main and the Staple Bend Tunnel Unit (Perles et al. 2007).

Metric	Alder River Shrubland	Japanese or Giant Knotweed Herbaceous Vegetation	Reed Canary Grass Riverland Grassland	Sugar Maple Floodplain Forest	Wet Meadow
Adj FQI	24	14	15	41	25
Mean C	3	2	2	4	3
% Non-Native	20	33.3	0	8.8	25

Wetlands in the main portion of ALPO range from *moderate concern* to *good* condition based on FQI score and *significant concern* to *good* based on $\bar{C}$ value (Table 49a). Two associations, the Reed Canary Grass Riverland Grassland and Wet Meadow were scored as *moderate-significant concern* and *moderate concern*, respectively. Both support reed canary grass, a native invasive species that opportunistically establishes in wet areas. Dense cover of existing vegetation may slow or prohibit the spread of reed canary grass; however, disturbances such as flood scouring that provide bare sediment will likely promote the expansion of this aggressive colonial grass (Kercher et al. 2007). Therefore, it is likely that wetland condition will diminish without further control measures.

The Sugar Maple Floodplain Forest was ranked in *good* condition for both metrics. This association contains many native species that are important elements of eastern forests including black cherry, blackgum, American hornbeam, American witch-hazel, eastern hop-hornbeam, northern spicebush, white ash, white wood aster, New York fern, sessileleaf bellwort and violets. However, this association also supports four target invasive species: garlic mustard, Japanese barberry, Japanese stiltgrass, and multiflora rose. These species pose a threat to habitat condition and their control should be included in any invasive species management plan (see Section 4.5.7 Non-native Invasive Plants for additional information on these species and their impacts to park habitats).

Wetlands in the SBTU ranged from *moderate* to *significant concern* (Table 49b). The Alder Shrubland association is ranked as moderate concern by both metrics. This association is dominated by the non-native European alder, a listed invasive on the PA DCNR's Exotic Plant Tutorial for Natural Lands Managers (PA DCNR 2005b; http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm). European alder forms monospecific stands in wetlands outcompeting native vegetation. It disperses readily by water and as a nitrogen fixer, can establish on poor soils, facilitating its ability to invade wetland sites. Its presence in wetlands in ALPO not only diminishes the condition of the wetlands where it is established, but also serves as a source of seed for future invasions.

The Japanese or Giant Knotweed Herbaceous Vegetation association ranked as a significant concern for both metrics. This association is virtually a monoculture of knotweed with few sub-dominates, namely staghorn sumac and wingstem. Tree-of-Heaven and Morrow's honeysuckle, two highly invasive species, are also present. The colonization of multiple non-native invasive species has substantially diminished floristic quality in these areas of the park. Because the spread of knotweed to new sites is facilitated by disturbance (Beerling 1991), these areas will likely maintain their current level of condition as long as existing vegetation remains intact. However, processes such as flood scour that remove vegetation and create bare ground will likely promote the expansion of this species, diminishing habitat quality. For this reason, control measures should be initiated to prevent the further spread of knotweed in wetlands within ALPO.

Table 49. a) Condition Assessment Metrics for ALPO Main Wetland Associations and b) Condition Assessment Metrics for the SBTU Wetland Associations.

ALPO Main Unit Metrics	Reed Canary Grass Riverland Grassland	Sugar Maple Floodplain Forest	Wet Meadow
FQI Score	🟡	🟢	🟡
Mean C	🔴	🟢	🟡

a)

Staple Bend Unit Metrics	Alder Shrubland	Giant Knotweed Herbaceous Vegetation
FQI Score	🟡	🔴
Mean C	🟡	🔴

b)

Landscape Context

In the eastern U.S., when the predominant landscape around wetlands shifts from forest (or natural wetland) cover, there are likely to be negative impacts to multiple parameters in wetlands, of which the vegetation community is one. Although the cause and effect mechanism is not fully understood, it appears that such changes in land use allow invasion by aggressive native species, such as *Phalaris*, as well as exotic plant species. This governs the land cover ranking of the NLCD/Vegetation classes from a high human disturbance level of 1.0 for developed, high intensity, declining through lower levels in development, crops, and pasture (Table 45). The more natural land cover types, such as forest and wetland, are assumed to have negligible negative impacts, and thus, are scored as zero. The increasing appearance of invasive species can be seen in the knotweed and reed canarygrass wetland types described by Perles et al. (2007), and are, therefore, reflected in the Adj. FQA score (higher for more natural communities, Table 46), and to some extent in the lower $\bar{C}$ value scores for those two communities. The other more natural wetland types, Alder, Sugar Maple, and Wet Meadow have scores suggesting a higher condition.

For the reasons addressed above, the condition of wetlands in the main portion of ALPO is lowest in the reed canarygrass type. For the SBTU, similarly, the knotweed type is ranked as having the lowest condition. Neither type is likely to show any improvement in condition without aggressive and persistent management. In addition, the significant presence of these invasive and exotic species exposes wetlands that are currently ranked in higher condition to colonization by these undesirable species in the future.

When comparing the wetland metrics to the landscape metrics, one can see that the surrounding landscape does contain significant proportions of forest and forest connectivity. However, the land cover tends to shift away from forest closer to the wetlands, in the immediate buffer. This is commonly seen, in that as one takes a closer look from a landscape perspective, down to buffer, and then site-specific, the ecological condition tends to worsen (Table 50).

Table 50. Condition results for ALPO wetlands within a landscape context.

METRIC		CONDITION RATING				
		MAIN UNIT				SBTU
		Summit	Incline 8	Incline 9	Foot of Ten	
Landscape Connectivity	Non-Riverine	Green				
	Riverine	Green		Green		Green
Buffer Index	Length	Yellow		Red		Green
	Width	Yellow		Red		Yellow
Surrounding Land Use		Green		Green		Green

Data Gaps and Confidence in the Assessment

The confidence in this assessment is *low*. The Perles et al. (2007) survey was the only study to formally sample wetlands. Our assessment, therefore, is based on a single point in time, providing minimal information on condition and precluding an analysis of trends due to a lack of sufficient time series data. In order to draw conclusions on the condition of wetlands in ALPO in the future, these associations should be added to the current Vital Signs multi-year monitoring effort.

Although FQI score and $\overline{C}$ value scored most wetland associations similarly, $\overline{C}$ appeared to be a more accurate indicator of condition for wetlands. Thresholds for FQI scores were developed by trisecting the range of scores, while according to Faber-Langendoen (2009) thresholds for $\overline{C}$ values were based on studies in Midwest habitats by Wilhelm and Masters (1995). Mean C scores ranked the Reed Canary Grass Riverland Grassland association as a significant concern. This appears to be a more accurate assessment of condition as this native grass aggressively invades wetlands and its presence within ALPO not only diminishes *in situ* wetland condition but also poses a threat to other wetlands within the park.

Sources of Expertise

Robert Brooks, Certified Professional Wetland Scientist and Professor of Geography and Ecology, Department of Geography, Pennsylvania State University

Peter Sharpe, Wetland Scientist, Northeast Region, National Park Service

4.5 Biological Integrity

4.5.1 Species of Concern

Relevance and Context

A continued concern with Park Service units is the conservation and management of species that have been given special status (vulnerable, rare, threatened, or endangered) by state or federal agencies. Species of special concern are often species with restricted habitat availability, limited population size, or species of ecological significance. Given their rarity on the landscape, these species are often the primary focus of monitoring efforts, habitat restoration and are targeted for evaluated from potential impacts resulting from changes in management within the vicinity of known species of special concern locations. In addition, the park units also maintain a list of species that warrant management concern. ALPO maintains a list of special status and management concern species that include plants, birds, mammals and other taxa. A select subset of the species list was targeted for inventory and monitoring efforts. These species included American bugbane (*Cimicifuga americana*), American ginseng (*Panax quinquefolia*), northern myotis (*Myotis septentrionalis*), and brook trout (*Salvelinus fontinalis*), which represent a combination of species of special concern and species of management concern. The remaining species on the park's list received no additional research or targeted monitoring (e.g., willow aster or northern saw-whet owl). Inventory and monitoring data are used to develop and tailor management strategies specifically for each species to improve habitat and bolster populations within the park. Currently there are no known federally listed threatened or endangered species within the park; however, management actions are coordinated with the appropriate state and federal agencies to ensure cross-boundary communication for special status species.

American Bugbane **–** often grows in areas with a rich hardwood forest component or following mountain streams. It is also found in areas with hemlock and on north-facing slopes and wooded corridors. Its range is restricted to central Appalachians, from Pennsylvania to Georgia and west to Illinois. American bugbane is a Pennsylvania state threatened (S3) plant species and is primarily imperiled due to habitat loss through development and forest harvesting pressure. It may also be mistakenly harvested as it is similar to the highly sought-after black bugbane which is used as a medicinal herb.

American Ginseng **–** is an herbaceous plant native to North America that grows in cool, shady wooded areas in Pennsylvania. Its fleshy tuber-like root is commonly used for medicinal and herbal remedies that have created a rich economic industry in its cultivation and trade. Ginseng is listed in Appendix II of the Conservation on International trade in endangered Species of Wild Fauna and Flora but can be harvested in 19 states including Pennsylvania. The USFWS outlines advice for sustainably harvesting the species within these 19 states. As the species is protected by both the USFWS and DCNR, DCNR regulates the buying, selling, and trading of vulnerable plants in Pennsylvania. This species is listed by the state of Pennsylvania as vulnerable (S3).

Northern Myotis **–** is a small bat species that is associated with forested areas. They often hunt over small bodies of water such as ponds or streams and near forest clearings and edges. Northern myotis, also known as northern long-eared myotis, inhabits caves and mines for winter hibernation and roosts in tree cavities, under exfoliating bark or buildings in the summer. The status of this species is currently listed as candidate rare (CR) in Pennsylvania, but their current population is unknown given the rapid decline in many bat populations due to white-nose syndrome. Recently this species was petitioned to be listed for protection under the Endangered Species Act.

Northern myotis (Myotis septentrionalis). Photo by Josh Johnson

Brook trout (Salvelinus fontinalis). Photo by B. Hollender

Brook Trout – is the only stream trout native to Pennsylvania. This species is found in small, cold, clean streams throughout the state. Wild reproducing populations can be found in Ohio, Susquehanna, Genesee, Potomac, and Delaware River watersheds, with the remaining watersheds stocked with hatchery fish. The introduction of non-native trout species such as rainbow trout and brown trout in addition to land use changes and a reduction in water quality has reduced populations of native brook trout throughout their range. This species does not currently appear on any state or federal protection lists, but was included because of its important social and recreational significance at ALPO.

Method

ALPO commissioned a number of studies targeting species of special concern that are summarized in this report. The Western Pennsylvania Conservancy was retained in 1998 to survey for rare plants within the park which was updated in 2002 and 2009. As an initial phase of the rare plant study, the Western Pennsylvania Conservancy conducted a search of the Pennsylvania Natural Heritage Program (PNHP) database for records of documented occurrences of species of special concern (flora and fauna) within the park. Field surveys were then implemented to confirm known locations of target species and determine if additional populations exist based on potential habitat for these species within the park.

The Pennsylvania Game Commission (PGC) surveyed the Staple Bend Tunnel for winter hibernating bats, including Northern myotis in 1997, 2001, 2005, and 2012. In addition, a more intensive survey of the bat community was conducted in 2004-2005 by Gates and Johnson (2007) focused on gaining basic information on the species distributions and activity of bats within the park.

The Tzilkowski and Sheeder (2006) study surveyed wild trout populations at five sites in Blair Gap Run above the confluence with Blair Run on April 26, 2006. These sites occur in a reach that passes through the Allegheny Portage Railroad NHS. Surveys were completed to determine the upstream extent of brown trout, a non-native trout species that competes with the native brook trout population for food resources and habitat and in the process, confirmed the locations of breeding populations of brook trout.

Reference condition

Due to the limited quantitative data available for species of concern that occur within the boundaries of ALPO, our condition assessment was based on small scale surveys conducted in the park and relied primarily on best professional judgment. Threshold values for American bugbane, American ginseng, or Northern myotis could not be determined given their low population levels and inconsistent identification on site. Additional consideration must be given to Northern Myotis thresholds since the majority of data available was taken prior to the onset of white-nosed syndrome.

Brook trout were assessed using the Pennsylvania Fish and Boat Commission standard for a Class A wild trout fishery. The Pennsylvania Fish and Boat Commission define a stream as a Class A water if the stream supports a population of naturally reproducing trout of sufficient size and abundance to support a long-term and rewarding sport fishery. These streams are therefore not stocked with hatchery fish. Additional details about trout water designations including biomass thresholds can be found in Tzilkowski and Sheeder (2006) or at the Pennsylvania Fish and Boat Commission website.

Current condition and Trends

***American Bugbane* –** The majority of American bugbane populations surveyed actually occur just outside the park property. Four small sub-populations are known to exist beyond the park boundary along the Blair Gap Run floodplain and down-slope of the NPS property (Grund and Bier 2000). The small population near the Blair Gap Run floodplain was surveyed in 1987 by Kunsman, who found a total of 144 plants (34 flowering and 110 immature stems). These population counts were reported in the Grund and Bier report (2000) when the area was resurveyed in 1999. Grund and Beir (2000) state that they found a similar number of plants to the 1987 Kunsman survey. Another small population totaling six stems was discovered near Gallitzin Spring during the surveys in 1999, which at that point was owned by the Altoona Water Authority. However, this property was subsequently acquired and incorporated as NPS lands. The Gallitzin Springs population was revisited during the 2006 survey and found 31 plants (10 flowering and 21 immature). Based on the limited survey data and no established threshold values that warrant immediate restoration action by the NPS, the condition of American bugbane could not be scored (Table 51). Additional monitoring at regular intervals of this species may be warranted to determine a baseline population estimate and to establish threshold values for future condition assessments.

***American Ginseng* –** Several very small populations of ginseng are known to occur within the park. No abundance data are available for these populations other than to say that they exist. Surveys found that ginseng plants occurred in two habitat types within the park, including near sandstone outcrops and rocky slopes associated with small seeps. So few individuals were found at each habitat type that habitat preference and population trends could not be assessed. Based on professional judgment and the susceptibility for ginseng to be over harvested, this species was scored as *moderate concern* given its rarity on the landscape and potential threat from harvest for medicinal purposes (Table 51).

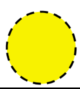
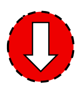
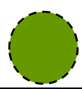
***Northern Myotis* –** Surveys to examine winter hibernating bats in the Staple Bend Tunnel were conducted in 1997, 2001, 2005, and 2012. Bats were identified as present in the tunnel but because the bats were not captured or handled, species identification was provided by experts based on grouping patterns, size and color. Northern myotis were identified as one of the species hibernating in the tunnel during the 1997 survey. However, this species has not been identified in any of the subsequent hibernation surveys conducted by the PGC.

Northern myotis were also confirmed to be present in ALPO during the intensive bat monitoring that included acoustic detection, mist-netting and roost exit surveys conducted in the summer breeding seasons of 2005-2006. There were 13 northern myotis captured in 2005 and only six in 2006 during the mist-netting portion of the study (Gates and Johnson 2006). Northern myotis were detected during acoustic monitoring on site; however population estimates from these data were not included in the Gates and Johnson report (2006). No northern myotis were detected during exit surveys or roost surveys within the park during the summer breeding seasons of 2005-2006 (Gates and Johnson 2006).

The majority of these records occur prior to the widespread decline seen in bat populations throughout the northeast attributed to white-nose syndrome. White-nose syndrome is a disease caused by a fungus originating in Europe that affects hibernating bats and causes them to use all their winter fats stores prematurely. White-nose syndrome has killed more than 5.5 million bats since 2006 when it was discovered in a cave in New York (USFWS 2012). Northern myotis along with several other species have been petitioned for listing under the Endangered Species Act due to the precipitous decline in the bat community. Given the difficulty in monitoring and assessing bat populations quantitatively, this condition assessment was based on professional judgment and the limited data available for the park. The condition assessment for this species was scored as *significant concern* with a *deteriorating* trend based on the overall decline of bat populations in the northeastern US and due to the apparent decline in the number of hibernating northern myotis in the Staple Bend Tunnel (Table 51).

Brook Trout **–** Brook trout were captured at all five sites sampled in Blair Gap Run and had an overall density of 0.102 individuals/m^2 (Tzilkowski and Sheeder 2006). Tzilkowski and Sheeder (2006) suggest that Blair Gap Run supports naturally reproducing populations of brook trout and may meet the Class A wild trout water criteria. Brook trout populations were found to be in *good* condition based on the natural reproduction of the population and the absence of a non-native competitor, the brown trout. No trend data are available for this metric given the single inventory data available from 2006 (Table 51). Additional surveys are warranted to establish a baseline population and trend data for native and non-native fish species

Table 51. Condition Assessment Metrics for ALPO Species of Concern.

Species of Concern			
American Bugbane	American Ginseng	Northern Myotis	Brook Trout
Data Gap			

Data Gaps and Confidence in the Assessment

Special status and management species data were limited for ALPO. Surveys were inconsistently implemented and no long-term monitoring data were available. Single-entry inventory surveys were able to document species present on site for the targeted species; however, a more consistent approach to monitoring would provide stronger data by which to assess the condition and trend of these species. Monitoring surveys should be conducted at regular intervals to establish trend data for species of interest. Confidence in the assessment is *low* based on the limited available data sources, including the facts that most of the data for the northern myotis was collected prior to the white-nose syndrome decline and the brook trout condition was based on a survey conducted eight years ago to establish initial condition.

Source of expertise

Cal Butchkoski, Wildlife Biologist, Pennsylvania Game Commission

Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

4.5.2 Bat Communities

Relevance and Context

Bats are a wonderfully diverse group with more than 1,200 species and represent approximately one-fifth of all mammalian species world-wide (Bat Conservation International 2013). They are also the only mammal to truly fly. Conservation and management strategies often target bat species because of their unique role in the ecosystem and as an indicator species of ecosystem health (Gates and Johnson 2007). Bats are insectivorous, and may consume over half their body weight in insects each night serving as a beneficial predator taking a wide variety of crop and forest pest species (Griffith and Gates 1985; Harvey et al. 1999). Wing shape and echolocation frequency are specially adapted to the type of habitat each bat species uses. Some species such as the big brown bat and hoary bat have low-frequency echolocation calls and are most often found in open areas or above forest canopy (Barclay 1985). Other species are found in the forest interior, such as the myotis group (including the northern myotis and Indiana bat), which use high-frequency echolocation (Kalcounis and Brigham 1995; Owen et al. 2003). Intermediate frequency echolocation used by the silver-haired bat, eastern red bats, or tricolored bat, allows these and other species to utilize both types of habitat.

Little brown myotis (Myotis lucifugus). Photo by Josh Johnson

Pennsylvania is home to 11 species of bats, several of which are protected by state or federal agencies. Bat populations in the northeastern US have declined dramatically in recent years due to white-nose syndrome (WNS) (USFWS 2012). With the rapid spread of WNS and the subsequent decline in many bat populations, conservation of remaining hibernacula have become increasingly important to the survival of these species. The National Park System maintains areas of land that may serve as refugia for these species and aid conservation while unprotected lands become more fragmented and disturbed by land-use change and human activities (Gates and Johnson 2007). Monitoring not only informs species specific management but also aids the conservation of the bat community at a broader geographic scale when information is linked with other parks in the region (Gates and Johnson 2007).

Method

ALPO teamed with the PGC to monitor hibernating bats in the Staple Bend Tunnel in 1997, 2001, 2005, and 2012. The park also commissioned a more in-depth bat community inventory that took place over the 2005 and 2006 summer breeding seasons by Gates and Johnson (2007). The findings of these surveys are summarized in this report.

Big brown bat (Eptisicus fuscus). Photo by Josh Johnson

The Gates and Johnson (2007) study was completed using acoustic detection, mist netting, roost surveys and visual observation techniques. Mist net surveys were completed at 9 sites totaling 102 net nights using single, double and triple high nets typically placed near stream corridors, small pools, hiking trails or service roads (Gates and Johnson 2007) (Figure 53). Acoustic surveys were conducted at 17 sites using the AnaBat II (Titley electronics, Ballina, Australia) for 20 minutes at each site between sunset and 0200 hours (Gates and Johnson 2007). Roost surveys were conducted at buildings identified by the Park Service to house roosting bat colonies. Observers with bat detectors surrounded the building and recorded emerging bats for greater than 30minutes around sunset (Gates and Johnson 2007).

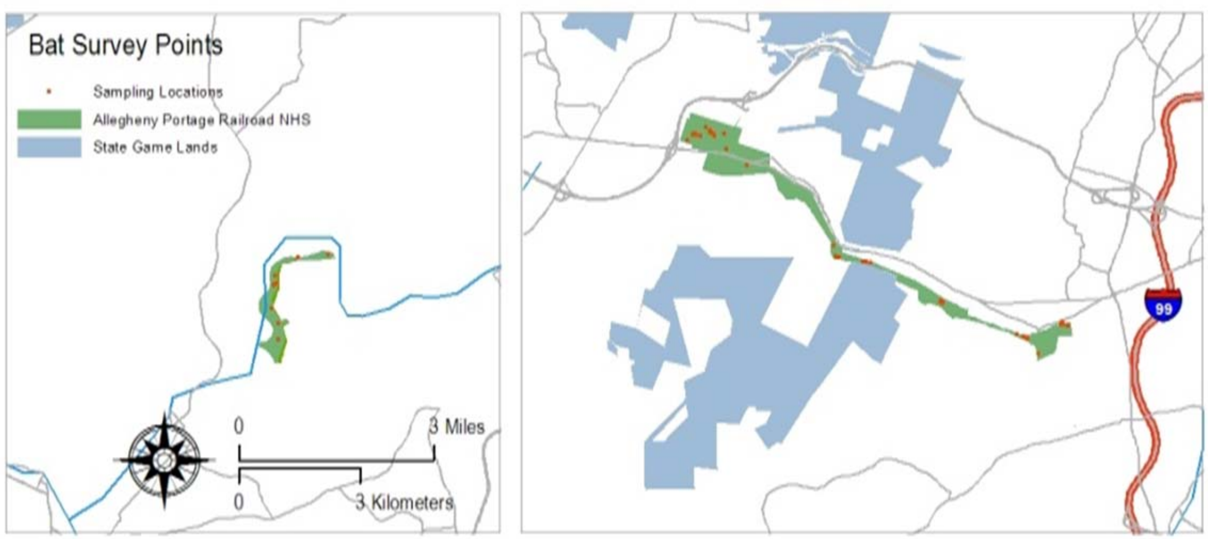


Figure 53. Mist-netting and acoustic detection sites administered to survey the bat community during the Gates and Johnson study in 2005-2006.

All other surveys consisted of visual inspections of the Staple Bend Tunnel for winter hibernating bats by the PGC. The Staple Bend Tunnel was the only location surveyed because it is the most likely location within the park to find cave hibernating bats. No effort to capture or handle bats observed in the Tunnel was made during the winter hibernation period; species identification was made based on size, color and hanging cluster patterns (i.e., bats hanging individually, small groups, etc.). Disturbance by human activity of the hibernating colony was kept at a minimum.

Reference condition

Nine of the eleven documented bat species in Pennsylvania were identified as potentially occurring within the park by the Gates and Johnson study (2007). These species were selected based known habitat requirements or species that commonly occurring in the state during the summer months (Gates and Johnson 2007), and were used as the reference condition for the summer breeding season. While potential species occurrence is often a poor metric by which to measure ecological condition, the lack of data on bat communities precludes the development of a more quantitative metric. The species identified as potentially occurring within ALPO during the summer months, included big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), eastern small-footed bat (*Myotis leibii*), little brown bat (*M. lucifugus*), northern myotis (*M. septentrionalis*), Indiana bat (*M. sodalis*), and tricolored bat (*Perimyotis subflavus*).

Table 52. Condition categories for percentage of bat species confirmed present in the park versus potential species that could occur based on range and known habitat types. Condition classes established are based on professional judgment.

% Species Found	Condition	Symbol
> 75%	Good	(green circle)
50 - 75%	Moderate Concern	(yellow circle)
< 50%	Significant Concern	(red circle)

Current Condition and Trends

The inventory surveys completed by the PGC found an oscillating occurrence of bats hibernating in the Staple Bend Tunnel (Figure 54). In 1997, prior to the presence of white-nose syndrome, PGC found four species of bats present in the tunnel totaling 33 individuals. These species included big brown, northern myotis, little brown, and tricolored bats. In 2001, only 5 individual bats were observed during the survey. While the species identification was not certain, they were likely big brown or tri-colored bats due to the bats hanging individually instead of in clusters. The Staple Bend Tunnel was also opened to hiking and biking traffic later that year. In 2005, no bats were detected in the tunnel by PGC. It was presumed by PGC biologists that the bats had relocated due to the additional human disturbance when the tunnel was reopened to visitor use. The most recent survey in 2012 found the tunnel to be recolonized by big brown bats, with a total of 38 individuals observed.

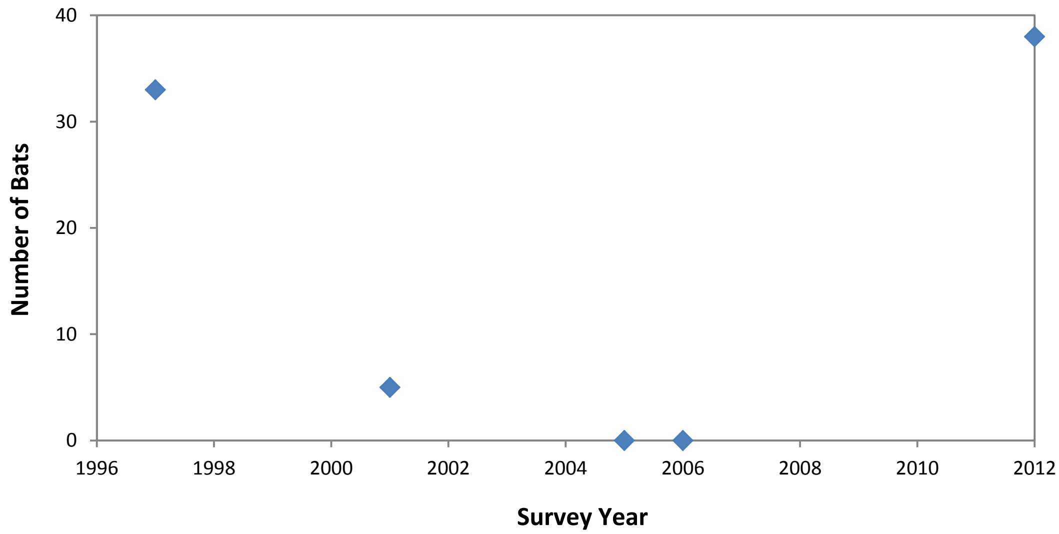


Figure 54. Number of bats observed hibernating in the Staple Bend Tunnel between 1997 and 2012. Missing data points indicate no surveys were completed during those years.

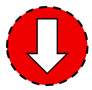
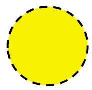
Eastern red bat (Lasiurus borealis). Photo by Josh Johnson

Hibernating bat communities scored as *significant concern* with a *deteriorating* trend for species diversity present in Staple Bend Tunnel (Table 53). While bats have been frequently observed in the area, the populations have never been documented to be very large. This assessment is based on professional judgment and the decline in the number of hibernating species present from four to one since 1997. It is also based on the concern for all bat species affected by WNS and the considerable declines seen in these populations across the northeast.

The park-wide inventory completed by Gates and Johnson in 2005-2006 resulted in 102 mist-net nights and 1,618 echolocation passes recoded through acoustic monitoring. They captured 113 bats including: 59 little brown bats, 28 big brown bats, 19 northern myotis, and 7 eastern red bats from mist-netting. Eastern red bats and big brown bats were the most commonly detected species from the acoustic monitoring, but also detected the same species captured in mist-nets and two additional species, the hoary and tri-colored bats.

Bat communities scored as *moderate concern* for species diversity park-wide (Table 53). Acoustic and mist-netting surveys completed in 2005 and 2006 found that 6 of the 9 species found in Pennsylvania, occur within the park. The diversity in habitat such as forests, openings, water availability at this location within the broader landscape on the Allegheny front likely contributed to the bat diversity (Gates and Johnson 2006). Gates and Johnson (2006) also calculated the Simpons's diversity index which was 0.640 for the park and a Simpon's measure of evenness as 0.683, indicating that moderate species diversity and evenness within the park. These measures range from 0 to 1 and the diversity index is weighted towards the most abundant species and is less sensitive to species richness (Magurran 2004). The surveys conducted over the 2005-2006 sampling period was the only time intensive bat inventories had been conducted within the park, therefore, no trend data are available for this metric.

Table 53. Condition Assessment Metrics for ALPO Bat Communities.

Metric	SBTU	Park-Wide
Bat Species Diversity		

Data Gaps and Confidence in the Assessment

The hibernating bat community was monitored multiple times over a period of 15 years allowing for a qualitative analysis of trends in the local bat population, but with a low level of confidence. These data were primarily visual inspections of the Staple Bend Tunnel limiting the geographic scale and therefor scope of inference of these trend analyses. Furthermore, these surveys did not capture or handled bats and so species identification is tentative. The Gates and Johnson surveys conducted over the 2005-2006 sampling period was the only time intensive bat inventories had been conducted within the park, therefore, no trend data are available for this metric. Future monitoring should occur on a regular schedule of 3 to 5 year intervals and include both winter hibernacula inspection and acoustic monitoring during the breeding season.

Source of expertise

Cal Butchkoski, Wildlife Biologist, Pennsylvania Game Commission

Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

4.5.3 Bird Communities

Lousiana waterthrush (Parkesia motacilla). Photo by T. O'Connell

Relevance and Context

Breeding birds are often used as indicators of biotic integrity and ecosystem health because each species has individual habitat requirements and levels of sensitivity to changes in their surrounding environment. Breeding birds have also been studied extensively and respond to environmental changes in predictable and well-documented patterns. Ecological variation in habitat use by the avian community allows researchers to track changes in population density and relative abundance through standardized monitoring protocols. State-wide monitoring efforts conducted by researchers and assisted by skilled amateurs have provided regional population trend data for central Pennsylvania. Regional bird surveys for the area in and around ALPO were conducted for the Breeding Bird Atlas (BBA) during two time periods (1983-89) and (2004-09). Additionally, long-term monitoring by the NPS has allowed researchers to track avian community metrics locally within the park. The ERMN began streamside bird monitoring in 2007 and recently completed their 2007 – 2012 monitoring report (Marshall et al. 2013). Streamside refers to bird species that occur within the area surrounding streams within the park. These streamside surveys provide information on the Bird Community Index (BCI), which is a measure of biotic integrity. The concept of biotic integrity provides an ecologically-based framework for evaluating and ranking species assemblage data (O’Connell et al. 1998a). Two inventory reports (Yahner and Keller 2000; Yahner et al. 2001) were previously conducted for ALPO.

Method

The ALPO bird community assessment consists of three parts: 1) results from the inventory reports (Yahner and Keller 2000; Yahner et al. 2001), which are not used to assess condition but rather to provide supplemental information to the streamside bird assessment; 2) the BCI results from the 2007-2012 streamside bird monitoring; and 3) results from the two BBA surveys to estimate regional condition and trends.

Inventory Surveys

The avian community was surveyed at ALPO during the spring migration period and summer breeding season of 1997. Survey transects were visited four times during each seasonal sample period. Birds were surveyed using a 50-m fixed width transect walking at a moderate pace (Yahner and Keller 2000). All birds seen or heard were recorded along with the perpendicular distance to the transect centerline. Bird surveys were also conducted in 1999 and 2001 during the spring and fall migration, winter residents and summer breeding season (Yahner et al. 2001). Sampling was conducted as fixed point-count surveys where all birds seen or heard during a 10 minute period were recorded. Point-count stations were visited twice during each seasonal period. Owl surveys were also conducted during the winter season (Yahner et al. 2001).

Streamside Bird Monitoring
In 2007 the NPS began implementing annual streamside bird surveys focused on understanding the occupancy, density, and abundance for a suite of species that primarily occur near streams. This information is incorporated into the BCI to evaluate the condition of the streamside bird community.

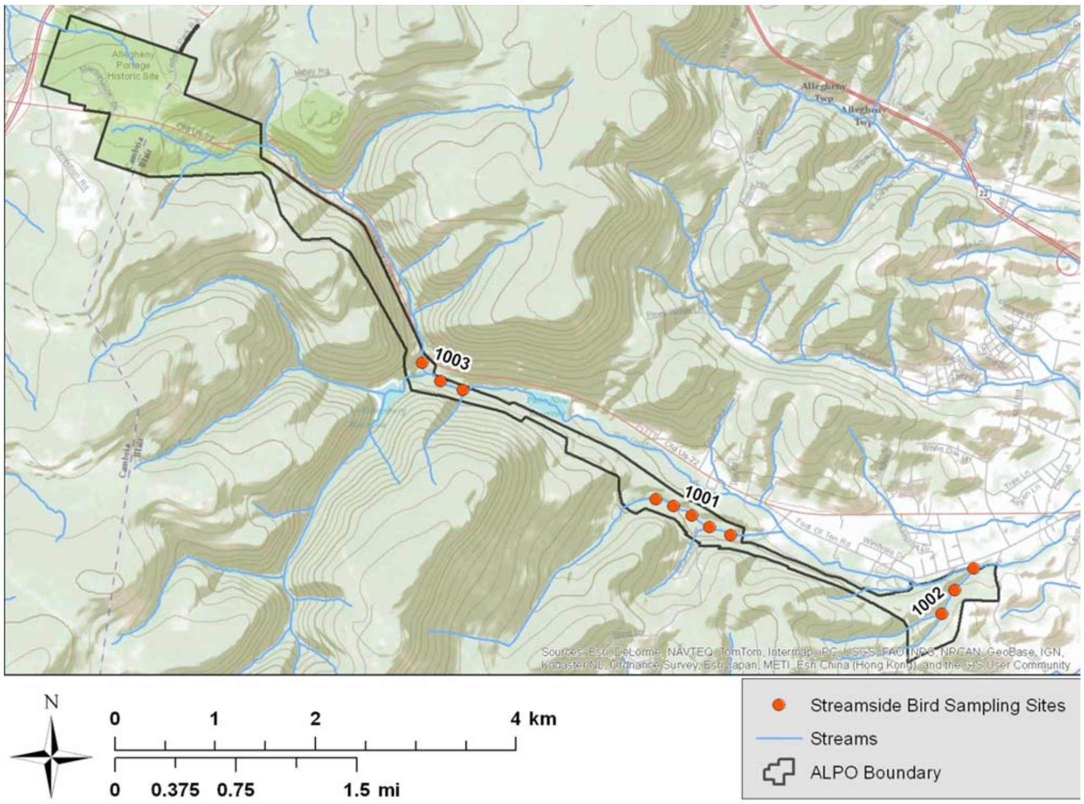


Figure 55. Locations of three sites within ALPO's Main Unit selected for monitoring streamside birds. Site areas are as follows: 1001=Millstone Run (established 2007); 1002=UNT to Blair Gap Run (Foot of Ten; established 2008); 1003=Blair Gap Run (Muleshoe; established 2009) (adapted from Marshall et al. 2013).

This index is based on 16 response guilds corresponding to breeding bird communities of the central Appalachians (O'Connell et al. 1998a, 1998b, 2000). Each guild is broadly classified as 'specialist' or 'generalist' with the former typically associated with elements indicating a more intact, mature forest structure and higher biological integrity (Table 54). 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 indicate higher biotic integrity (Marshall et al. 2013). For the 2007-2012 monitoring results, the entire bird community detected during all four passes along each site each year was used to calculate BCI scores. We used the average of the 2007-2012 results to report condition for each site.

Table 54. Biotic integrity elements, guild categories, response guilds, and guild interpretations used in the Bird Community Index (BCI; O'Connell et al. 1998a, 1998b, and 2000) of ecological integrity.

Biotic Integrity Element	Guild Category	Response Guild	Specialist	Generalist
Functional	trophic	omnivore		X
Functional	insectivore foraging behavior	bark prober	X	
Functional	insectivore foraging behavior	ground gleaner	X	
Functional	insectivore foraging behavior	upper-canopy forager	X	
Functional	insectivore foraging behavior	lower-canopy forager	X	
Compositional	origin	exotic/non-native		X
Compositional	migratory	resident		X
Compositional	migratory	temperate migrant		X
Compositional	number of broods	single-brooded	X	
Compositional	population limiting	nest predator/brood parasite		X
Structural	nest placement	canopy nester	X	
Structural	nest placement	shrub nester		X
Structural	nest placement	forest-ground nester	X	
Structural	nest placement	open-ground nester	X	
Structural	primary habitat	forest generalist		X
Structural	primary habitat	interior forest obligate	X	

Regional Survey (BBA)

To compare bird community condition within the park with that of the surrounding region, we calculated BCI scores for the BBA blocks located within a 30-km radius around the Main Unit and SBTU of ALPO. Each block corresponds to 1/6th of a USGS topographic quad map (~24 sq km). BBA records (species detections) collected under the standard volunteer protocols were used for this analysis. To improve the validity of this analysis data were restricted to the *Confirmed* or *Probable* BBA confidence levels. BBA records reported with the lower two confidence levels of *Possible* or *Observed* were not included in this analysis (Brauning 1992; Wilson et al. 2012).

We did not report trends within the park due to limited monitoring data. As ERMN streamside bird monitoring continues, more annual data will be added and trends can be ascertained. We did report a regional trend based on comparison between the 1983- 1989 BBA results and the 2004 -2009 BBA results.

Reference Conditions

Reference conditions for both the ERMN streamside bird monitoring and the regional BBA results were based on the overall BCI score and were rated as follows: highest integrity (60.1 – 77.0) and high integrity (52.1 – 60.0) = *good* condition; medium integrity (40.1 – 52.0) = *moderate concern*; and low integrity (20.5 – 40.0) = *significant concern*. We merged the highest integrity and high integrity classes to form three condition categories for consistency with the NRCA condition rating methods (Table 55). To determine regional trends, a BBA block that jumped to a higher condition category was assigned an *improving* trend, while a BBA block that fell to a lower condition category was assigned a *deteriorating* trend, and BBA blocks that remained in the same condition category were considered to be *unchanging* (e.g., a block rated as *significant concern* in 1983-89 study but rated as *moderate concern* in the 2004-09 study was considered to be *improving* in condition). To derive an overall BCI score for each BBA study period, we tallied the number of BBA blocks in each condition category and based the overall BCI score on the condition category with the most blocks. We followed the same method for predicting the overall regional trend in condition.

Table 55. BCI Scores and associated condition ratings used in the ALPO NRCA.

BCI Score	Condition Rating	Symbol
52.1 - 77.0	Good	
40.1 - 52.0	Moderate Concern	
20.0 - 40.0	Significant Concern	

Current Condition and Trends

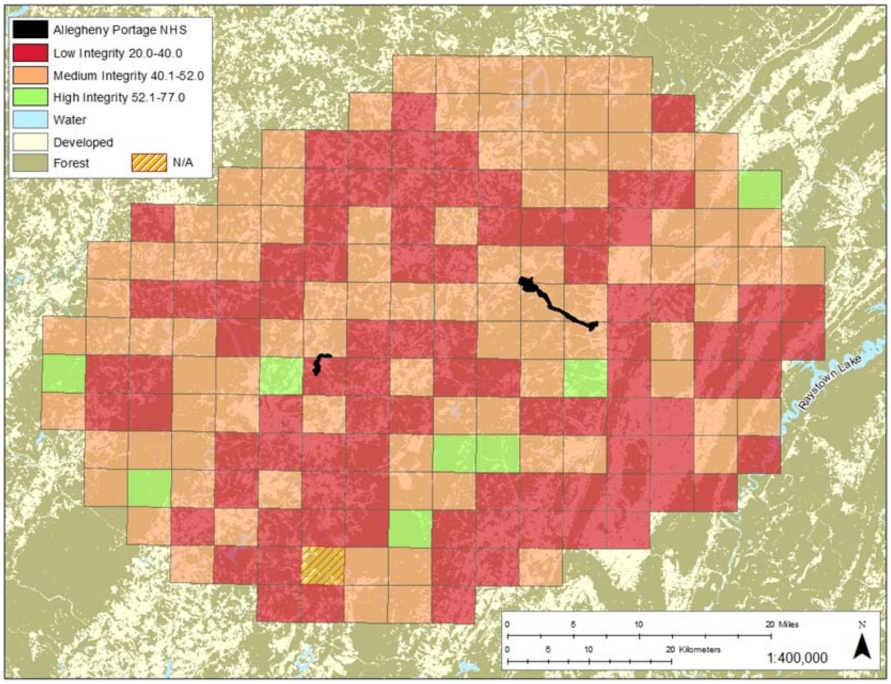
Inventory Results

Avian community surveys were completed in the spring of 1997 to assess spring migration within the park. Yahner and Keller detected 61 species at site #9 and 43 species at the Visitors Center. Of the most commonly detected species in each site only two species overlapped, the Ovenbird and the American Redstart. During the summer breeding season, site #9 and the Visitors Center were resurveyed and found 37 and 33 species respectively. There were five species in common among the sites most common species detected, the Red-Eyed Vireo, Ovenbird, Chipping Sparrow, Indigo Bunting and Song Sparrow. Yahner and Keller found that the most species detected within the park were long- and short-distant migrants, with fewest detections coming from resident species. When avian surveys were conducted two years later they found 113 species at ALPO. These surveys documented 39 new species previously unknown to the park. Refer to Appendix B for supplemental information regarding the species detected in these surveys.

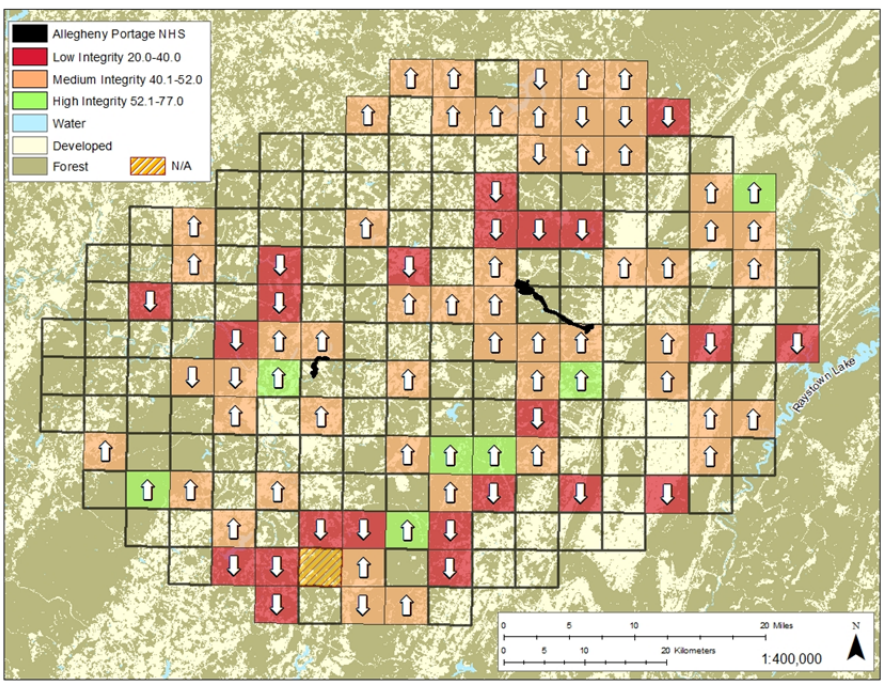
Streamside Bird Monitoring Results (BCI)

The BCI calculated from the three transects found that the biological integrity of the bird community was moderate to high, with only a small level of variation among transects. Bird community integrity was scored as *good* as part of the park-wide bird community metrics with a five-year average of 55 ± 5.9 (Table 57). This corresponds to a bird community comprised of more species in specialist guilds than generalist guilds and reflects a relatively intact, extensive, and mature forest structure (Marshall et al. 2013). It is important to note, however, that these results reflect the streamside bird community around streams in the Main Unit and are not necessarily indicative of the entire bird community throughout the park. Refer to Appendix B for a list of bird species detected in the streamside bird monitoring.

Regional Survey Results (BBA)



a.)



b.)

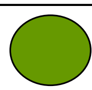
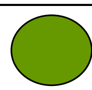
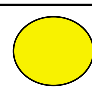
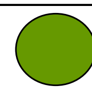
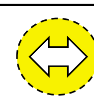
Figure 56. Regional results from the Breeding Bird Atlas (BBA) studies showing a) condition of each block from the 2004-09 study and b) the blocks that changed in condition from the previous (1983-89) study. Downward arrows correspond to a *deteriorating* trend in condition, while upward arrows correspond to an *improving* trend in condition from the earlier study.

BCI scores for BBA blocks in the 2004-09 study (BCI_2) were primarily rated as warranting *moderate concern* or *significant concern* (Figure 56a, Appendix B). This corresponds to the largest proportion of blocks (49.7%) as warranting *moderate concern* (Tables 56 and 57). Fifty-five (28.2%) of the BBA blocks in the 2004-09 study improved in condition from the previous study, while 30 (15.4%) deteriorated in condition (Figure 56b, Table 56). The majority of BBA blocks in the 2004-09 study (110 or 56.4%) remained in the same condition category as the previous BBA study (Figure 56b, Table 56). Refer to Appendix B for supplemental information on the BBA results.

Table 56. Number and percentage of Breeding Bird Atlas (BBA) blocks from the 2004-09 study in each NRCA condition and trend category.

Condition Rating	BCI_2 (2004-09)	% of Blocks	Trend	# Blocks	% of Blocks
Good	8	4.1%	Improving	55	28.2%
Moderate Concern	97	49.7%	Unchanging	110	56.4%
Significant Concern	90	46.2%	Deteriorating	30	15.4%

Table 57. Condition assessment results (green = *good* and yellow = *moderate concern*) for ALPO streamside bird communities and the 2004-09 Breeding Bird Atlas (BBA) study based on BCI scores. Park-wide condition represents the five-year average BCI score of the three transect locations (Muleshoe, Millstone Run, and Foot of Ten). Regional condition represents the overall condition and trend from the BBA study results. The BBA data is based on species lists collected by volunteers and, as such, received a lower confidence rating (dashed border) than the park assessment.

SITE	Blair Gap Run (Muleshoe)	Millstone Run	UNT to Blair Gap Run (Foot of Ten)	Park-wide	Regional
CONDITION					

Data Gaps and Confidence in Assessment

Avian community data were moderately abundant for ALPO, but none of the data was intended for park-wide condition assessments. Inventory surveys were not included in the condition assessment. Although these surveys were able to document species present on site, the lack of detection of a species does not equate to a local extirpation. The absence of a species may be an artifact of the sampling design or the seasonal timing of the survey. Confidence in the park condition assessment is *medium*, primarily because the annual monitoring data (2007 through 2012) targeted the stream network, not the entire park (although much of the Main Unit parallels the targeted stream). Inventory and monitoring surveys should continue to be conducted at regular intervals to maintain trend data for species of interest. Confidence in the regional assessment based on the BBA data is *low*, primarily due to potential inconsistencies in the BBA data and the fact that the data represent species lists collected by volunteers. Variations in survey effort, both time per block and evenness of coverage area, and volunteer experience coupled with changes in survey protocols between the two atlases are important to note but do not outweigh the value of these data.

Source of expertise
Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

Matt Marshall, Eastern Rivers and Mountains Network Program Manager, National Park Service and Adjunct Assistant Professor of Wildlife Conservation, Pennsylvania State University

Joseph Bishop, Research Associate, GeoSpatial Coordinator, Riparia, Department of Geography, Pennsylvania State University

4.5.4 Amphibians and Reptiles

Relevance and Context
Amphibians and reptiles (collectively known as herptofauna) are often used as indicators of environmental quality (Gibbons et al. 2000). As a group, herptofauna have experienced extensive world-wide declines in population at a disproportionally high rate compared to other taxa (Cushman 2006; Gibbons et al. 2000; Stuart et al. 2004). The 2008 IUCN red list of threatened and endangered species found that nearly one-third of the 6,260 amphibian species are globally threatened or extinct (Frost et al. 2008). Research has found that many of these declines can be linked with pathogens such as the chytrid fungus, increased ultraviolet exposure, habitat degradation and fragmentation, toxic chemicals and other terrestrial and aquatic pollutants (Cushman 2006; Gibbons et al. 2000; Stuart et al. 2004; Frost et al. 2008). However, by far the greatest threat to herptofauna is habitat loss (Gibbons et al. 2000; Frost et al. 2008).

An eft (terrestrial stage) of the eastern or red-spotted newt (Notophthalmus viridescens viridescens). Photo courtesy of NPS/Joseph F. Tate II

Northern two-lined salamander (Eurycea bislineata). Photo by G. Rocco

The National Park System may serve as a refugia for some species as the management of these areas restore conditions or hold constant the habitat requirements necessary for herptofauna to maintain viable populations. ALPO is known to support a wide variety of reptiles and amphibians that require both aquatic and terrestrial habitats (Yahner and Ross 2006). For terrestrial salamanders, both redback (*Plthodon cinereus*) and northern slimy salamanders (*Plethodon glutinosus*) were found in abundance and northern two-lined salamanders (*Eurycea bislineata*) were the most abundant aquatic salamander found within the Park (Yahner and Ross 2006). ALPO also supports populations of the smooth green snake (*Opheodrys vernalis*) and the Eastern box turtle (*Terrapene carolina*) both of which are listed as species of special concern in Pennsylvania by the Pennsylvania Fish and Boat Commission.

Method

Herptofauna were surveyed at ALPO from March to October in 2004 and 2005 by Yahner and Ross (2006) (Figure 57). The information presented in this report is the summary of their findings. Based on distribution maps and historic records of species occurrence, 47 species of herptofauna potentially occur within ALPO. These species include 17 species of salamander, 10 frogs and toads, 4 species of turtles, two lizards and 14 species of snakes (Table 59). Sampling techniques included visual encounter, artificial cover-object, pitfall-trapping, anuran-calling, and general search surveys in order to sample the spatial variation and cover types available within the park area (Yahner and Ross 2006).

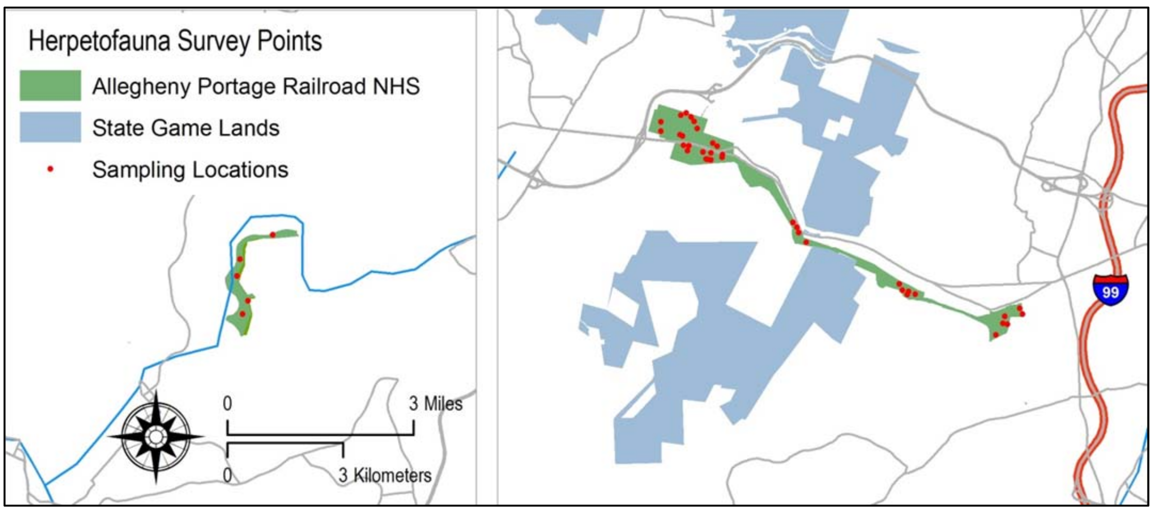


Figure 57. Herpetofauna sampling locations for the 2004 – 2005 inventory (Yahner and Ross 2006).

Reference condition

Reference conditions were determined to be the potential species that could occur within the park. These species were identified by Yahner and Ross (2006) from the NPSpecies database, and other published reports with known occurrences in the area. Yahner and Ross (2006) also accounted for suitable habitat within the park unit that was available for each species. More quantitative metrics and thresholds describing the population dynamics of specific species or the herptofauna group as a whole could not be determined at this time due to limitations associated with the data available. However, the Yahner and Ross (2006) study does allow us to make some inference regarding the condition of herptofauna within the park and should be used as the basis for future monitoring efforts.

Table 58. Condition categories for percentage of herptofauna species confirmed present in the park versus potential species that could occur based on range and known habitat types. Condition classes established based on professional judgment.

% Species Found	Condition	Symbol
> 85%	Good	(green circle)
50 - 85%	Moderate Concern	(yellow circle)
< 50%	Significant Concern	(red circle)

Current condition and Trends

Herptofauna communities scored as *moderate concern* for the moderate success rate of species confirmed park-wide from those expected due to their range (Table 60). The inventory survey completed by Yahner and Ross in 2004-2005 sampling period found 67% of expected amphibians and 50% of expected reptiles. Overall there was a 60% success rate of confirming the presence for 28 of the 47 expected species occurrence within the park (Figure 58). Ratios of observed to expected species were as follows: 6/10 frogs (60%); 12/17 salamanders (71%); 2/4 turtles (50%); 0/2 lizards (0%); and 8/14 snakes (57%). Because surveys only indicate presence of a species, the lack of an observation does not indicate species absence or local extirpation. For example Sharpe et al. (2012) observed frog larva within a wetland system previously unknown to the park and thus unsampled by Yahner and Ross in 2004-2005. The lack of a species observation may be an artifact of the sampling design or sampling season. No trend assessment is currently possible for this metric due to the single sample period.

Table 59. Herptofauna species and number observed in the 2004-2005 inventory (Yahner and Ross 2006).

AMPHIBIANS

Common Name	Latin Name	Number Observed
Mudpuppy	*Necturus maculosus*	0
Jefferson salamander	*Ambystoma jeffersonianum*	0
Spotted salamander	*Ambystoma maculatum*	5
Marbled salamander	*Ambystoma opacum*	0
Red-spotted newt	*Notophthalmus viridescens*	61
Northern dusky salamander	*Desmognathus fuscus*	62
Seal salamander	*Desmognathus monticola*	0
Mountain dusky salamander	*Desmognathus ochrophaeus*	688
Northern two-lined salamander	*Eurycea bislineata*	115
Longtailed salamander	*Eurycea longicauda*	0
Northern spring salamander	*Gyrinophilus porphyriticus*	67
Four-toed salamander	*Hemidactylium scutatum*	1
Redback salamander	*Plethodon cinereus*	151
Northern slimy salamander	*Plethodon glutinosus*	137
Valley and ridge salamander	*Plethodon hoffmani*	1
Wehrle's salamander	*Plethodon wehrlei*	0
Northern red salamander	*Pseudotriton ruber*	1
Eastern American toad	*Bufo americanus*	13
Fowler's toad	*Bufo fowleri*	0
Gray treefrog	*Hyla versicolor*	0
Mountain chorus frog	*Pseudacris brachyphona*	0
Northern spring peeper	*Pseudacris crucifer*	444
Bullfrog	*Rana catesbeiana*	3
Green frog	*Rana clamitans*	20
Pickerel frog	*Rana palustris*	5
Northern leopard frog	*Rana pipiens*	0
Wood frog	*Rana sylvatica*	96

REPTILES

Common Name	Latin Name	Number Observed
Common snapping turtle	*Chelydra serpentina*	1
Painted turtle	*Chrysemys picta*	0
Wood turtle	*Glyptemys insculpta*	0
Eastern box turtle	*Terrapene carolina*	2
Northern fence lizard	*Sceloporusundulates hyacinthus*	0
Five-lined skink	*Eumeces fasciatus*	0
Eastern worm snake	*Carphophis amoenus*	0
Northern black racer	*Coluber constrictor*	2
Northern ringneck snake	*Diadophis punctatus*	2
Rat snake	*Elaphe obsoleta*	0
Eastern hognose snake	*Heterodon platirhinos*	0
Eastern milk snake	*Lampropeltis triangulum*	5
Northern water snake	*Nerodia sipedon*	2
Smooth green snake	*Opheodrys vernalis*	2
Northern brown snake	*Storeria dekayi*	1
Northern redbelly snake	*Storeria occipitomaculata*	45
Eastern ribbon snake	*Thamnophis sauritus*	0
Eastern garter snake	*Thamnophis sirtalis*	74
Northern copperhead	*Agkistrodon contortrix mokasen*	0
Timber rattlesnake	*Crotalus horridus*	0

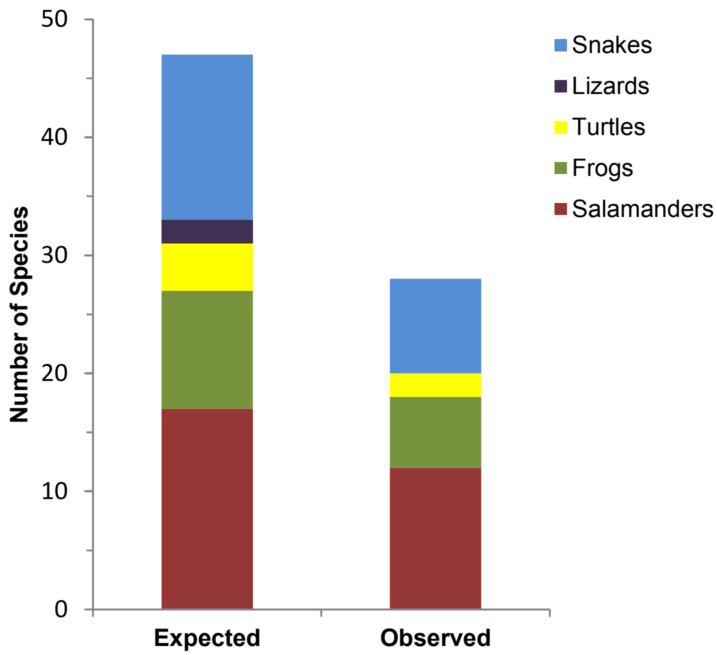
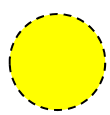
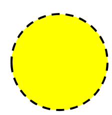


Figure 58. Number of herpetofauna species expected and observed within ALPO (Yahner and Ross 2006).

Table 60. Condition Assessment Metrics for ALPO Reptile and Amphibian Communities

	Reptiles	**Amphibians**
Success rate of expected number of species		

Data Gaps and Confidence in Assessment

Herptofauna data were limited for ALPO. Survey data were only available for a single time period and no monitoring data were available. Inventory surveys were able to document species present on site, however, the lack of detection of a species does not equate to a local extirpation. The absence of a species may be an artifact of the sampling design or the seasonal timing of the survey. Trends were not identified for herptofauna within the park area due to the single survey effort results available. Inventory and monitoring surveys should be conducted at regular intervals to establish trend data for species of interest. Confidence in the assessment is *low*.

Source of expertise

Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

4.5.5 Mammals

Relevance and Context

There are more than 70 species of mammals native to Pennsylvania (Williams et al. 1985). Mammals are often chosen as biological indicators because of their direct association with vegetative structure (Abramsky 1978; Yahner 1992). Changes in climate and forest management coupled with a rapidly increasing human population have altered or in some cases determined vegetation characteristics across the landscape. These changes have played a key role in the composition and distribution of species remaining in the Mid-Atlantic region (Bellows et al. 2001). During the colonial era (approximately 200 plus years ago), European settlers experienced an abundance of mammal species that quickly started to disappear. Unrestricted exploitation of mammalian species to protect livestock or hunted for fur trades led to the local extirpation of species such as the gray wolf (*Canis lupus*), mountain lion (*Puma concolor*), lynx (*Lynx canadensis*), wolverine (*Gulo gulo*), moose (*Alces alces*) and marten (*Martes americana*) (Handley 1992; Williams et al. 1985). Several species such as the beaver (*Castor canaensis*), elk (*Cervus canadensis*), river otter (*Lontra canadensis*), and fisher (*Martes pennanti*) have been successfully re-introduced and have established populations in the state (Williams et al. 1985).

Black bears (Ursus americanus) and bobcats (Lynx rufus) are two of the largest mammals inhabiting eastern temperate forests today. Photos by S. Yetter

Habitat fragmentation in the areas surrounding national park units are causing national parks to become more insular and valuable as a resource in sustaining local populations of faunal diversity (Ambrose and Bratton 1990). Today ALPO supports a broad assemblage of mammals given the diversity of habitats. More than 50 species of mammals can potentially occur within the park boundary (Yahner and Ross 2006). Moist riparian areas provide habitat for several species of shrews including the masked shrew (*Sorex cinereus*) and the smoky shrew (*Sorex fumeus*). Upland areas provide habitat from species ranging from Eastern cottontail (*Sylvilagus floridanus*) to the gray fox (*Urocyon cinereoargenteus*).

Method

The park commissioned researchers Yahner and Ross from Pennsylvania State University to inventory mammal populations within the park. The results of these surveys are summarized in this document. Mammals were surveyed at ALPO from March to October in 2004 and 2005 by Yahner and Ross (2006) (Figure 59). Sampling techniques included live-trapping with small Sherman traps and larger Tomahawk cage traps, morning and evening vehicular road surveys, and opportunistic observations. Survey points were stratified in order to sample the spatial variation and cover types available within the park area (Yahner and Ross 2006). The sample sampling points used for herptofauna surveys were also used for mammal survey locations (see Figure 57).

Based on distribution maps and historic records of species occurrence, 55 species of mammals potentially occur within ALPO (Table 61). Reference lists of mammals in the park were compiled from the NPSpecies database which yielded 15 species of mammals, including 4 species of bats. In addition, 13 species previously not recorded within the park boundaries have now been documented (Yahner and Ross 2006).

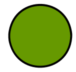
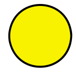
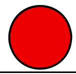
Reference condition

Reference conditions were determined to be the potential species that could occur within the park. These species were identified by Yahner and Ross (2006) from the NPSpecies database, and other published reports with known occurrences in the area. Yahner and Ross (2006) also accounted for suitable habitat within the park unit that was available for each species. A more quantitative metric and threshold describing the population dynamics of specific species or the mammalian fauna as a whole could not be determined at this time due to limitations associated with the data available. However, the Yahner and Ross (2006) study does allow us to make some inference regarding the condition of mammals within the park and should be used as a baseline for future monitoring efforts. Condition categories for the percentage of potential species that were found within the park are listed below (Table 62).

Table 61. Mammalian species that could potentially occur within the Allegheny Portage Railroad NHS (Yahner and Ross 2006).

Common Name	Latin Name
Virginia opossum	*Didelphis virginiana*
Masked shrew	*Sorex cinereus*
Smokey shrew	*Sorex fumeus*
Long-tailed shrew	*Sorex dispar*
Pygmy shrew	*Sorex hoyi*
Northern short-tailed shrew	*Blarina brevicauda*
Least shrew	*Cryptotis parva*
Hairy-tailed shrew	*Parascalops breweri*
Star-nosed shrew	*Condylura cristata*
Little brown bat	*Myotis lucifugus*
Northern long-eared bat	*Myotis septemtrionalis*
Indiana bat	*Myotis sodalis*
Eastern small-footed myotis	*Myotis leibii*
Silver-haired bat	*Lasionycteris noctivagans*
Tri-colored bat	*Perimyotis subflavus*
Big brown bat	*Eptesicus fuscus*
Red bat	*Lasiurus borealis*
Hoary bat	*Lasiurus cinereus*
Eastern cottontail	*Sylvilagus floridanus*
New England cottontail	*Sylvilagus transitionalis*
Snowshoe hare	*Lepus americanus*
Eastern chipmunk	*Tamias striatus*
Woodchuck	*Marmota monax*
Gray squirrel	*Sciurus carolinensis*
Fox squirrel	*Sciurus niger*
Red squirrel	*Tamiasciurus hudsonicus*
Southern flying squirrel	*Glaucomys volans*
Northern flying squirrel	*Glaucomys sabrinus*
American beaver	*Castor canadensis*
Deer mouse	*Peromyscus maniculatus*
White-footed mouse	*Peromyscus leucopus*
Appalachian woodrat	*Neotoma magister*
Southern red-backed vole	*Clethrionomys gapperi*
Meadow vole	*Microtus pennsylvanicus*
Woodland vole	*Microtus pinetorum*
Southern bog lemming	*Synaptomys cooperi*
Muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus*
House mouse	*Mus musculus*
Meadow jumping mouse	*Zapus hudsonius*
Woodland jumping mouse	*Napaeozapus insignis*
Porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus*
Black bear	*Ursus americanus*
Raccoon	*Procyon lotor*
Ermine	*Mustela erminea*
Least weasel	*Mustela nivalis*
Long-tailed weasel	*Mustela frenata*
Mink	*Mustela vison*
Striped skunk	*Mephitis mephitis*
Feral cat	*Felis catus*
Bobcat	*Lynx rufus*
White-tailed deer	*Odocoileus virginianus*

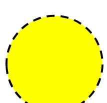
Table 62. Condition categories for percentage of mammalian species confirmed present in the park versus potential species that could occur based on range and known habitat types. Condition classes established based on professional judgment.

% Species Found	Condition	Symbol
> 85%	Good	
50 - 85%	Moderate Concern	
< 50%	Significant Concern	

Current condition and Trends

Mammal communities scored as *moderate concern* for species diversity and success rate of detection park-wide (Table 63). This score was based on the success rate of species documentation and professional judgment. The inventory survey completed by Yahner and Ross in 2004-2005 sampling period found 93% (14 of 15) of the species identified in the historical records for the park. In addition, they also documented the presence of 13 species previously unrecorded in the park. Overall there was a 42% success rate of confirming the presence for 23 of the 55 expected species occurrence within the park (Figure 59). Ratios of observed to expected species were as follows: 3/8 shrews and moles (Soricomorpha 38%); 11/21 mice, squirrels, and voles (Rodentia 52%); 1/3 rabbits and hares (Lagomorpha 33%); 1/1 opossum (Didelphimorphia 100%); 1/9 bats (Chiroptera 11%); 5/12 fox, bear, weasel and bobcats (Carnivora 42%); and 1/1 deer (Artiodactyla 100%). Bats were not sampled extensively in the Yahner and Ross (2006) survey; however, the four species identified by the Pennsylvania Game Commission were confirmed at the Staple Bend Tunnel. Medium-sized mammals often have sizable home ranges and can be secretive making this group difficult to inventory. Because surveys only indicate presence of a species, the lack of an observation does not indicate species absence or local extirpation. The lack of a species observation may be an artifact of the sampling design or sampling season. No trend assessment is currently possible for this metric due to the single sample period.

Table 63. Condition assessment metrics for ALPO mammal communities. Confidence in this assessment is low due to the single inventory period.

	Mammal
Success rate of expected number of species	

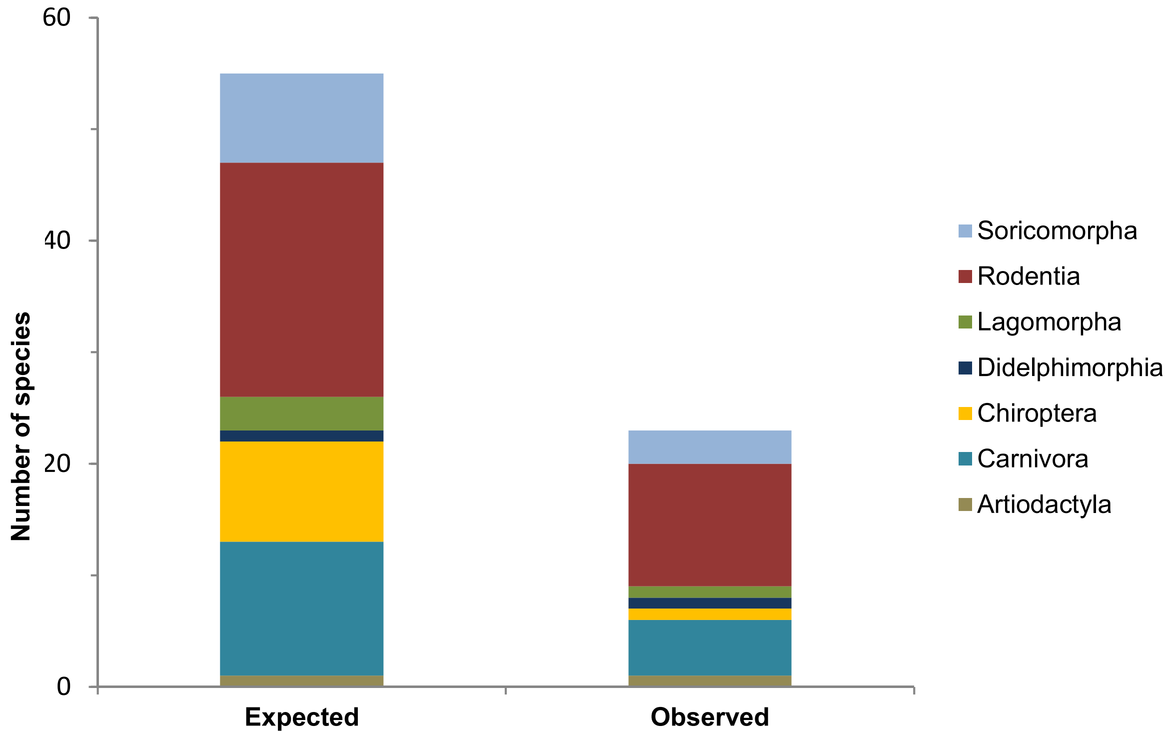


Figure 59. Number of mammalian species expected and observed within the ALPO NHS (Yahner and Ross 2006).

Data gaps and confidence in assessment

Mammal data were limited for ALPO. Survey data were only available for a single time period and no monitoring data were available. Inventory surveys were able to document species present on site, however, the lack of detection of a species does not equate to a local extirpation. The absence of a species may be an artifact of the sampling design or the seasonal timing of the survey. Trends were not identified for mammals within the park area due to the single survey effort results available. Inventory and monitoring surveys should be conducted at regular intervals to establish trend data for species of interest. Confidence in the assessment is *low.*

Source of expertise

Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

4.5.6 Non-native Invasive Animals

Relevance and Context

Non-native animal species are those that colonize areas where they would not naturally occur. An invasive non-native species often aggressively overtakes habitats to the detriment of native plants or animals and can alter the dynamics of entire ecosystems. These rapid expansions in population are often a result of the lack of direct competitors or predators that would help control the populations of the species in their native environments.

Park managers at ALPO have identified four non-native invasive animal species of concern, which are described in more detail below. These species include the Hemlock Woolly Adelgid (*Adelgid tsugae*), Gypsy Moth (*Lymantria dispar*), Brown Trout (*Salmo trutta*), and crayfish (*Orconectes sp.*). Early detection of non-native invasive species is vital to increasing the efficacy of control measures and reduction in associated treatment costs.

Hemlock Woolly Adelgid

This soft-bodied insect species is native to Japan, and attacks eastern hemlock (*Tsuga Canadensis*) and Carolina hemlock (*T. caroliana*). Both hemlock species are highly susceptible and illustrate no resistance to attack (Felton and Onken 2009). This adelgid species was first identified in the western U.S. in the 1920s, with little impact on western hemlock species. However, the hemlock woolly adelgid has caused significant impact on eastern forests, where tree mortality has reached 90% in some stands (Felton and Onken 2009). The hemlock woolly adelgid is parthenogenetic in the Eastern US in the absence of host spruce trees where sexual reproduction can occur in other parts of its range. Parthenogenetic means it is an all-female population with asexual reproduction, and has six stages of development including the egg, four nymphal instar, and an adult stage (Felton and Onken 2009). Dispersal and invasion of new trees through movement by wind, birds, deer and other small mammals, occurs during the egg and first instar stages (Felton and Onken 2009). This tiny insect feeds on all life stages of a hemlock and can kill a mature tree in 5-7 years (Felton and Onken 2009).

There are several options available to treat hemlock woolly adelgid infestations. Systematic insecticide treatments can be applied to the soil or through a direct injection into the stem of the tree. Biological control agents in the form of predatory beetles can also be released in newly infested sites to remove adelgids while the trees are still healthy and can recover from the infestation.

Gypsy Moth

The gypsy moth is a European species that was brought to North America in 1869 by a French lithographer (Tobin et al. 2009). It is suspected that the man was rearing them in his yard when a wind storm tore the containment netting that resulted in the release of larvae (Tobin et al. 2009). Since their release the gypsy moth populations have expanded to cover the entire northeast including Pennsylvania and as far west as Wisconsin (USDA 2007). Gypsy moths cause massive areas of defoliation in mixed hardwood forests each year and are blamed for more than 80 million acres of defoliated forests since 1970 (Gypsy Moth Digest 2009). Oaks are often the host species for feeding caterpillars, but sweetgum, basswood, apple, gray and white birch, poplar and willow also serve as host species (USDA 2007).

Brown Trout

The brown trout is a European species that was introduced throughout Pennsylvania and North America as a sport fish and has become established with wild reproduction populations here in Pennsylvania (Tzilkowski and Sheder 2006). Brown trout are slightly larger and can withstand a broader array of environmental conditions than the native brook trout. The introduction of the non-native brown trout appears to out compete and have detrimental ecological impacts on the populations of native trout adding to the factors that have led to their decline (Tzilkowski and Sheder 2006).

Crayfish

Crayfish have not been well studied in Pennsylvania over the last century (Lieb et al. 2007). There are approximately 12 species of native crayfish with the most common being *Cambarus bartonii* also called the common crayfish or the Appalachian brook crayfish. Since the early surveys completed in 1906 by Arnold Ortmann, two species of crayfish have invaded or been introduced to Pennsylvania including the rusty crayfish (*Orconected rusticus*) and the northern crayfish (*Orconected virilis*) (Lieb et al. 2007). These non-native crayfish can be very aggressive and have often been the leading cause of local extirpation of native crayfish populations where the species overlap (Lieb et al. 2007). Nonnative crayfish not only displace native crayfish from high quality habitat, but this displacement makes them more susceptible to predation (Lieb et al. 2007). Land use changes such as urbanization have been shown to negatively affect macroinvertebrate communities from sedimentation and runoff (Lieb et al. 2007).

<u>Method</u>

This report summarized data and information available in other reports gathered for this assessment. Hemlock woolly adelgid surveys were completed within ALPO in 2009 following the sampling plan developed by Costa and Onken (2006). This sampling plan sets the maximum number of trees to sample at 100 and provides a quick and precise method of detecting and characterizing the severity of the infestation by using the percentage of trees infested (Felton and Onken 2009). A total of 16 hemlock stands were surveyed at ALPO. In addition, park management monitor the spread of hemlock woolly adelgid through state-wide surveys conducted annually by the Pennsylvania Department of Conservation and Natural Resources (DCNR).

Gypsy moth surveys were conducted by the DCNR across the state of Pennsylvania on an annual basis to identify and monitor trends. Surveys were conducted at 1,167 sampling sites focused on egg mass detection. Park specific surveys have not been completed.

Brown trout were surveyed at five sites within Blair Gap Run to determine the upstream limit of overlap between brook trout and non-native brown trout populations (Tzilkowski and Sheeder 2006). Trout sampling was conducted in stream reaches between areas that served as fish passage impediments using a three pass depletion method (Tzilkowski and Sheeder 2006). Electrofishing techniques were used in three consecutive passes. Captured fish were held in plastic buckets until subsequent passes were complete and then released back into the reach they were captured from (Tzilkowski and Sheeder 2006).

Crayfish were sampled at five sites within ALPO in 2005. At each sampling site, multiple pool-rifle sequences were thoroughly searched for crayfish and captured species using dip nets or kick screens (Lieb et al. 2007).

<u>Reference Condition</u>

Reference conditions were not established for non-native species. Ideally they should not be present within the park boundaries. Condition categories for hemlock woolly adelgid were established based on known survey data and action thresholds from previous statewide forest surveys (Felton and Onken 2009). Quantitative metrics and thresholds for condition assessments for other non-native species were unavailable. Condition assessments were based on professional judgment due to limitations associated with the data available and the single entry inventories (Table 64).

Table 64. Condition categories for percentage of stands infested with non-native hemlock woolly adelgid species.

% Non-Native Species	Infestation Level	Condition	Symbol
0	None	Good	(green circle)
1 - 25	Light	Moderate Concern	(yellow circle)
> 25	Moderate	Significant Concern	(red circle)

<u>Current Condition and Trends</u>

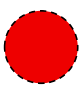
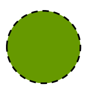
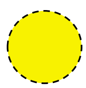
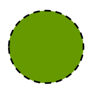
Through state-wide surveys conducted by DCNR, hemlock woolly adelgid was found to infest stands in 16 counties in western Pennsylvania (DCNR 2011). Within the main unit of ALPO 16 of 20 hemlock stands were last surveyed in 2009, 50% of which had been infested with hemlock woolly adelgid. Stand number 168 in Incline 6 to 8 had a light level infestation with only 16% of trees within the stand infested. However, the remaining 7 stands that had adelgid infestations were 100% infested. This invasion at ALPO is of *significant concern* due to their natural resource value (shady habitats, cooling effects on streams, year-round cover), the historical reference of the 'towering hemlocks' in park documents, and the potential to become hazardous trees if they should die along trails. Recent surveys by Park personnel have confirmed the spread of the infestation to the main unit (Kathy Penrod pers. Comm.). Treatment through chemical application has begun on more than 22 acres. The park is currently working on an environmental assessment to move forward with biological control agents such as the predatory beetle release. Additional surveys within the park boundary are necessary to confirm the trend of increase invasion by hemlock woolly adelgid (Table 65).

Gypsy moth egg masses were found at 47 of the 1,167 sites sampled. This detection rate equates to approximately 4% of surveyed sites across Pennsylvania between the winter 2010 and spring 2011 (DCNR 2011). Egg masses were found in 20 counties in Pennsylvania (DNCR 2011). Preliminary results from the 2012 spring hatch sampling indicate that approximately 20% of sites visited detected gypsy moth egg masses suggesting that an outbreak was possible (DCNR 2011). Gypsy moths have been noted within the park, however significant defoliation has not been a significant problem over the past 5-10 years (Kathy Penrod pers. Comm.). Due to the lack of a major outbreak of gypsy moth defoliation, the invasive species was scored as *good* (Table 65).

Brown trout were captured at 3 of the 5 sites surveyed, however, were not captured or seen above the Blair Gap Reservoir (Tzilkowski and Sheeder 2006). This suggests that the reservoir is serving as a barrier to the upstream movement by the non-native brown trout. In the sites where both trout species distribution overlapped, the non-native brown trout was less abundant than the native brook trout species (Tzilkowski and Sheeder 2006). While there appears to be a barrier that prevents the upstream movement of the non-native trout species to expand its range, the species is already present in much of Blair Gap Run. Due to their presence in the majority of sites surveyed brown trout were scored as *moderate concern* (Table 65). Management scenarios including non-native removal could improve the conservation and management of native brook trout populations within the park.

Crayfish were captured at 4 of the 5 sites surveyed. No crayfish were seen or captured at the fifth site. Only native species of crayfish were captured during survey collections at ALPO (Lieb et al. 2007). The common crayfish (*Cambarus bartonii*) was the most commonly detected species in ALPO, followed by the Allegheny crayfish (*Orconectes obscurus*). While habitat was available at site 5 it appears to be currently unoccupied by crayfish species (Lieb et al. 2007). Crayfish populations were scored as *good* because relative abundance of native populations was moderately high and no non-native species were present within the park boundaries.

Table 65. Condition assessment metrics for ALPO non-native animal invasions.

ALPO Main Metrics	Hemlock Woolly Adelgid	Gypsy Moth	Brown Trout	Crayfish
% Non-Native Species				

Data gaps and confidence in assessment

Non-native invasive species data were limited for ALPO. Survey data were often only available for a signal time period and no monitoring data were available except for the statewide surveys completed for the hemlock woolly adelgid. Trends were not identified for non-native invasive species within the park area due to the single survey effort results available. Inventory and monitoring surveys should be conducted at regular intervals within the park for each of these species to establish trend data for species of interest. Confidence in the assessment is *low*.

Sources of Expertise

Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

4.5.7 Non-native Invasive Plants

Relevance and Context

Non-native plants are those species that colonize areas where they did not naturally evolve. Invasive non-native species aggressively take over the habitats they invade to the detriment of native plants and entire ecosystems. Invasive plants typically share several common traits including rapid growth rates, short life cycle, high reproductive output (primarily through vegetative growth), large seed size, and pollination by wind or generalist pollinators (D'Antonio 1993, Burke and Grime 1996, Anderson et al. 1996). They also readily exploit excess resources such as light and minerals that are released when habitats are disturbed (Anderson et al. 1996). The lack of natural herbivores, pests, and parasites in their newly adopted habitats contributes to the spread of these plants, which can subsequently alter plant community structure and impact biogeochemical cycles (D'Antonio 1993, Blossey and Notzold 1995, Gordon 1998, Mack et al. 2000). Non-native invasive plants not only threaten the ecological integrity of ecosystems worldwide (Mooney et al. 2005) they may result in economic harm or negatively impact human health (USPEO 1999). Invasive non-native species, therefore, are one of the greatest threats to natural areas and an important consideration in their conservation and management.

European colonization and the subsequent globalization of our economy over the past two centuries have vastly accelerated the introduction and spread of non-native plants (Mack et al. 2000). Once established, these species readily invade disturbed, successional, and fragmented habitats (Robertson et al. 1994, Cadenasso and Pickett 2001). Smaller areas with high perimeter-to-area ratios, large areas of successional habitat, or highly heterogeneous vegetation associations are particularly vulnerable to invasion – all characteristics of habitats within ALPO (Zimmerman 2007).

Park managers at ALPO have identified eight non-native invasive species of concern that are described in more detail below (information compiled from NPS *Weeds Gone Wild* Web site http://www.nps.gov/plants/alien/index.htm). In addition, the ERMN Vital Signs Monitoring

Program (Keefer 2011) has identified nine potentially problematic taxa that are not known to occur in the park, but should be tracked to prevent their spread within the park and one species, mile-a-minute (*Polygonum perfoliatum*), that has been detected within park boundaries (Table 66). Early detection of non-native invasive plants have been shown to increase the efficacy of control measures and reduce the costs associated their treatment.

Table 66. 2010 list of plant species included in the Invasive Species Early Detection (ISED) program for the Eastern Rivers and Mountains Network (ERMN). Only *Polygonum perfoliatum* (mile-a-minute) has been detected within the park.

Scientific Name	Common Name
Cardamine impatiens	Narrowleaf bittercress
Cynanchum louiseae/*C. rossicum*	Louise's & European swallow-worts
Frangula alnus	Glossy buckthorn
Heracleum mantegazzium	Giant hogweed
Oplismenus hirtellus ssp. *undulatifolius*	Wavyleaf basketgrass
Polygonum perfoliatum (*Persicaria perfoliata*)	Mile-a-minute
Pueraria montana var. *lobata*	Kudzu
Ranunculus ficaria	Lesser celandine
Rhodotypos scandens	Jetbead
Viburnum dilatatum	Linden arrowood

Garlic Mustard (*Alliaria petiolata*) is a biennial herb in the mustard family that was likely introduced by early settlers for food and medicinal purposes (*Weeds Gone Wild Web* site: http://www.nps.gov/plants/alien/fact/alpe1.htm). First recorded in 1868 from Long Island, it is now prevalent throughout the northeastern US, as well as in scattered locations in the Midwest, Southeast, western states and Alaska. It readily invades moist to dry forest habitats, forest edges, floodplains, roadsides and disturbed lands. White-tailed deer assist in its spread by preferentially eating native plant species, leaving the garlic mustard behind.

Through aggressive colonization of natural areas, garlic mustard has displaced many native spring wildflowers and chemicals in the plant are toxic to the larvae of the native butterflies. Other chemicals have been found to affect mychorrhizal fungi associated with native trees, resulting in suppression of native tree seedling growth.

Alliaria petiolata (Chris Evans, Illinois Wildlife Action Plan)

Japanese Barberry (*Berberis thunbergii*) is a spiny, deciduous shrub that was introduced to the United States as an ornamental in 1875(*Weeds Gone Wild* Web site: http://www.nps.gov/plants/alien/fact/beth1.htm). Native to Japan, Japanese barberry is invasive throughout the northeastern US from Maine to North Carolina and west to Wisconsin and Missouri. It grows well in full sun to deep shade and forms dense stands in closed canopy forests, open woodlands, wetlands, fields and other areas.

Berberis thunbergii (Leslie J. Mehrhoff, University of Connecticut)

Japanese barberry produces abundant seeds that are eaten and subsequently spread by birds like turkey and grouse and other wildlife. Vegetative spread is through root creepers and tip-rooting branches. Where it is well established, barberry displaces many native herbaceous and woody plants. In large infestations, its leaf litter causes changes in the chemistry of the soil, making it more basic.

Celastrus orbiculatus (James R. Allison, Georgia Department of Natural Resources)

Oriental Bittersweet (*Celastrus orbiculatus*) is a woody vine or trailing shrub introduced into the United States in the 1860s as an ornamental plant (Weeds Gone Wild Web site: http://www.nps.gov/plants/alien/fact/ceor1.htm) Native to Asia, oriental bittersweet is invasive from Maine to North Carolina and west to Wisconsin and Missouri. It occurs in forest edges, open woodlands, fields, hedgerows, coastal areas, salt marshes and disturbed lands. While often found in more open, sunny sites, its tolerance of shade allows it to invade forested areas.

Oriental bittersweet forms thick masses of vines that sprawl over shrubs, small trees and other plants, producing dense shade that weakens and eventually kills them. Shrubs and trees can also be killed by girdling and by uprooting as a result of excessive weight of the vines. In the Northeast, oriental bittersweet appears to be displacing the native American bittersweet (*Celastrus scandens*) through competition and hybridization.

Lonicera japonica (Chuck Bargeron, University of Georgia)

Japanese Honeysuckle (*Lonicera japonica*) is a semi-evergreen vine introduced to Long Island, New York, in 1806 for ornamental, erosion control and wildlife uses (*Weeds Gone Wild* Web site: http://www.nps.gov/plants/alien/fact/ceor1.htm). Native to eastern Asia, Japanese honeysuckle is now one of the most recognizable and well established ornamental vines in the US. It is documented to occur and reported to be invasive throughout the eastern US from Maine to Florida and west to Wisconsin and Texas, with scattered occurrences in the Southwest. It is adapted to a wide variety of habitats from full sun to shade.

Japanese honeysuckle is fast-growing, twining around stems of shrubs, herbaceous plants and other vertical supports. In full sun it forms large tangles that smother and kill vegetation. It can kill shrubs and saplings by girdling

Shrub Honeysuckles (*Lonicera morrowii* and *L. maackii*) were imported from Asia in the 1800s as ornamentals and subsequently widely planted for both soil erosion control and wildlife food and cover (*Weeds Gone Wild* Web site: http://www.nps.gov/plants/alien/fact/loni1.htm). Today, they are common inhabitants of natural areas as well as managed parks, gardens and other lands. Shrub honeysuckles invade forest edges and interiors, floodplains, pastures, old

Lonicera morrowii (Leslie J. Mehrhoff, University of Connecticut)

fields, roadsides and other disturbed areas where they can form dense thickets, outcompeting and displacing native shrubs, trees and herbaceous plants. Their dense growth can impede reforestation efforts. Birds and mammals readily disperse the seeds, facilitating their spread.

The prevalence of shrub honeysuckles has had detrimental effects on native bird populations. Shrub honeysuckles have been implicated in increased nest predation due to their branching structure. In addition, compared to native shrubs, the fruits of shrub honeysuckles provide inadequate nutrition to sustain migrating birds.

Japanese stiltgrass *(Microstegium vimineum*) is a small, annual grass that was introduced into the United States in 1919 (*Weeds Gone Wild* Web site: http://www.nps.gov/plants/alien/fact/mivi1.htm). Native to Japan, Korea, China, Malaysia and India, its introduction is thought to have resulted from its use as a packing material for porcelain. It is currently established in 16 eastern states, from New York to Florida, occurring on stream banks, river bluffs, floodplains, emergent and forested wetlands, moist woodlands, early successional fields, uplands, thickets, roadside ditches, and gas and power-line corridors. It can be found in full sun to deep shaded forest conditions and is associated with moist, rich soils that are acidic, neutral or basic and high in nitrogen.

Microstegium vimineum (Chuck Bargeron, University of Georgia)

Stiltgrass readily invades shaded areas, forming dense colonies that threaten native vegetation. Disturbances including natural scouring in floodplains, areas subject to mowing and tilling and even white-tailed deer traffic facilitate its spread.

Multiflora rose (*Rosa multiflora*) is a large, multi-stemmed shrub native to Japan, Korea and eastern China (*Weeds Gone Wild* Web site: http://www.nps.gov/plants/alien/fact/romu1.htm). Introduced initially in 1866 as rootstock for ornamental roses, multiflora rose was later promoted for use in erosion control, as “living fences” to contain livestock, and as cover for wildlife. More recently, it has been planted in highway median strips to serve as crash barriers and reduce automobile headlight glare. Since its introduction, multiflora rose has aggressively colonized pasture and unplowed lands, where it disrupts cattle grazing, as well as natural habitats. Dense thickets exclude most native shrubs and herbs from establishing and may be detrimental to nesting of native

Rosa multiflora (James H. Miller, USDA Forest Service)

birds. It is designated a noxious weed in several states, including Iowa, Ohio, New Jersey, Pennsylvania and West Virginia.

Multiflora rose tolerates a wide range of soil, moisture and light conditions. As a result it readily colonizes a variety of habitats including forests, prairies, and some wetlands. An average plant produces an estimated one million seeds per year, which remain viable in the soil for up to 20 years. Seed dispersal is via a variety of birds that eat the fruit (hip).

Japanese Knotweed and Giant Knotweed *(Polygonum cuspidatum, Polygonum sachalinense*) are shrub-like herbaceous perennial plants that were introduced as ornamentals in the late 1800s (*Weeds Gone Wild* Web site http://www.nps.gov/plants/alien/fact/faja1.htm) These two species are grouped together because of the difficulty in identifying each species and their hybrids. Native to Eastern Asia, knotweed has also been planted for erosion control and used for landscape screening, facilitating its spread. Knotweed is invasive throughout the northeastern US, south to northeast Georgia and west to Missouri.

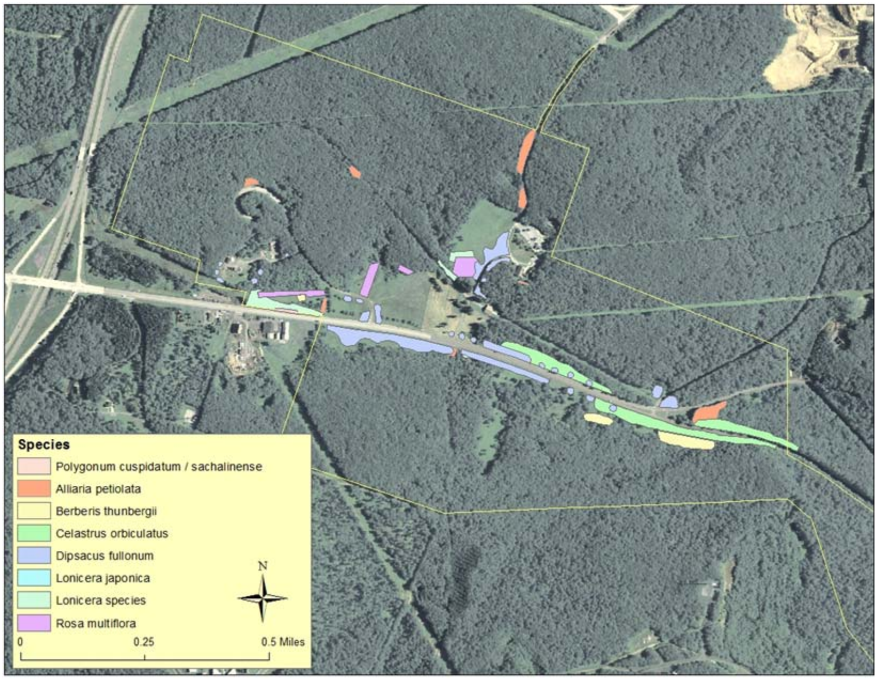
Polygonum sachalinense (Tom Heutte, USDA Forest Service)

Knotweed is commonly found near sources of water (streams, rivers, ditches) where it forms dense thickets to the exclusion of native species. Knotweed can tolerate a wide variety of conditions including deep shade, high salinity, high heat and drought. In riparian areas it is particularly problematic as it rapidly colonizes scoured shores and islands and once established, is extremely difficult to eradicate.

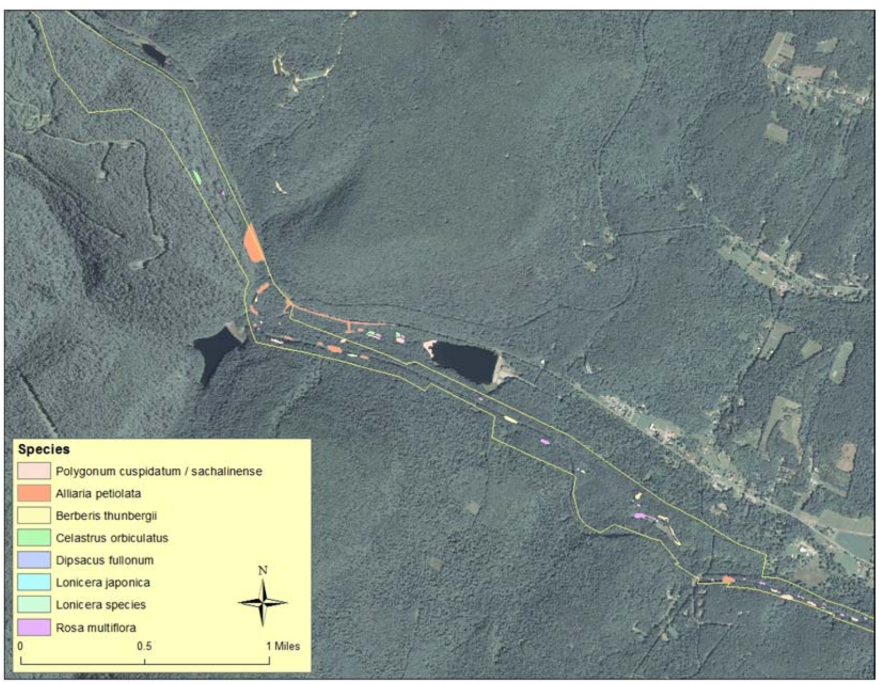
Melton (1982) documented the earliest occurrence of three of the aforementioned non-native invasive plant species within park boundaries: garlic mustard (*Alliaria petiolata*), Japanese knotweed (*Polygonum sacheliense*), and oriental bittersweet (*Celastrus orbiculatus*). In 1999, inventory and mapping was undertaken by park staff to identify and map any large infestations of major non-native plant populations at ALPO (Figure 60).

At the Main Unit of ALPO (StapleBend Tunnel was not mapped), staff mapped garlic mustard, Japanese honeysuckle and oriental bittersweet. Subsequent studies by Grund and Bier (2000) and

Western Pennsylvania Conservancy (2003) although focusing on species of special concern, documented the presence of target non-native invasives within park boundaries.

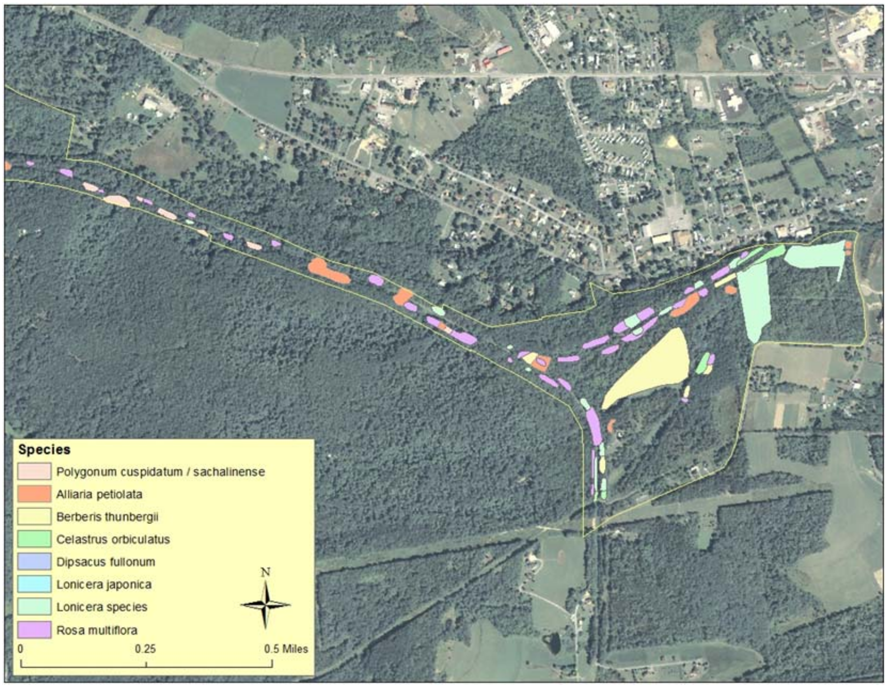


a.)



b.)

Figure 60. Non-native plant populations mapped by park staff in 1999 at the a) Summit area, b) Inclines, and c) Foot-of-Ten area of ALPO's Main Unit. The SBTU was not mapped.



c.)

Figure 60 (cont'd). Non-native plant populations mapped by park staff in 1999 at the a) Summit area, b) Inclines, and c) Foot-of-Ten area of ALPO's Main Unit. The SBTU was not mapped.

The first formal inventory of non-native invasive plant species was undertaken by Zimmerman in 2005-2006 (Zimmerman 2007). He sampled 200- 25-m radius circular plots throughout the park and recorded the both presence and abundance of non-native taxa. In addition, presence and abundance was assessed along 50m transects for trails and other common transportation corridors within the park. Ninety-two non-native species were identified with 12 listed as a serious threat and seven as a moderate threat. From 2007-2011, Perles et al. (2010 and additional unpublished data) collected plant data at 24 long-term monitoring plots as part of the ERMN Vital Signs Monitoring Program. This latter study provides the most up-to-date assessment of non-native invasive species within park boundaries.

Methods

The ERMN monitoring data set (Perles et al. 2010 and additional unpublished data) was used to estimate condition. This data set includes 24 sample plots within the eight forest associations categorized by Perles et al. (2007). For each vegetation association, we calculated two metrics, the average number of target non-native invasive species by plot and the overall percentage of non-native species in each association. To determine condition for target non-native invasive plant species we used a rating system established for the NETN Vital Signs Program (Miller et al. 2010) (Table 67). For the percentage of non-native species by association, we trisected the data into three condition categories (Table 68).

Table 67. Condition categories for target non-native invasive species by plot based on the thresholds defined by the NETN Vital Signs Program.

Average Target Non-Native Invasive Species/Plot	Condition	Symbol
< 0.5 target species/plot	Good Condition	(green circle)
0.5 to < 3.5 target species/plot	Moderate Concern	(yellow circle)
≥ 3.5 target species/plot	Significant Concern	(red circle)

Table 68. Condition categories percentage of non-native species.

% Non-Native Species	Condition	Symbol
0	Good Condition	(green circle)
> 10 - 20	Moderate Concern	(yellow circle)
> 20	Significant Concern	(red circle)

Current Condition and Trends

In the ALPO Main Unit, associations with the greatest percentage of non-native flora were Successional Old Field and Northern Red Oak-Northern Hardwood Forest, respectively, followed by Northern Hardwood Forest and Modified Successional Forest (Table 69). These associations also scored highest for the number of target invasive species per plot. In the SBTU, the Tuliptree-Beech-Maple Forest Association had higher numbers of non-native species as well as target invasives (Table 70). Multiflora rose and Japanese barberry are the most widespread target non-native invasive species, occurring at almost one quarter of all plots sampled, while knotweed occurred in all plots sampled in the Staple Bend Tunnel Unit. No new target invasive species were recorded at ALPO by the vegetation monitoring crew or park personnel in 2008 or 2009.

Table 69. Non-native invasive plant species metrics for the eight forest associations in ALPO Main Unit.

ALPO Main Unit Metrics	Allegheny Hardwood Forest (n=4)	Dry Eastern Hemlock - Oak Forest (n=1)	Eastern Hemlock - Northern Hardwood Forest (n=3)	Modified Successional Forest (n=2)	Northern Hardwood Forest (n=7)	Northern Red Oak - Northern Hardwood Forest (n=2)	Successional Old Field (n=2)
# of Target Species	0	0	0.3	1.5	1.3	3	1.5
% Non-Native Species	3	0	5	12	15	26	22

Table 70. Non-native invasive plant species metrics for the two forest associations in Staple Bend Tunnel Unit.

SBTU Metrics	Allegheny Hardwood Forest (n=2)	Tuliptree - Beech - Maple Forest (n=1)
# of Invasive Target Species by Plot	1	2.5
% Non-Native Species	2	7

All vegetation associations scored similarly for both metrics. Three of the forest associations within ALPO Main Unit scored *good* for non-native invasive species (Table 71). The Dry Eastern Hemlock-Oak Forest and Allegheny Hardwood Forest association had no non-native invasive species present. However, the Allegheny Hardwood Forest association supports Oriental ladysthumb (*Polygonum cespitosum*) a potentially invasive species and the Eastern Hemlock-Northern Hardwood Forest Association supports Japanese stiltgrass (*Microstegium vimineum*), one of the target non-native invasives species at ALPO.

Four forest associations scored *moderate concern* for target non-native invasive species. The Northern Hardwood Forest unit, in addition to supporting five of the eight target species, contains more non-native species (21) than any other association. The Modified Successional Forest and Northern Hardwood Forest also contain one or more target invasive species.

The Northern Red Oak – Northern Hardwood Forest and Successional Old Field associations scored from *moderate concern* to *significant concern*. At least one stand classified as Northern Red Oak – Northern Hardwood Forest in the Foot-of-Ten area of the park is at particular risk for further degradation. Of the eight target non-native invasive species identified by the park, the plot sampled in this area contained six.

While dense vegetation may inhibit or slow the spread of invasives, the presence of bare ground naturally or via disturbance will facilitate the spread of these opportunistic plants and condition will diminish. In forested areas of the park, the herbaceous layer is sparsely vegetated and, therefore, long-term management is recommended to control these species and prevent them from expanding and infesting other areas of the park.

Table 71. Condition Assessment Metrics for ALPO Main Unit Forest Associations

ALPO Main Metrics	Allegheny Hardwood Forest (n=4)	Dry Eastern Hemlock - Oak Forest (n=1)	Eastern Hemlock - Northern Hardwood Forest (n=3)	Modified Successional Forest (n=2)	Northern Hardwood Forest (n=7)	Northern Red Oak - Northern Hardwood Forest (n=2)	Successional Old Field (n=2)
# of Invasive Target Species by plot	Green	Green	Green	Yellow	Yellow	Yellow	Yellow
% Non-Native Species	Green	Green	Green	Yellow	Yellow	Red	Red

In the SBTU, the Tulip Tree-Beech-Maple Forest and Allegheny Hardwood Forest vegetation units were both scored as a *moderate concern* for target invasive species (Table 72). For percent non-native species, both Allegheny Hardwood Forest and Tulip Tree-Beech-Maple Forest vegetation units scored as *good* condition.

Because all of the non-native species in the Tulip Tree-Beech-Maple Forest vegetation unit are also target invasive species, this unit is at risk for decreasing condition. In contrast, knotweed is the only non-native species identified in the Allegheny Hardwood Forest vegetation type. Active management of this plant has greatly decreased its occurrence and spread and its removal and control along Park trails is a top priority (Kathy Penrod pers. comm.).

Table 72. Condition Assessment Metrics for Staple Bend Tunnel Unit Forest Associations.

Staple Bend Tunnel Metrics	Allegheny Hardwood Forest (n=2)	Tuliptree - Beech - Maple Forest (n=1)
# of Invasive Target Species by Plot	Yellow	Yellow
% Non-Native Species	Green	Green

<u>Data Gaps and Level of Confidence</u>

The confidence in the condition assessment was *low* to *medium*. Because vegetation studies within ALPO (Melton 1982, Grund and Bier 2000, WPC 2003, Zimmerman 2007, Perles et al. 2007) used different sampling methods, varying sample sizes, and both qualitative and quantitative data sets, we did not attempt to use this data to elucidate condition or report on trends. Instead, we chose to use the Perles et al. Vital Signs monitoring data (2010 and additional unpublished data). Using a single data set eliminates many of the problems associated with merging multiple studies, however, the small sample size constrains data interpretation and does not allow an analysis of trends.

Vital Signs monitoring is conducted annually. To date, 24 randomly-placed plots (6 per year) have been sampled in forested areas within the Park with 21 plots located in the ALPO Main Unit and three in the SBTU. This data set, albeit small and exclusive to forested habitats, provides a preliminary snapshot of overall condition for most forest associations within the park and can be used as a baseline for monitoring and control efforts.

Protocols developed by ERMN's Invasive Species Early Detection (ISED) Program (Manning and Keefer, 2013) can be used to detect incipient populations invasive species, while other methods are available to identify and address established (target) invasive species (USFWS Managing Invasive Plants – Concepts, Principles and Practices;
http://www.fws.gov/invasives/stafftrainingmodule/assessing/inventory.html

Sources of Expertise
Kathy Penrod, Natural Resource Specialist Allegheny Portage Railroad NHS/Johnstown Flood National Memorial

Stephanie Perles, Plant Ecologist, Eastern Rivers and Mountains Network, National Park Service.

4.6 Landscapes

4.6.1 Land Use, Patterns, and Fragmentation

Relevance and Context
Land conversion to anthropogenic land covers is progressing in the eastern United States thus making land use planning ever more important. Trends beginning during the early 1980s show the majority of land conversion in the Mid-Atlantic states is from agricultural lands (pasture and row crop) to developed (suburban and urban) lands (NRCS 2000). Total conversion of forest cover has slowed with some states showing small increases in total forest cover. What remains to be studied is the condition of the forest that remains. Goodrich et al. (2002) reported that, based on 1992 land cover data, approximately 65% of Pennsylvania was forested but of that 65% forest cover, 57% of that forest would be considered edge forest. Bishop (2008) examined edge forest and fragmentation further and noted a 16% increase in edge forest area from 1992 and 2001 as well as an increase in the quantity of small forest patches those between 1 and 10 ha. After further analysis it was discovered that most of the small patches present in 1992 had been converted to non-forest cover revealing that most of the 2001 small forest patches had been connected to larger forest areas (> 10 ha) in 1992.

Habitat fragmentation has been described as the breakup and conversion of extensive habitats into smaller isolated habitat fragments too small to support their original species compositions (MacArthur & Wilson 1967; Myer 1994). Harris (1984) notes two components of fragmentation as: (1) conversion of natural habitat in a landscape to other covers; and (2) separation and isolation of the remaining natural habitat into smaller patches. As fragmentation progresses, maintaining connectivity of habitats becomes critical to the sustainability of the wildlife populations found within a landscape (Bennett 2003). A species ability to move and utilize appropriate habitats is critical to that species survival (Hanski 1999). Disturbances can alter this balance by affecting a species ability to move in a landscape. Natural disturbances are temporary, often ecologically necessary, impacts that can cause shifts within an ecological system (e.g., fire, wind). Following a natural disturbance, under natural conditions, animal species shift their habitat use to adjacent areas (Garton 2002). However, anthropogenic disturbances often are permanently maintained conditions interfering with natural regeneration and previously resident species are prevented from re-colonization, thus permanently altering species composition (Pickett & Rogers 1997). As anthropogenic disturbance occurs and expands it becomes more difficult for the original resident population of a species to find appropriate habitat. Studies have shown that as fragmentation increases, it will eventually isolate habitats making it difficult for wildlife to forage and disperse among the remaining habitat patches (Harris 1988; Bennet 2003; ELI 2003; Keller & Yahner 2007).

Edge effects, one byproduct of fragmentation, are an important consideration for land management. Edge forest occurs where natural habitats meet a disturbance such as a road or suburban housing. Natural habitats are further influenced at these junctures even though the natural habitat still exists. Edge effects are caused by the varying amounts of light, humidity, and wind that are different than those found in habitat interiors. These disturbed areas are also more susceptible to pest and predator species as well invasive plant species that can subsequently have negative impacts on habitat interiors (Primack 1993, ELI 2003).

Methods

Studies have shown that landscape condition (e.g., composition, fragmentation and pattern) directly reflects habitat health and resistance to change (Turner 1989, Angermeier and Karr 1994, Debinkski and Holt 2000). Bishop (2008) reported that areas in Pennsylvania experiencing forest fragmentation were more likely to continue to fragment and Brooks et al. (2004 & 2009) demonstrate that percent forest and forest pattern within a watershed predict water quality and wetland condition. We used three spatial data sets to help judge the conditions in and near ALPO. Pennsylvania land cover data from the National Land Cover Dataset (NLCD) were used to calculate landscape metrics that inform fragmentation levels. This classified 30 m x 30 m Landsat data are available from 1992, 2001 and 2006. These data were manipulated, for Bishop (2008), and specifically classified to differentiate core vs. edge forest, edge forest is defined as forest that is within 100 m of a disturbed land cover (Robbins et al. 1989; Bishop 2008). The last data included were roads data acquired from the US Census Bureau and used to tabulate road density.

To get a better understanding of current and recent conditions potentially affecting ALPO we looked at the landscape conditions from within three boundaries; 1) ALPO park boundary; 2) a 1 km buffer distance around ALPO; and 3) the 30 km buffer distance established by NPScape (Monahan et al. 2012). By using three assessment zones a more complete understanding of conditions surrounding the park can be included to help predict possible future and guide management. However, we only used the park plus the 1-km buffer results or the catchment results to establish landscape condition

(Tables 74 and 75). These three scales help to separate conditions as well as the stressors affecting the conditions and help to target management activities. To guide our work we focused on the 1 km buffer zone immediately adjacent to the park boundary considering that area to be the most important to continued health of the natural habitats contained within the park boundary. We also calculated landscape metrics for the two catchment areas: Blair Gap Run for the Main Unit of ALPO and the Little Conemaugh River above the SBTU to better understand the landscape's influences on water quality. We used catchment to determine condition for the developed landscape metric.

With guidance from ELI (2003), Wardrop et al. (2007), Bishop (2008), Brooks et al. (2009) we focused on Forest Percent, and Road Density as the primary landscape metrics and then we used Core Forest Percent as a modifier and indicator of increased edge forest. Following Brooks et al. (2009) a road density index was calculated within each of the three boundaries, dividing total length of road (meters) by the surface area of each boundary (hectares) and then scaling the values between zero and one (0-1) where zero reflects poor conditions caused by roads and the value of one reflects little to no adverse conditions caused by roads. We also included Percent Developed (non-forest) in the two catchment areas to account for the increased surface runoff from developed lands. Due to the number of potential landscape metrics a complete Trends Analysis was not completed for the landscape metrics and review of Tables 74 and 75 will, however, reveal the differences reported by our three land cover data layers.

While the landscape condition assessment was based on the NLCD land cover data we also preformed additional analysis using a series of historical aerial photographs. Aerial photographs from 1939, 1994 and 2006 were collected, georeferenced (when necessary), and interpreted following an Anderson Level 2 classification. Interpretation was completed for the three years for the area inside the 1-km buffer zone around ALPO's Main Unit.

<u>Reference Condition</u>

Table 73. Metrics and the condition ratings that we used to assess current conditions in the three areas. As previously mentioned, while we did not conduct a complete trends assessment, we did evaluate change in % core forest over time and used that as a modifier of % forest.

EXTENT	METRIC	CONDITION RATING		
		Good	***Moderate Concern***	***Significant Concern***
1-km	% Forest	> 50%	25 - 50 %	< 25%
	% Core Forest	Modifier: Decreasing trend in amount of core forest within 1-km surrounding the park lowers % Forest metric by one condition category for % forest <60%		
	Road Density	> 0.66	0.34 - 0.66	0 - 0.33
Catchment	% Developed Land	< 10%	10 - 15%	>15%

Current Condition and Trends

Land cover conditions appear stable both inside the park boundary as well as within the 1 km buffer zone. Percent forest dropped in the Main Unit of ALPO from 90.26 %, in 1992 to 87.43 % in 2006 within the ALPO boundary and from 81.86 % to 80.24 % inside the 1 km buffer (Table 74). The SBTU showed a greater loss in forest percent dropping from 96.37 % in 1992 to 88.14 % in 2006 within the park boundary and from 78.92 % to 68.61 % in the 1 Km buffer zone (Table 75)(Fig. 61 & 62). Core forest dropped approximately 10 %, from 56.07 % to 46.17 % in the Main Unit of ALPO and it dropped 4 % from 47.94 % to 43.71 % inside the 1 km zone of the Main Unit. The Staple Bend Unit had 70.28 % core forest in 2006 but only had 30.09 % core forest in the 1 km buffer zone (Fig. 63& 66). The road density index is also showing increases during the same 14 year period, see Table 75 for details. Although not used in the condition assessment, we also provide landscape results for a 30-km buffer surrounding the park (Table 76).

Table 74. Summary land cover metrics for ALPO's Main Unit covering three time periods (1992, 2001, and 2006) and the three spatial extents used in the study (within park, 1-km area surrounding park, and watershed/catchment). All values are percentages and shaded values represent those from the 2006 data directly used to establish condition.

	PARK BOUNDARY			PARK + 1-km BUFFER			CATCHMENT		
CLASS	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**
Water	0.13	0.11	0.11	0.53	0.52	0.52	0.14	0.37	0.44
Developed	0.85	10.20	10.20	5.18	11.87	11.87	0.46	2.29	3.65
Barren	0.00	0.00	0.00	0.76	0.08	0.08	0.21	n/a	n/a
Agriculture	8.77	3.06	2.26	11.67	7.70	7.25	4.06	7.89	10.01
Forest	90.26	86.63	87.43	81.86	79.83	80.24	87.95	86.35	85.71
Core Forest	56.07	45.52	46.17	47.94	46.07	43.71	62.74	63.08	59.49
Road Density	0.9091	0.8874	0.8713	0.898	0.8529	0.8529	0.959	0.9246	0.925

Table 75. Summary land cover metrics for ALPO's SBTU covering three time periods (1992, 2001, and 2006) and the three spatial extents used in the study (within park, 1-km area surrounding park, and watershed/catchment). All values are percentages and shaded values represent those from the 2006 data directly used to establish condition.

	PARK BOUNDARY			PARK + 1-km BUFFER			CATCHMENT		
CLASS	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**
Water	2.35	8.23	8.23	3.81	5.35	5.35	0.83	1.07	1.13
Developed	0.21	2.67	2.67	1.59	13.47	13.47	1.72	5.16	9.20
Barren	0.96	0.96	0.96	11.96	3.03	2.20	1.35	n/a	n/a
Agriculture	0.11	0.00	0.00	3.72	9.99	10.37	20.44	25.56	21.48
Forest	96.37	88.14	88.14	78.92	68.16	68.61	62.61	64.24	67.17
Core Forest	*	76.43	70.28	*	29.49	30.09	30.02	35.22	37.27
Road Density	0.8268	0.9905	0.9911	0.8851	0.8761	0.8767	0.8933	0.8521	0.8522

Table 76. Summary land cover metrics for the 30-km buffer surrounding ALPO covering three time periods (1992, 2001, and 2006). Due to considerable overlap between buffers, we did not calculate the Main Unit and SBTU separately. This information is provided as comparison to the other spatial extents shown in Tables 74 and 75. All values are percentages.

	PARK + 30-km BUFFER		
CLASS	**1992**	**2001**	**2006**
Water	0.90	1.10	1.06
Developed	2.83	9.40	9.52
Barren	1.68	0.80	0.95
Agriculture	21.44	19.00	18.65
Forest	73.15	69.60	69.82
Core Forest	32.15	34.36	36.42

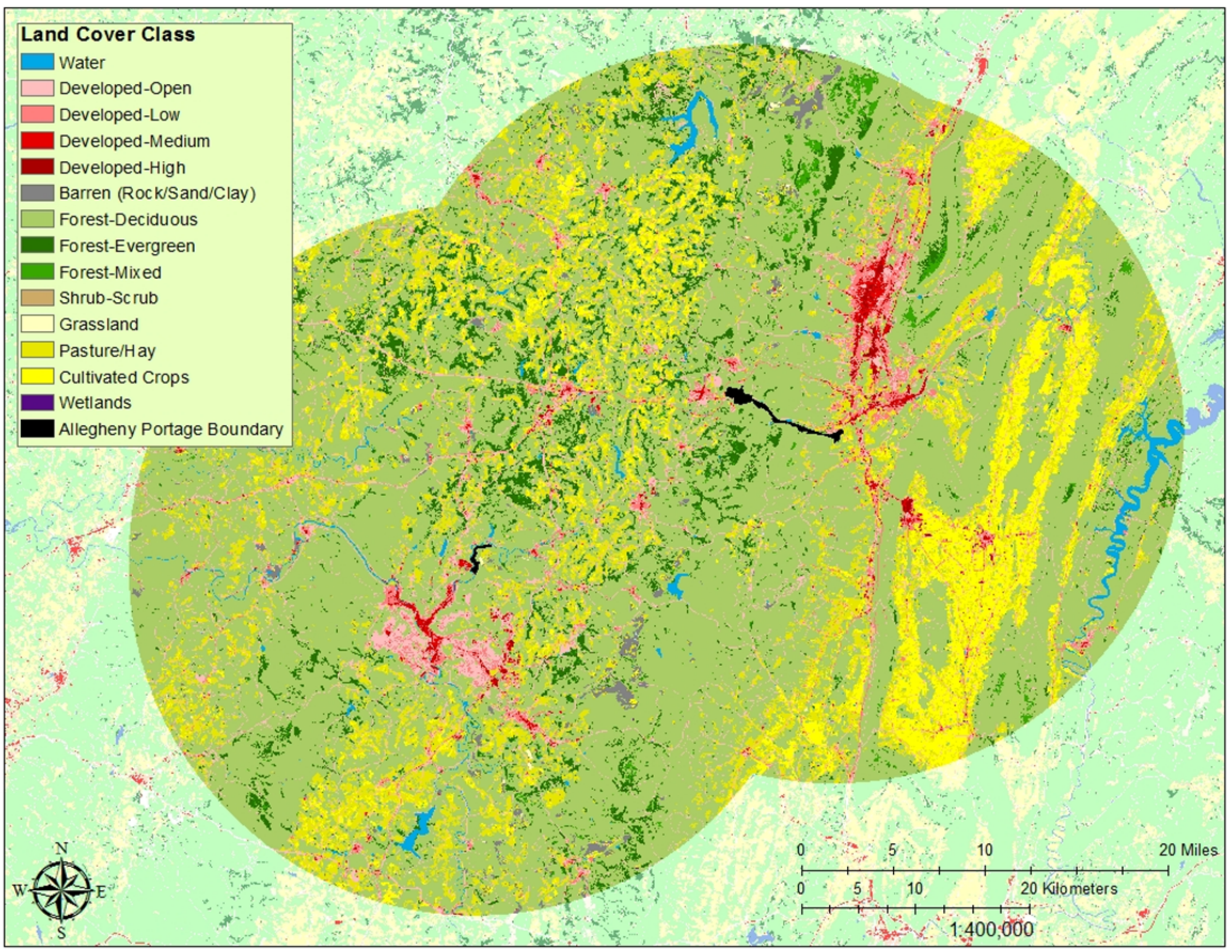


Figure 61. Depiction of the NLCD Land Cover for the 30 km zone around ALPO. This version shows the larger landscape view and helps to illustrate its proximity to urbanized areas like the city of Altoona located NE of the park Main Unit and the city of Johnstown to the SW of the SBTU.

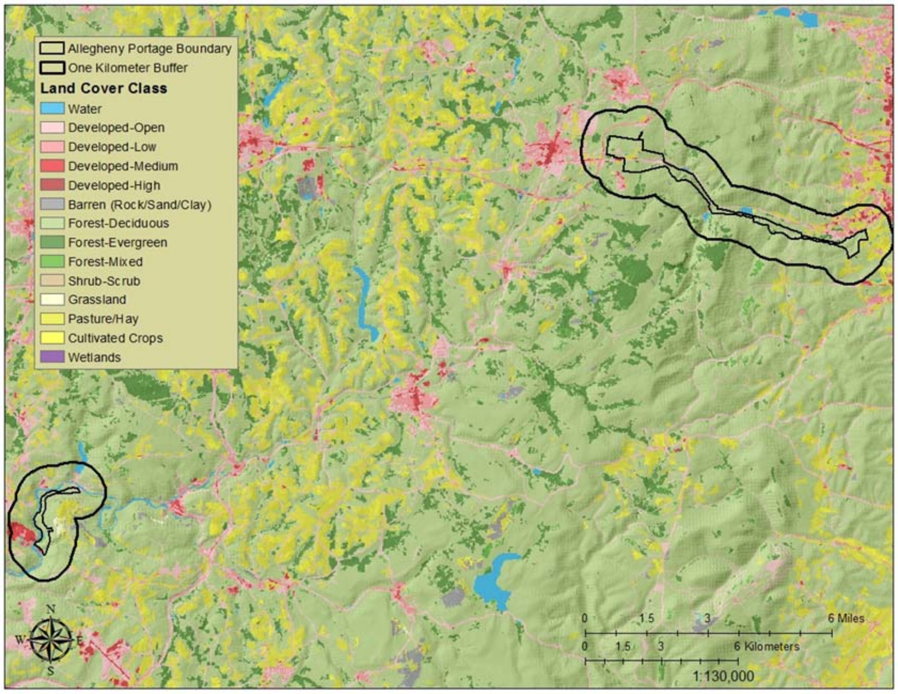


Figure 62. This graphic shows the NLCD Land Cover “zoomed in” on ALPO to better interpret the land cover conditions in and near to each of the parks’ units; Main Unit in the NE (upper right) and the SBTU in the SW (lower left). The second boundary represents the 1 km buffer zone used to help evaluate conditions near to the park.

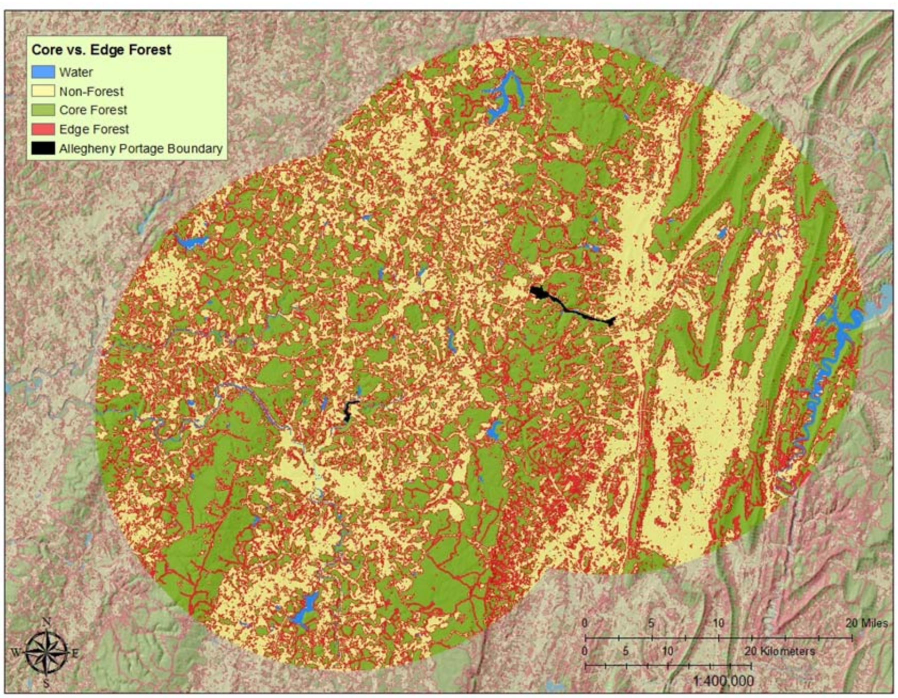


Figure 63. This mapped version of the NLCD Land Cover shows the value-added data isolating Core vs. Edge Forest in the 30 km buffer zone around ALPO. Edge forest is that forested cover found within 100 meters of a disturbance, such as agriculture and roads.

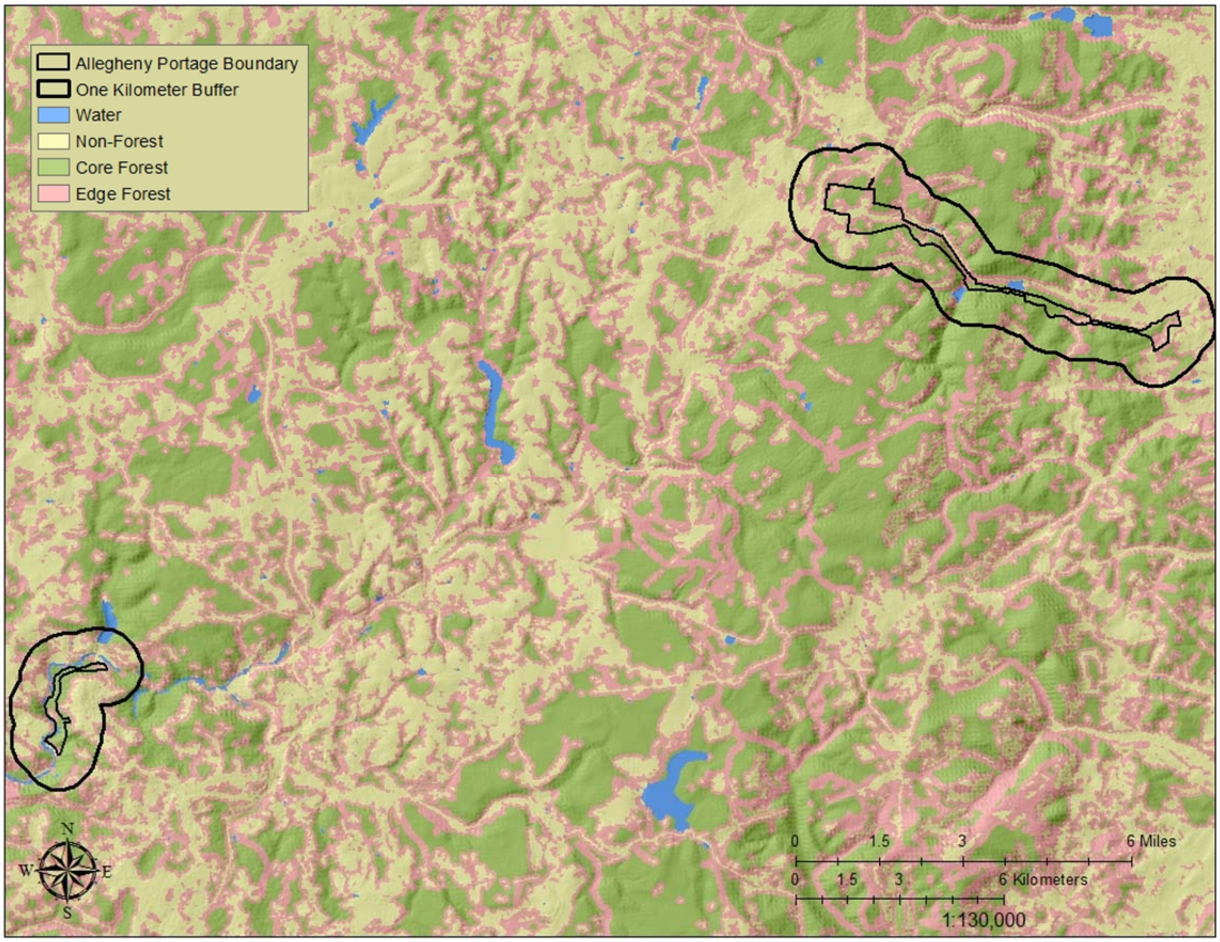
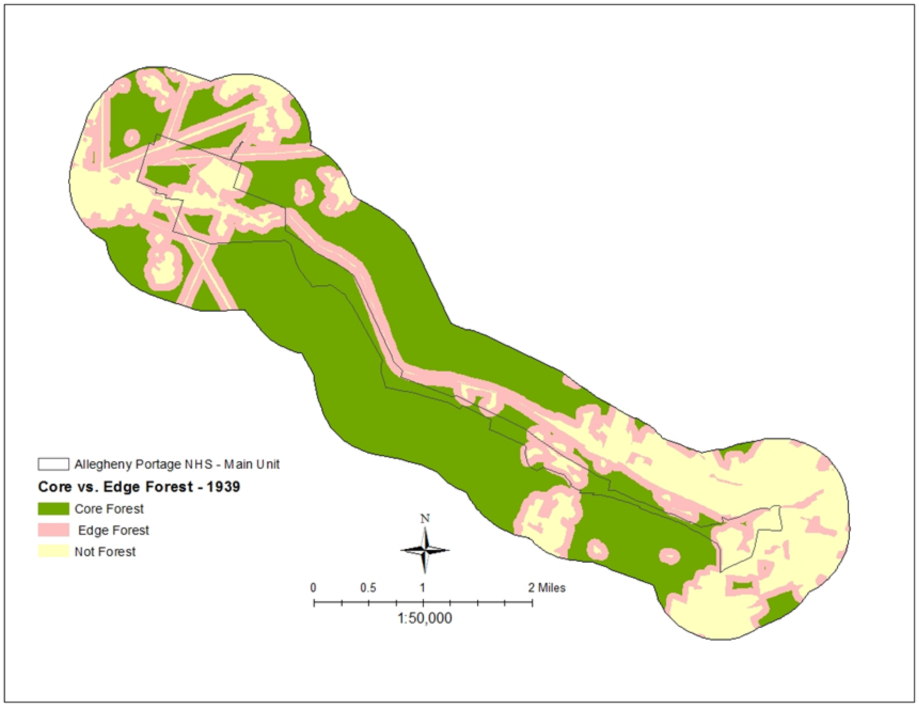


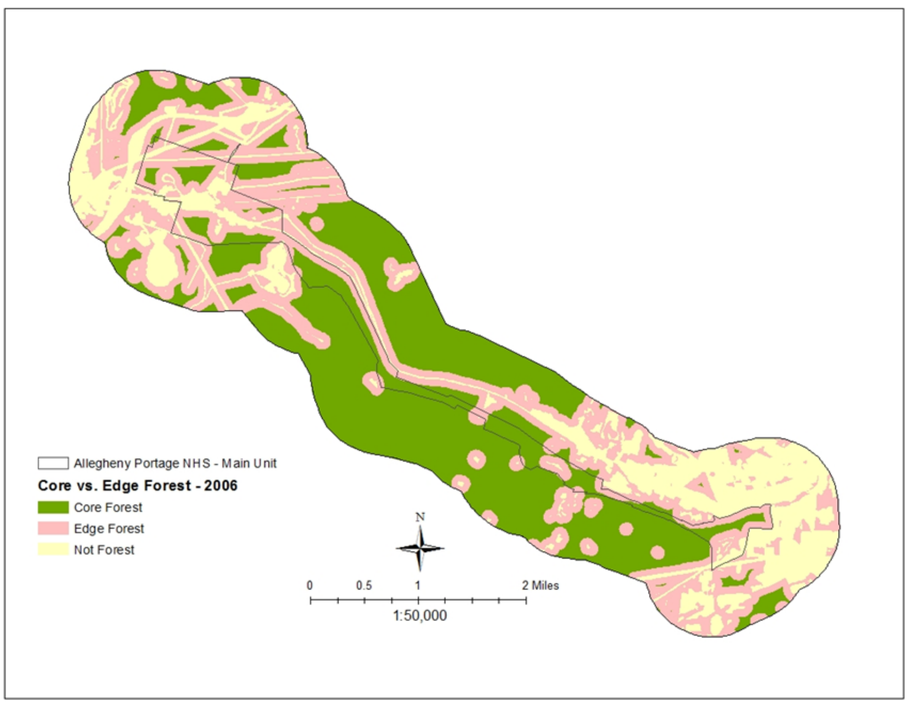
Figure 64. This image is a "zoomed in" version of the "Core vs. Edge Forest distinction for the areas inside and near ALPO. The extra boundary represents the 1 km buffer zone around each of the parks units.

Historical Photo Interpretation for ALPO's Main Unit

As a means for comparison we also used photo interpretation to study land use within the 1-km buffer zone around the Main Unit of ALPO. Digital aerial photographs from 1939, 1994 and 2006 were interpreted into an Anderson Level 1 & 2 classification (Anderson et al, 1976). Results of this analysis had no effect on the condition reported by the coarser scaled NLCD data it did offer a more precise view of land use in and near ALPO's Main Unit and it allowed for land use to be tracked back to 1939. Based on this scale of interpretation percent forest increased from 74.26 % in 1939 to 77.08 % in 2006 and, following state-wide trends, while total forest increased near the ALPO the percent of core forest decreased from 50.36 % in 1939 to 42.08 % in 2006 indicating an increase in forest fragmentation in and near ALPO's Main Unit (Figure 65).



a.)



b.)

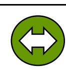
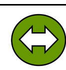
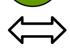
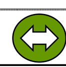
Figure 65. This image is land use within 1-km buffer zone around the Main Unit of ALPO from a) 1939 and b) 2006 that was classified into three categories to aid fragmentation analysis. This separates core forest and edge forest with edge forest defined as the area within the first 100 m into a forest from a disturbance.

Table 77. Summary land cover metrics from interpreted aerial photography for ALPO's Main Unit covering two time periods (1939 and 2006) within 1-km area surrounding park.

Land Use	Hectares 1939	Acres 1939	Percent 1939	Hectares 2006	Acres 2006	Percent 2006
Agriculture	608.64	1542.15	18.32	142.27	351.56	4.28
Forest	2467.74	6097.91	74.26	2561.42	6329.41	77.08
Developed	117.69	290.81	3.54	438.53	1083.63	13.20
Barren	N/A	N/A	N/A	43.12	106.55	1.30
Shrubland	119.94	296.38	3.61	120.08	296.72	3.61
Water	9.03	22.31	0.27	17.59	43.46	0.53
Core Forest	1673.47	4135.24	50.36	1398.20	3455.02	42.08

Table 78shows the condition assessment results for the landscape metrics calculated at a 1-km buffer around the park (% forest, % core forest, and road density index) and % developed land within the catchment area. All metrics scored in *good* condition. The percentage of core forest did not change dramatically for either unit of the park. It decreased slightly at the Main Unit and remained relatively unchanged at the SBTU. Although % developed land increased at both units, only the Main Unit experienced a significant increase corresponding to a *deteriorating* trend.

Table 78. Condition assessment results for landscape metrics at ALPO's Main Unit and SBTU.

		CONDITION RATING	
EXTENT	**METRIC**	**MAIN UNIT**	**SBTU**
1-km	% Forest		
	% Core Forest		
	Road Density		
Catchment	% Developed Land		

<u>Data Gaps and Level of Confidence</u>

Data for the landscape analyses are derived from geospatial data sources and evaluated by internal accuracy standards adopted by each host agency, roads by the US Census Bureau, and the NLCD by the US Geological Survey. The most important of the two to this study, the NLCD Land Cover, when used at the Anderson Level 1 classification (Anderson et al. 1976) reports accuracies at, or above, 85% (Bishop 2008). For this study we are enhancing the interpretation accuracies by combining data layers (i.e., roads with land cover) and adding value to the land cover by re-classifying it to reveal Core Forest vs. Edge Forest. For these reasons we have a *medium* to high level of confidence in these results.

<u>Sources of Expertise</u>

Joseph Bishop, Research Associate, GeoSpatial Coordinator, Riparia, Department of Geography, Pennsylvania State University.

Chapter 5 Discussion

Condition assessment results are first presented by resource in order to compile information for the data sources and references used to assess the condition of each indicator (Tables 79 – 89).

For regional resources or resources that extend beyond park boundaries (i.e., air quality) or represent drivers of ecosystem change (i.e., weather and climate), condition results must be presented and interpreted at much larger spatial scales. The condition or state of these resources are largely beyond a park's ability to control, however, they are important to monitor in order to understand the actual or probable impacts to other, more manageable natural resources within or immediately surrounding the park in order to develop feasible management plans or strategies to minimize or even prevent these impacts and, thus, maintain or improve the condition of resources within the park.

For local park resources, the condition assessment is best interpreted and managed by park unit, specifically the Main Unit and the SBTU. Very few management actions and strategies are applied park-wide but are instead tailored to site-specific issues (e.g., threats, impacts, and important resources). Thus, we find these results to be far more useful if they are scaled up within each of these units, rather than park-wide, especially given the large distance between their locations. In some cases, the nature of the data and other information used in the assessment prohibited scaling up by park unit. In these instances, we reported results park-wide. Although landscape-level indicators also extend beyond park boundaries, landscape condition results may vary by park unit and should be evaluated within this context in order to properly characterize natural resource conditions throughout the park and within each unit. As with the regional resources, these summaries describe the rationale, reference criteria, and data sources, and are organized by resource/indicator. The only difference is that they include separate results for the Main Unit and SBTU.

To facilitate interpretation of these results within each park unit, we also provide separate summary tables for the Main Unit and the SBTU (Tables 88 and 89). The final section of this chapter identifies data gaps with respect to important resources or threats (present and imminent) for which the park has limited or no data and does not currently monitor.

5.1 Air Quality

Air quality, although beyond the ability of the park to control, is an important concern to ALPO. Important indicators include total wet deposition of nitrogen (N) and sulfur (S), mercury (Hg), ozone, and visibility. In addition, night skies and soundscapes are also important natural resources to the park.

Table 79. Summary results for air quality at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving (*upward arrow)*, unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

AIR QUALITY			**Wet deposition of nitrogen, sulfur, and mercury are of *significant concern* with the former demonstrating improvement in condition**	
Indicator of Condition	**Specific Measure**	**Condition Status/Trend**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Ozone	5-year average of the 4th highest ozone concentration		Ozone concentration estimates were between 61 - 75 ppb, exceeding the US EPA's standards for human health and warranting *moderate concern*[1]	≤ 60 ppb[2]
	Sum06		Ozone exposure (SUM06) was considered *moderate concern* at 13.1 ppm-hrs	< 8 ppm-hrs[3]
	W126		Ozone exposure (W126) was considered *moderate concern* at 10.3 ppm-hrs	< 7 ppm-hrs[3]
Visibilty	average current visibility - estimated average natural visibility		The most recent ALPO 5-year average of visibility was 11.4 dv, which is > 8 dv warranting *significant concern*[1]	2 dv[2]
Wet Deposition	N - (NH_4 + NO_3) (kg/ha/yr)		NPS-ARD and PA13 data were > 3 kg/ha/yr indicating *significant concern* for wet nitrogen deposition[1,4]	< 1 kg/ha/yr[2]
	S - (SO_4) (kg/ha/yr)		Both the NPS-ARD estimate and the PA13 data were > 3 kg/ha/yr indicating *significant concern* for wet nitrogen deposition[1,4]	< 1 kg/ha/yr[2]
	Acidification risk		Pollutant exposure & ecosystem sensitivity to acidification very high, park protection moderate, giving ALPO an overall summary risk of very high[5]	Pollutant exposure low, ecosystem sensitivity low, park protection high[5]
	Nutrient enrichment risk		Pollutant exposure to nutrient enrichment very high, ecosystem sensitivity low, and park protection moderate, giving ALPO an overall summary risk of high[6]	Pollutant exposure low, ecosystem sensitivity low, park protection high[6]
Mercury Deposition	Wet Deposition Hg (ng/L)		Current condition well above the indirect regulatory mean annual threshold constituting *significant concern*[4]	2 ng/L Hg in rainwater[7]
Night Skies	Bortle Dark-Sky Scale		ALPO is located in a region corresponding to a 5 on the Bortle scale[9]	Minimum Quality definition approximates a Bortle Class 6[8]
Soundscapes	DATA GAP			

[1]http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm

[2]http://www.nature.nps.gov/air/Planning/docs/AQ_ConditionsTrends_Methods_2013.pdf

[3]NPS ERMN. 2004. Assessing the risk of foliar injury from ozone on vegetation in parks in the Eastern Rivers and Mountains Networ

[4]Boyer et al. 2010. Atmospheric deposition in Pennsylvania: spatial and temporal variations 2009.

[5]Sullivan et al. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: Eastern Rivers and Mountains Network

[6]Sullivan et al. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: Eastern Rivers and Mountains Network

[7]Meili et al. 2003. Critical levels of atmospheric pollution: Criteria and concepts for operational modeling of mercury in forest and lake ecosystems.

[8]Bortle 2001. Introducing the Bortle Dark-Sky Scale.

[9]Cinzano et al. 2001. The first world atlas of the artificial night sky brightness.

Following NPS-ARD standards, wet S and N deposition are both considered to be of *significant concern*, although conditions appear to be improving. No current standards have been established for mercury; however, ecological guidelines established for freshwater fish suggest that mercury levels in the park are of *significant concern*. Seasonal linear trend models show a declining trend in mercury concentration but no significant decrease in mercury wet deposition, the latter of which is also dependent on precipitation. ALPO's air quality for ozone is considered to be of *moderate concern* with an improving regional trend. Visibility is an area of *significant concern* with no apparent trend in condition. Night skies around ALPO correspond to a Bortle Class 5 or *moderate concern* due primarily to the park's location near urban areas. No data is available for soundscapes. We recommend continued monitoring, especially of wet nitrogen, sulfur, and mercury deposition within the park. In addition, monitoring of dry mercury deposition is highly encouraged, since this component may represent at least half of the total mercury entering the system.

5.2 Weather and Climate

As mentioned in Chapter 4, we did not conduct a condition assessment on weather and climate, primarily because these indicators represent drivers of change in the condition of natural resources. Thus, assessments of condition do not make sense. Rather, we reported the trends in precipitation and temperature data collected from the Ebensburg Sewage Treatment Plant, which represented the monitoring location with the longest period of record of data collection that was most representative of park conditions. The trend arrows also differ from the standard terminology used in this NRCA, because an increase or decrease in precipitation or temperature does not necessarily coincide with improving or deteriorating condition. These indicators serve a very important purpose in understanding the effects of climate change on both terrestrial and aquatic ecosystems at multiple scales from communities to populations of species and even individual organisms. Therefore, it is essential to view these results within the proper context. Molding them into a condition assessment defeats that purpose.

Precipitation and temperature trends indicate that ALPO has been experiencing milder winters with less snow cover. The lowest recorded temperature during the calendar year increased throughout the entire period of record, while the number of sub-zero days decreased. Thus, the coldest days of the year are becoming warmer. In accord with these milder temperatures, the growing season length has increased. Although the cumulative annual precipitation has remained roughly the same, all precipitation in the form of snow is decreasing. These changes can have substantial impacts to aquatic and terrestrial plant and wildlife communities, affecting multiple factors related to overall population success, including life cycles, adaptive strategies, reproductive health, range expansion and contraction, competition with invasive species, etc. We recommend continued monitoring to provide important context for interpreting results from other natural resources condition assessments.

Table 80. Summary results for weather and climate at ALPO, including precipitation and temperature trends, the specific measure that indicated significant change over time, the direction of that change (upward arrow = increasing; downward arrow = decreasing), the rationale, references and data sources used.

WEATHER AND CLIMATE		⇩ ⇧	**Winters are milder with less snow cover; growing season length is increasing**	
Indicator of Condition	**Specific Measure**	**Condition Status/Trend**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Temperature Trends	Average Annual Temperature	⇔	Yearly means for average daily, maximum daily, and minimum daily temperatures have remained relatively unchanged [1]	Trends and 30-year climatological normals for weather indicators used to describe temperature patterns[2]
	Average Annual Maximum Temperature	⇔		
	Average Annual Minimum Temperature	⇔		
	Maximum Temperature	⇔	The highest recorded temperature during the calendar year has remained relatively unchanged[1]	
	Minimum Temperature	⇧	The lowest recorded temperature during the calendar year is rising[1]	
	Hot Days	⇔	Hot days, cold days, and sub-freezing days have not changed substantially over the entire period of record[1]	
	Cold Days	⇔		
	Sub-Freezing Days	⇔		
	Sub-Zero Days	⇩	The number of days during the calendar year with minimum temperatures ≤ 0° F is decreasing[1]	
	Growing Season Length	⇧	Growing season length is increasing[1]	
Precipitation Indicators	Annual Precipitation	⇔	The cumulative yearly total liquid precipitation has remained relatively unchanged[1]	Trends and 30-year climatological normals for weather indicators used to describe precipitation patterns[2]
	Heavy Precipitation Days	⇔	The number of days during the calendar year with ≥ 1.0 in. of liquid precipitation has remained relatively unchanged[1]	
	Extreme Precipitation Days	⇔	The number of days during the calendar year with ≥ 2.0 in. of liquid precipitation is increasing[1]	
	Micro-Drought	⇔	The number of micro-droughts (7+ consecutive days) per year is relatively unchanged[1]	
	Annual Snowfall	⇩	The cumulative yearly snowfall, as well as the number of days during the calendar year with measurable snowfall of ≥ 0.1 in., ≥ 3.0 in., and ≥ 5.0 in. is decreasing[1]	
	Measurable Snow Days	⇩		
	Moderate Snow Days	⇩		
	Heavy Snow Days	⇩		

[1]http://climate.psu.edu/gmaps/NPS_DEVELOPMENT/interface.php

[2]Marshall et al. 2012. Weather and climate monitoring protocol: Eastern Rivers and Mountains Network and Mid-Atlantic Network

5.3 Water Quality

Past land use has substantially impacted water quality at both the Main Unit and SBTU. Historical land use in and around the headwaters of Blair Gap Run and Bradley Run included surface and subsurface mining activities, resulting in several acidic and net-alkaline seeps throughout this area (Kathy Penrod, ALPO natural resource manager, pers. comm.). The SBTU has been severely impacted by AMD, with many of its small drainages resulting from acidic abandoned mine drainage and iron mounds.

Water chemistry, overall, suggested rankings of *good* condition at the Main Unit and *moderate* to *significant concern* at the SBTU. With the exception of some small headwaters in the Summit area, pH, temperature, and dissolved oxygen measures met PA DEP’s regulatory standards for water quality at the Main Unit. Specific conductivity levels were typically low, which is to be expected in free-stone streams flowing over erosion-resistant bedrock, resulting in *good* condition at most locations. Dissolved oxygen and temperature results ranked the SBTU as *moderate concern* and *good* condition, respectively; however, impacts from acidic abandoned mine drainage caused pH and specific conductivity ratings of *moderate* to *significant concern*. It is important to note that these water chemistry results are based on one-time measurements, which are meant more as supplemental background information rather than determinants of water quality. Continuous measures of these parameters are necessary in order to capture the full range of diurnal and seasonal variability in core water chemistry parameters. The data sondes installed in Blair Gap Run by the ERMN network will provide such measures and can be used as more accurate predictors of water quality.

The aquatic macroinvertebrate community ranked the mainstem of Blair Gap Run as *moderate concern*, while two tributaries were considered to be in *good* condition. Like the water chemistry parameters, biological condition in the headwater reaches of the Summit Area were largely of *significant concern.* Long-term monitoring by the ERMN will provide important water quality information, including trends in condition, for this indicator. As aquatic macroinvertebrates represent a more reliable and robust indicator of water quality than discrete water chemistry measurements, the overall water quality rating for the Main Unit is based primarily on the BMI results, which corresponds to *moderate concern*.

Water quality is recognized as an important vital sign with water chemistry and aquatic macroinvertebrates being monitored regularly by the ERMN. We recommend these monitoring activities continue in order to protect these valuable resources. Although the impacts from AMD are of significant concern, steps to correct these impacts are typically beyond the available resources of park managers. Thus, we recommend the park continues to work with local, state, and federal agencies to assist in remediation efforts.

Table 81. Summary results for water quality at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving (*upward arrow)*, unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

WATER QUALITY				**Overall water quality is rated as *moderate concern* given the results of the biological indicator and the mixed results of the chemical measures**	
Indicator of Condition	**Specific Measure**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Water Chemistry Core	pH	Main Unit		> 86% of samples fell within the 6 - 9 pH range criteria for supporting aquatic life[1, 2, 3, 4, 5, 6, 7]	Cannot exceed Pennsylvania's and US EPA's standards for water bodies[10, 11]
		SBTU		Only 3.3% of samples were within the 6 - 9 pH range for aquatic life[8, 9]	
	DO	Main Unit		~85% of samples were above the threshold value for the aquatic life use and time of year[2, 3, 4, 5, 6, 7]	> 8 mg/L good for aquatic life; cannot fall below 5 for CWF or 4 for WWF and TSF (8/01 to 2/14)[10, 12]
		SBTU		~66% of samples were above the threshold value for the aquatic life use and time of year; ~23% were of *significant concern*[8, 9]	
	Temperature	Main Unit		>84% of samples were below the threshold criteria for temperature[2, 3, 4, 5, 6, 7]	Threshold criteria depends on aquatic life use and time of year. See Table 24
		SBTU		>70% of samples were below the threshold criteria for temperature[8, 9]	
	Specific Conductivity	Main Unit		>89% of samples were within the natural range for inland freshwaters[1, 2, 3, 4, 5, 6, 7]	Specific conductance should range between 2 and 500 µS/cm[2] for inland freshwaters[13]
		SBTU		All but 1% of samples exceeded the threshold for inland freshwaters: 54% of samples warranted *moderate concern*; 45% of samples warranted *significant concern*[8, 9]	
Aquatic Macroinvertebrates	MBII	Main Unit		Average MBII score for Blair Gap Run (including tributaries) was 56.3 indicating a condition rating of *moderate concern*[1, 4, 5, 7]	MBII Scores: > 63 = Good 49 - 63 = Moderate Concern <49 = Significant Concern[14]

[1]Arnold et al. 1997. Aquatic resources of ALPO, Final Report.
[2]Park Monitoring Data (1999 - 2003).
[3]Environmental Alliance for Senior Involvement (2002 - 2007).
[4]Sheeder and Tzilkowski 2006. Level I water quality inventory and aquatic biological assessment of ALPO and JOFL.
[5]Laubscher et al. 2007. Condition assessment of 5 tributary watershed ecosystems of ALPO & NERI.
[6]Tzilkowski and Sheeder 2006. Assessment of wild trout populations in Blair Gap Run, ALPO.
[7]Tzilkowski et al. 2011. Wadeable stream monitoring in ALPO, DEWA, JOFL, and UPDE.
[8]Kaktins and Carney 2001. Chemical and hydrological parameters for the Staple Bend Unit of ALPO.
[9]Cravotta 2005. Assessment of characteristics and remedial alternatives for abandoned mine drainage.
[10]Chapter 93 (Water Quality Standards) of the Pennsylvania Code, Title 25 (Environmental Protection).
[11]US EPA Redbook (1976).
[12]US EPA (1986). Ambient water quality criteria for dissolved oxygen.
[13]http://www.water.epa.gov/type/rsl/monitoring/vms50.cfm
[14]Klemm et al. 2003. Development and evaluation of a macroinvertebrate biotic integrity index (MBII) for regionally assessing mid-Atlantic highland streams.

5.4 Ecosystem Integrity

5.4.1 Forest/Wood/Shrubland

Forests in the Eastern United States have not maintained a stable composition since the onset of European-American settlement. This instability resulted from at least two key factors that caused major shifts in forest composition: 1) severe disturbances caused by extensive logging, severe fires, and other activities promoted the expansion of fire-tolerant and disturbance-adapted species (e.g., red oak); followed by 2) a long period of little to no physical land disturbance coupled with increasing acid deposition from industrialization, which favored the replacement of the dominant tree species with later successional, shade- and acid-tolerant species (e.g., red maple and striped maple). As a result, forests are continuing to shift in composition away from the reference forest type. Forest types with canopy layers dominated by various mixtures of oak, hemlock, American beech, sugar maple, cherry, and red maple have a regeneration layer dominated by striped and red maple, both trees with low floristic quality. Furthermore, hickory, oak, American linden, and eastern white pine all of which showed large declines in cover between the reference and contemporary data set are likely to continue to decline. The direction and magnitude of compositional differences between the four size classes within each forest type, as determined from NMDS can aid park management programs by identifying which forest types are most likely to change in the future, what species are most likely to dominate future forest types, whether or not a change is desirable to the park, and what possible management actions could prevent or reverse undesirable trends.

While most forest associations within ALPO ranked *good* for floristic quality, all associations contain non-native, invasive species, as well as several other non-target invasive and weedy species that could potentially become problematic. It is likely these areas will decrease in quality if measures to control invaders are not undertaken or continued. For these reasons, we are designating a condition rank of *moderate concern* for Forest/Wood/Shrubland habitats within the park.

We recommend that control measures be put in place immediately to slow the spread of both undesirable understory and non-native invasive species. A management plan should be developed for each species that includes inventory and mapping of existing populations, treatment options, treatment schedule, mid-course corrections and prescribed follow-up measures, and an estimate of treatment efficacy. Removal of non-natives may help to release the seedbank, allowing for recolonization by native forest species, but results are often site-specific (a.k.a. non-native removal sometimes results in the release of more non-native species).

Table 82. Summary results for forest/wood/shrubland communities at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving (*upward arrow)*, unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

ECOSYSTEM INTEGRITY				Overall rating of *moderate concern* given the shift in understory composition to less desirable tree species and the increasing threat from invasive species	
Indicator of Condition	**Specific Measure**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Forest/Wood/ Shrubland	Floristic Quality Index Score	MAIN		Mean FQI was 36.3 (good condition); however, 3 of 7 forest associations were rated as *moderate concern* and contained several non-native invasive species, lowering the condition rating[1]	FQI Score (trisected): 35 - 52 = good; 18 - 34 = moderate concern; 0 -17 = significant concern[2]
		SBTU		Adjusted FQI for the SBTU was 46.6 (*good* condition); both forest associations also in *good* condition[1]	
	Mean C	MAIN		Mean *C* was 4 (good condition); however, 3 of 7 forest associations were rated as *moderate concern* and contained several non-native invasive species, lowering the condition rating[1]	Mean *C* condition categories: >3.7 = good; 1.9 -3.6= moderate concern; 0 - 1.8 = significant concern[2, 3]
		SBTU		Mean *c* was 4.8 (*good* condition); both forest associations also in *good* condition[1]	

[1]Perles et al. 2010. Condition of vegetation communities in ALPO and JOFL.
[2]Chamberlain and Ingram. 2012. Developing coefficients of conservatism to advance FQA in Mid-Atlantic Region.
[3]Wilhelm and Masters. 1995. Floristic quality assessment (FQA) in the Chicago Region and application computer programs.
[4]Perles et al. 2007. Vegetation classification and mapping at ALPO.
[5]PA State Archives: Land Records (www.portal.state.pa.us/portal/server.pt/community)
[6]Abrams and Ruffner. 1995. Physiographic analysis of witness tree distribution and present forest cover through north-central PA.
[7]Abrams and McCay. 1996. Vegetation-site relationships of witness trees in the presettlement forests of eastern West Virginia.

5.4.2 Grasslands

Specific measures of grassland metrics indicated mixed condition rating indicating an overall rating of *moderate concern*. Although grasslands are an important natural resource that provide habitat for declining bird populations, the steep terrain and dense forests covering much of the park severely limits the ability of park management to establish and maintain sufficient patch sizes to support breeding grassland bird populations. Therefore, we recommend that the focus remain on optimizing the habitat quality of the existing grassland patches around the Lemon House. Seizing opportunities to increase the size and perimeter-to-area ratio of these patches and adhering to the current mowplan of once per year in the fall should allow for adequate habitat for sink populations or possibly a few breeding pairs of grassland species most likely to occur within the park.

Table 83. Summary results for grassland communities at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving (*upward arrow)*, unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

ECOSYSTEM INTEGRITY				Specific measures of grassland condition indicated mixed condition ratings, suggesting an overall rating of *moderate concern*	
Indicator of Condition	**Specific Measure**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Grasslands	Minimum Field Size	MAIN		Only 25% of potential grassland habitat is represented by a contiguous patch >5 ha[1, 2, 3]	Size of contiguous habitat: >10ha = good; 4.9 - 10ha = moderate concern; >4.9 ha = significant concern[2, 3, 4, 5]
	Perimeter:Area Ratio	MAIN		Average condition score of 4 grassland patches is 52.8 indicating *moderate concern* [1]	Ratio of Reference P:A / Actual P:A >66 = good; 33 - 66 = moderate concern; <33 = significant concern[6]
	Mowplan	MAIN		Assuming 33% of grassland habitat is not feasible for mowplan management, ~90% of managed grassland habitat is mowed only once per year in the fall[7]	Reference condition: Areas of potential grassland habitat mowed no more than once per year in Sept/Oct[4, 5]

[1]PA Natural Heritage Program 2006 ALPO vegetation map (Perles et al. 2007).
[2]PAMAP 2006.(Land use interpretation from aerial photos).
[3]Hill. 2012. Population ecology of grassland sparrows on reclaimed surface mine grasslands in PA.
[4]Peterjohn. 2006. Conceptual ecological model for management of breeding grassland birds in the Mid-Atlantic Region.
[5]Wilson and Brittingham. 2012. Initial response of bird populations to conservation grasslands in southern PA.
[6]Johnson and Igl. 2001. Area requirements of grassland birds: a regional perspective.
[7]ALPO Mowplan Maps.

5.4.3 Wetlands

Minimal information exists regarding wetlands. The Perles et al. (2007) study and a recent wetland delineation conducted in the fall of 2012 are the only studies to formally sample wetlands. In order to properly address concerns for this critical resource, multi-year monitoring is necessary. This is especially important considering many of the wetlands throughout the park have been invaded by aggressive plant species. The condition of wetlands in the main portion of ALPO is lowest in the Reed Canary Grass Riverine Grassland and Wet Meadow types (*moderate-significant concern* and *moderate concern*, respectively). Both of these associations support reed canary grass, a native invasive species that opportunistically establishes in wet areas following disturbances. Although the Sugar Maple Floodplain Forest ranked in *good* condition for the plant community, it supported several target invasive species, suggesting condition will most likely decline in the future if control measures are not included in management plans. Several associations along the Little Conemaugh River are dominated by invasive species (e.g., European alder, Japanese or Giant knotweed, and tree-of-heaven). This colonization of multiple non-native invasive species has substantially reduced the floristic quality at the SBTU ranking the condition of the wetland communities there as *moderate* to *significant concern*. All wetland types are unlikely to show any improvement in condition without aggressive and persistent management. In addition, the significant presence of these invasive and exotic species exposes wetlands that are currently ranked in higher condition to colonization by these undesirable species in the future. We recommend control measures be maintained to prevent the further spread of these species, especially knotweed species. When comparing the wetland metrics to the landscape metrics, one can see that the surrounding landscape does contain significant proportions of forest and forest connectivity. However, the land cover tends to shift away from forest closer to the wetlands, in the immediate buffer. Efforts to increase the quality of buffer length and widths surrounding ALPO wetland habitats are highly encouraged.

Table 84. Summary results for wetland communities at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

ECOSYSTEM INTEGRITY				**5 0f 10 specific measures of wetland condition indicate *moderate concern* and 1 indicates *significant concern***	
Indicator of Condition	**Specific Measure**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Wetlands	FQI	MAIN		Average FQI score = 27 (*moderate concern*)1	FQI Score (trisected): 30-41 = good; 15-29 = moderate concern; 0-14 = significant concern[2]
		SBTU		Average FQI score = 19 (*moderate concern*)1	
	Mean C	MAIN		Average mean C = 3 (*moderate concern*)[1]	Mean C condition categories: >3.5 = good; 3.0 - 3.5 = moderate concern; 0 - 3.0 = significant concern[2, 3]
		SBTU		Average mean C = 2.5 (*significant concern*)[1]	
	Landscape Connectivity	MAIN		Combined length of all non-buffer segments met reference criteria[4, 5, 6, 7]	Reference condition defined as: Combined length of all non-buffer segments < 400 m for each side (riverine); embedded in 60-100% natural habitat (non-riverine)[8]
		SBTU			
	Buffer Index	MAIN		average buffer length and width was between 50-99m (*moderate concern*)[4, 5, 6, 7]	Reference condition defined as: buffer length >50-100% of perimeter; average buffer width >100m[8]
		SBTU		Average buffer length was good but width was between 50-99m (*moderate concern*)[4, 5, 6, 7]	
	Surrounding Land Use Index	MAIN		Surrounding land use score was between 0.80 and 1.0 (*good*)[4, 5, 6, 7]	Reference condition defined as: average land use score = 0.80 - 1.0[8]
		SBTU			

[1]Perles et al. 2010. Condition of vegetation communities in ALPO and JOFL.
[2]Chamberlain and Ingram. 2012. Developing coefficients of conservatism to advance FQA in Mid-Atlantic Region.
[3]Wilhelm and Masters. 1995. Floristic quality assessment (FQA) in the Chicago Region and application computer programs.
[4]Fall 2012 ALPO wetland delineation (Sharpe)
[5]USFWS National Wetlands Inventory
[6]National Land Cover Database (2006)
[7]PAMAP 2006.(Land use interpretation from aerial photos).
[8]Faber-Langendoen. 2009. Freshwater wetlands monitoring and assessment framework for the Northeast Temperate Network

5.5 Biological Integrity

The wildlife focused biological integrity indicators were rated across a variety of condition levels. Four species of concern were inventoried within the park. These species received an overall rating of *moderate concern* given their low population numbers within the boundary of the surveyed areas, although brook trout and crayfish populations at the Main Unit were considered *good*. Northern myotis was considered to be of *significant concern.* Additional surveys to assess the bat community as a whole also found declining populations and diversity of bats using the Staple Bend Tunnel as a winter hibernacula and also warranted *significant concern* while bat diversity park-wide was rated as *moderate concern*. The Bird Community Index (BCI) was used to evaluate the avian community, both for streamside birds at the Main Unit and for Breeding Bird Atlas (BBA) surveys regionally. BCI scores rated the Main Unit as *good* and the surrounding region as *moderate concern* with and *unchanging* trend. Reptiles and amphibians and mammal communities warranted *moderate concern* because only 67% of expected reptile and amphibian species and only 42% of expected mammal species were found to be in the park. This was based on a single sampling period and may be an artifact of small sample size. Four species were monitored as non-native invasive species indicators, which included hemlock woolly adelgid, gypsy moth, brown trout, and crayfish. Gypsy moths occur at low levels within the park and were considered *good*. Non-native crayfish were not found within the park and levels of native crayfish populations were also *good*. Brown trout are known to occur just outside the boundary of the park resulting in a rating of *moderate concern*. Additionally, hemlock woolly adelgid has now been found within the park and received a rating of *significant concern*. Action to remove or maintain their absences within the park is at the utmost importance. We recommend that park managers continue to monitor all relevant biological indicators on a regular schedule (i.e., approximately every 2-5 years) to gain or maintain trend information and provide an opportunity to intervene when invasive species issues or urgent changes in protected species arise.

Of the eight target non-native invasive species identified by park, all still occur or are expected to occur within park boundaries. An invasive plant study conducted along with the vegetation mapping and classification project found 91 non-native plant species in the park, of which 19 were considered to be moderate or serious threats by DCNR. In 1999, eight non-native invasive plant species were targeted by the park as high priorities for control, and a few additional species were targeted since then as they invaded the cultural landscape or species new to the park were detected. Although it's difficult to elucidate trends from the existing data, studies over the past 20 years indicate that most of these species are spreading. While forests within ALPO currently range from good to significant concern, we have designated an overall condition rating of *moderate concern* for two reasons. First, target non-native invasives as well as other non-native plants with the potential to become invasive, have well established populations within the park. Second, the highly invasive nature of these species leads to a high probability that they will continue to spread and further degrade forested habitats without immediate and sustained intervention.

We recommend that control measures be continued to slow the spread of target non-native invasive species. A management plan should be developed for each species that includes inventory and mapping of existing populations, treatment options, treatment schedule, mid-course corrections and prescribed follow-up measures, and an estimate of treatment efficacy.

Table 85. Summary results for biological integrity indicators (species of special concern, bats, birds, amphibians, reptiles, and mammals) at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving (*upward arrow), *unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

BIOLOGICAL INTEGRITY				**9 of 17 (53%) specific measures of condition warranted *moderate concern***	
Indicator of Condition	**Specific Measure**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Species of Concern	American Bugbane	Park-Wide	Data Gap	Condition not assessed due to limited survey data and no established threshold values[1, 2]	Reference conditions based on small scale surveys conducted in the park and best professional judgment
	American Ginseng	Park-Wide		Only a few individuals found; scored as *moderate concern* given its rarity on landscape and vulnerability to harvest[1, 2]	
	Northern Myotis	Park-Wide		Species present in 1997 & 2001 surveys but not 2012; 13 bats found in 2005 and only 6 in 2006; deteriorating trend due to these declines and overall regional declines due to white-nose syndrome[4, 5]	
	Brook Trout	Main Unit		Density in Blair Gap Run (0.102 indiv./m^2) and evidence of naturally reproducing populations suggest *good* condition[6]	
Bat Communities	Bat Species Diversity	Park-Wide		6 to 11 species found in PA occur within the park[5]	Reference conditions determined to be the potential species that could occur within the park[5]
		SBTU		In 1997, 4 species (33 individuals) found; in 2001 only 5 bats observed; no bats detected in 2005; 2012 found 1 species (38 individuals); deteriorating trend due to these declines and overall regional declines due to white-nose syndrome[4, 5]	
Bird Communities	BCI	Main Unit		Average BCI score for the parkwide based on 2007 - 2012 annual streamside bird surveys = 55 $\pm$ 5.9[7]	Reference conditions determined through BCI scoring criteria: 52.1 - 77.0 (good); 40.1 - 52.0 (moderate concern); 20.5 - 40.0 (significant concern)8
		Region		49.7% of BBA blocks from the 2004-09 survey had BCI scores warranting *moderate concern* ; 56.4% of the 2004-09 BBA blocks had condition ratings *unchanged* from the 1983-89 survey results[9]	
Amphibians & Reptiles	Herpetofauna Diversity	Park-Wide		67% of expected amphibians and 50% of expected reptiles were surveyed within the park[10]	Reference conditions determined to be the potential species that could occur within the park[10]
Mammals	Mammal Diversity	Park-Wide		42% of expected mammal species occurred within the park[10]	Reference conditions determined to be the potential species that could occur within the park[10]

[1]Western Pennsylvania Conservancy. 2000. Inventories for Species of Special Concern (ALPO & JOFL).
[2]Western Pennsylvania Conservancy. 2003. Plant community mapping and surveys for Species of Special Concern.
[3]Pennsylvania Natural Diversity Inventory (PNDI).
[4]Pennsylvania Game Commission Hibernating Bat Surveys at SBTU (1997, 2001, 2012).
[5]Gates and Johnson. 2007. Bat inventory of four ERMN parks.
[6]Tzilkowski and Sheeder. 2006. Assessment of wild trout populations in Blair Gap Run, ALPO.
[7]Marshall et al. 2013. ERMN streamside bird survey (2007 - 2012).
[8]O'Connell et al. 1998b. The bird community index: a tool for assessing biotic integrity in the Mid-Atlantic Highlands report.
[9]Breeding Bird Atlas Surveys (1983-89 & 2004-09).
[10]Yahner and Ross. 2006. Inventory of amphibians, reptiles, and mammals at ALPO and JOFL.

Table 86. Summary results for biological integrity indicators (non-native animals and plants) at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = *good;* yellow = *moderate concern;* red = *significant concern*; and trend, if known (*improving (*upward arrow)*, unchanging,* or *deteriorating* (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

BIOLOGICAL INTEGRITY				**9 of 17 (53%) specific measures of condition indicate moderate concern**	
Indicator of Condition	**Specific Measure**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Non-native Invasive Animals	Hemlock Woolly Adelgid	Main Unit		50% of surveyed stands infected with 7 of the 8 stands 100% infested[1]	Based on % of stands infected: 0 = good; 1-25 = moderate concern; >25 = significant concern[1]
	Gypsy Moth	State-Wide		Gypsy moth egg masses detected at only ~4% of surveyed sites across PA[2]	Low detection rate with no major outbreaks
	Brown Trout	Main Unit		Brown trout present in majority (3 of 5) of surveyed sites but less abundant than native brook trout[3]	Low detection and little to no overlap with native brook trout[3]
	Crayfish	Main Unit		Relative abundance of native populations ~high (captured at 4 of 5 sites); no non-natives detected[4]	Reference condition defined as lack of non-native crayfish species[4]
Non-native Invasive Plants	Target Non-Native Invasive Species	Main Unit		Of the 7 main forest associations, 4 had >0.5 target species/plot warranting *moderate concern* [5]	Based on average target non-native species/plot: <0.5 = good; 0.5 to < 3.5 = moderate concern; > 3.5 = significant concern[6]
		SBTU		Of the 2 main forest associations, both had between 0.5 and 3.5 target species/plot (*moderate concern*)[5]	
	% of Non-Native Species	Main Unit		Of the 7 main forest associations, 3 had <10% non-natives, 2 had 10-20% non-natives and 2 had >20% non-native species, giving an average condition rating of *moderate concern* [5]	Based on % non-native species: 0-10 = good; > 10-20 = moderate concern; > 20 = significant concern[6]
		SBTU		Both main forest associations had <10% non-natives indicating *good* condition[5]	

[1]Felton and Onken. 2009. Biological evaluation of hemlock woolly adelgid at ALPO.
[2]Pennsylvania Department of Conservation and Natural Resources forest health report.
[3]Tzilkowski and Sheeder 2006. Assessment of wild trout populations in Blair Gap Run, ALPO.
[4]Lieb et al. 2007. Status of native and invasive crayfish in 10 NPS properties in Pennsylvania.
[5]Perles et al. 2010. Condition of vegetation communities in ALPO and JOFL.
[6]Miller et al. 2010. Northeast Temperate Network forest health monitoring report.

5.6 Landscapes

Landscape analyses were initially completed at four spatial scales; park boundary, park boundary +1 km buffer zone, park boundary +30 km buffer zone, and watershed catchment. After processing of the land cover data we focused work on the park boundary +1 km landscape and the catchment to keep our assessment to the areas with the most direct influence on the landscape conditions of the park. Land cover condition was compared to detect change between 1992 and 2006. Based on past work we selected Percent Forest, Percent Core Forest, Road Density, and Percent Developed as our primary metrics for evaluation as they help to inform on forest habitat condition and forest fragmentation. To aid land cover interpretation we included photo interpreted land use using historic aerial photography from 1939, 1994 and 2006.

Between 1992 and 2006 both percent forest and percent core forest decreased slightly in the Main Unit using the park +1 km landscape. Staple Bend had a similar trend for forest but remained unchanged for core forest. Road density was unchanged for both the Main Unit and Staple Bend Unit and within the catchment landscape percent development increased in both park units with the Staple Bend Unit being the highest at 9.2% but still within the <10 % Good condition threshold. From the land use data we found that percent forest increased from 1939 to 2006 but percent core forest decreased suggesting increased forest fragmentation in or near ALPO's Main Unit.

There does not appear to be indications of important landscape change in the region but park conditions are directly influenced by areas close to the park boundary. However, forest fragmentation appears to be increasing in the region and with the potential for still unknown changes brought by energy development, efforts should be made to influence regional development decisions, especially in that 1 km buffer zone, to reduce the impacts of forest fragmentation on the habitats inside the park.

Table 87. Summary results landscape indicators at ALPO, including the indicator of condition, the specific measures or metrics for the indicator, the condition status (green = good; yellow = moderate concern; red = significant concern; and trend, if known (improving (upward arrow), unchanging, or deteriorating (downward arrow)), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

LANDSCAPES				↔	**Measures of land use and landscape pattern and fragmentation indicate good condition**	
Indicator of Condition	**Specific Measure**	**Extent**	**Park Unit**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Land Use, Patterns, & Fragmentation	% Forest	Park + 1-km Buffer	Main Unit	↔	% Forest decreased only slightly from 81.9% in 1992 to 80.2% in 2006 but remained well above the threshold criteria for good condition[1, 2]	Reference condition based on the following criteria: >50% = good; 25 - 50% = caution; <25% = significant concern[2, 4, 5, 6]
			SBTU	↔	% Forest decreased from 78.9% in 1992 to 68.6% in 2006 but remained above the threshold criteria for good condition[1, 2]	
	% Core Forest	Park + 1-km Buffer	Main Unit	↔	% Core Forest decreased slightly from 1992 to 2006 but not significantly[1, 2]	Decreasing trend in the amount of core forest within 1-km buffer lowers % Forest metric by one condition category for % forest <60%[2, 4, 5, 6]
			SBTU	↔	% Core Forest remained ~unchanged from 2001 to 2006[1, 2]	
	Road Density	Park + 1-km Buffer	Main Unit	↔	Road Density remained ~unchanged from 1992 to 2006 at ~0.85 indicating good condition[3]	Reference condition based on the following criteria: >0.66 = good; 0.34 - 0.66 = caution; 0 - 0.33 = significant concern[6]
			SBTU	↔	Road Density remained ~unchanged from 1992 to 2006 at ~0.88 indicating good condition[3]	
	% Developed Land	Catchment	Main Unit	↓	% Developed Land in the catchment increased significantly from 0.46 in 1992 to 3.6% in 2006[1,2]	Reference condition based on the following criteria: <10% = good; 10 - 15% = caution; >15% = significant concern[2, 4, 5, 6]
			SBTU	↔	% Developed Land in the catchment increased from 1.72 in 1992 to 9.2% in 2006[1,2]	

[1]National Land Cover Database 2006.
[2]Bishop. 2008. Temporal dynamics of forest patch size distribution and fragmentation of habitat types in Pennsylvania.
[3]United States Census Bureau.
[4]Environmental Law Institute (ELI). 2003. Conservation thresholds for land use planners.
[5]Wardrop et al. 2007. The condition of wetlands on a watershed basis: The Upper Juniata Watershed in Pennsylvania.
[6]Brooks et al. 2009. A stream-wetland-riparian (SWR) index for assessing condition of aquatic ecosystems in small watersheds along the Atlantic slope of the eastern U. S.

5.7 Data Gaps

Important indicators that were not included in the NRCA due to lack of data include the following:

- Soundscapes: Although we included a section on soundscapes, no data were available to ascertain condition. Sound monitoring is essential for managing noise and can be a powerful tool to document patterns in both wildlife and visitor activity. Unfortunately the narrow, linear boundaries of the park parallel busy highways and roads, making it difficult for managers to protect or restore natural soundscapes from unacceptable impacts. However, managers can take steps to prevent or minimize these impacts through (1) monitoring of human activities that generate noise in and adjacent to the park and (2) development of action plans where possible to reduce the frequency, magnitude, and/or duration of these adverse activities. Managers can use audio recordings to chronicle wildlife behavior in response to visitor use and to identify and track sources of noise and document daily and seasonal patterns in ambient sound levels
- Water quantity: Monitoring of stream discharge will provide a better understanding of the hydrology of the larger watershed and the establishment of baseline discharge values will allow for the impacts of future disturbance and landscape changes on the stream to be quantified. Stream flow data will be useful in evaluating the status of pollutants and other water quality metrics in the stream including rates of whole-stream metabolism. Changes in stream flow can also impact fish populations and recreational fishing opportunities by reducing habitat variability, and decreased discharge can result in increased water temperatures and lower dissolved oxygen concentrations. Annual or seasonal variations in discharge can impact the ecosystem services provided by the channel and riparian zone, influence management decisions, and indicate changes in groundwater supply from disturbance elsewhere in the watershed. Discharge monitoring during high flows can also aid in the prediction of overbank events and provide data on the timing and frequency of high flow events. More specifically, baseline groundwater and streamflow monitoring will be necessary to assess the vulnerability and risk of shallow groundwater fed wetlands to any proposed water extraction activities near the park.

Specific data gaps pertaining to the indicators used in this condition assessment are listed below. The following list consolidates the indicators for which we lacked sufficient information to conduct a rigorous condition assessment:

- Insufficient data on mercury dry deposition and lack of better reference and scoring criteria that account for the effects of methylmercury.
- Lack of data for dark night skies.
- Lack of aquatic macroinvertebrate data at the SBTU.
- Insufficient monitoring data on fish communities.
- Lack of data on breeding grassland birds.
- Lack of site-level information and other data for wetland habitats.
- Spotty inventory and monitoring information for species of special concern.
- Limited data on amphibians, reptiles, and mammals.
- Lack of park-specific data on gypsy moth infestations.
- Insufficient long-term (comparable) data for monitoring trends for the majority of resources. This is especially vital for detecting and controlling the spread of invasive species.

Table 88. NRCA condition results for ALPO's Main Unit. Condition status (green = *good*; yellow = *moderate concern*; red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging*, or *deteriorating* (downward arrow)), comments and recommendations are included.

RESOURCE	CONDITION STATUS/TREND	COMMENTS	RECOMMENDATIONS
Water Quality			
Water Chemistry--Core	Good with Unknown Trend	Water chemistry rated as *good*	Monitoring of water chemistry along Blair Gap Run and its major
Aquatic Macroinvertebrates	Moderate Concern with Unknown Trend	Aquatic macroinvertebrates rated overall as *moderate concern* with parts of the headwaters as *significant concern* and downstream tributaries *good*	Long-term monitoring along Blair Gap Run and its tributaries
Ecosystem Integrity			
Forests/ Wood/ Shrubland	Moderate Concern with Unknown Trend	Forest associations in the Summit area and slopes mostly *good* but rated *moderate concern* due to threat of invasives; successional forest types around Foot of Ten area rated as *moderate concern*	Implement control measures to slow the spread of undesirable understory species and non-native invasive species
Grasslands	Moderate Concern with Unknown Trend	Small patch sizes of significant concern; perimeter to area ratio a *moderate concern*; mowplans mostly *good*	Optimize habitat quality of existing grassland patches
Wetlands	Moderate Concern with Unknown Trend	Sugar maple floodplain forests *good* but reed canary grass/riverine grassland and wet meadows rated as significant concern and/or *moderate concern*. Landscape connectivity and surrounding land use *good* but buffer index varied from *moderate concern* at Summit to *significant concern* at Incline 9	Implement control measures to slow the spread of invasive species; increase quality of wetland buffers
Biological Integrity			
Species of Special Concern			
American Bugbane	Not Rated		
American Ginseng	Moderate Concern with Unknown Trend	Only a few individuals or small populations found in or near park; under threat of harvest	
Northern Myotis	Moderate Concern with Deteriorating Trend	Intensive bat monitoring showed species decline from 2005 to 2006; regional declines due to white-nose syndrome	
Brook Trout	Good with Unknown Trend	Density in Blair Gap Run and evidence of naturally reproducing populations suggest *good*	
Bat Communities	Good with Unknown Trend	6 of 11 species found in Pennsylvania occur within the park	Continued inventory and monitoring of existing populations
Bird Communities	Good with Unknown Trend	Streamside bird communites along Blair Gap run *good* at Muleshoe and Millstone Run; *moderate concern* at Foot of Ten	
	Moderate with Unchanging Trend	Regional condition warrants *moderate concern* with an unchanging trend	
Amphibians & Reptiles	Moderate Concern with Unknown Trend	Only 60% of species confirmed park-wide	
Mammals	Moderate Concern with Unknown Trend	23 of 55 expected species occur within the park.	

Table 88 (cont'd). NRCA condition results for ALPO's Main Unit. Condition status (green = *good*; yellow = *moderate concern*; red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging*, or *deteriorating* (downward arrow)), comments and recommendations are included.

RESOURCE	CONDITION STATUS/TREND	COMMENTS	RECOMMENDATIONS
Biological Integrity			
Non-Native Invasive Animals			
Hemlock Woolly Adelgid	Significant Concern with Unknown Trend.	50% of surveyed stands infected with 7 of the 8 stands 100% infested	Regular monitoring to gain and maintain trend information and intervene when invasive species issues arise.
Gypsy Moth	Good with Unknown Trend.	Gypsy moth egg masses detected at only ~4% of surveyed sites across PA	
Brown Trout	Moderate Concern with Unknown Trend.	Brown trout present in majority (3 of 5) of surveyed sites but less abundant than native brook trout	
Crayfish	Good with Unknown Trend.	Crayfish captured at 4 of 5 sites; no non-natives detected	
Non-Native Invasive Plants	Moderate Concern with Unknown Trend.	Of the 7 main forest associations, 4 had >0.5 target species, 3 had <10% non-natives, 2 had 10-20% non-natives and 2 had >20% non-native species warranting *moderate concern*	Control measures to slow the spread of invasive species;comprehensive management plans for target species.
Landscapes			
Land Use, Patterns, & Fragmentation	Good with Unchanging Trend	% forest, % core forest, and road density remained relatively unchanged between 1992 and 2006; % developed land did increase significantly from 1992 to 2006	Track changes to identify areas of potential concern to natural resource condition

Table 89. NRCA condition results for ALPO's SBTU. Condition status (green = *good*; yellow = *moderate concern*; red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging*, or *deteriorating* (downward arrow)), comments and recommendations are included.

RESOURCE	CONDITION STATUS/TREND	COMMENTS	RECOMMENDATIONS
Water Quality			
Water Chemistry--Core	Moderate to Signficant Concern with Unkown Trend.	Water ph warrants *significant concern;* specific conductivity and dissolved oxygen warrant *moderate concern;* temperatures below threshold criteria	Periodic monitoring of water chemistry; work with outside agents to address AMD issues
Ecosystem Integrity			
Forests/ Wood/ Shrubland	Good with Unknown Trend.	Tulip-Beech-Maple and Allegheny Hardwood Forest associations *good*	Continue monitoring to detect non-native invasive species and other threats
Wetlands	Moderate Concern with Unknown Trend	Alder shrubland and Japanese or giant knotweed/herbaceous vegetation associations rated as *moderate concern* to *significant concern;* wetland buffer rated as *moderate concern;* landscape connectivity and surrounding land use *good*	Implement control measures to slow the spread of invasive species; increase quality of wetland buffers
Biological Integrity			
Species of Special Concern (Northern Myotis)	Moderate Concern withDeteriorating Trend.	Both northern myotis occurrence and bat species diversity declined. Amhibian communities good. Mammal communities rated as moderate concern	Continued inventory and monitoring of existing populations
Bat Communities	Moderate Concern with Deteriorating Trend	Monitoring over 15 years found oscillating numbers but an overall species decline	
Amphibians & Reptiles	Moderate Concern with Unknown Trend.	Only 60% of species confirmed park-wide	
Mammals	Moderate Concern with Unknown Trend.	23 of 55 expected species occur within the park	
Non-Native Invasive Plants	Moderate Concern with Unknown Trend	Target non-native invasive species warranted *moderate concern;* % non-natives considered *good*	Control measures to slow the spread of invasive species;comprehensive management plans for target species
Landscapes			
Land Use, Patterns, & Fragmentation	Good with Unchanging Trend	% forest, % core forest, and road density remained relatively unchanged between 1992 and 2006; % developed land increased from 1992 to 2006, but not significantly	Track changes to identify areas of potential concern to natural resource condition

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Appendix A: Additional Water Quality Information

Water Quality Studies at ALPO

Arnold et al. (1997): The Pennsylvania Cooperative Fish and Wildlife Research Unit conducted an aquatic resource inventory at ALPO in 1996 and 1997, collecting information on water chemistry (pH, conductivity, alkalinity, and turbidity), discharge, macroinvertebrates, and fish (Arnold et al. 1997). The majority of sample collections focused on the Main Unit along Blair Gap Run and its tributaries (n=6), but one site was also sampled at the Staple Bend Tunnel Unit (n=1). Arnold et al. (1997) concluded that the aquatic resources of ALPO were 'functioning well in an ecological sense', despite some mine drainage entering the upper reaches of Blair Gap run on and off of park lands and the appearance of the stream sampled at the SBTU having been an acid mine drainage carrier.

Park Monitoring Data (1999 – 2003): To enhance the Arnold et al. (1997) dataset, ALPO staff conducted additional water quality sampling at Blair Gap Run and its tributaries between 1999 and 2003. The goal of the additional park inventories along Blair Gap Run was to establish baseline water chemistry for the stream during all seasons. During this time period, sites were moved, added, and deleted; hence, the same or similar sampling location may have multiple station IDs, depending on the year and data source. For example, in the initial year (1999-2000) the six sites at Blair Gap Run matched the site locations established by Arnold et al. 1997. From May 2001 until March 2003, only five sights matched the original study sites, one was moved downstream, and two new sites were added. Water chemistry field data included discrete samples of the core parameters (pH, temperature, specific conductivity, and dissolved oxygen), as well as alkalinity and turbidity.

Environmental Alliance for Senior Involvement (EASI) (2002 – 2007): Four sites were monitored in the Main Unit as part of the park's Senior Ranger program with support from the Pennsylvania Department of Environmental Protection. Three sites were located at Muleshoe Curve, near the Incline 8 area of the Portage Trace Corridor. These sites were located above and below the confluence of Blair Gap Run and the Hollidaysburg Reservoir tributary, and at the tributary from the reservoir. The fourth site was located at the Foot of Ten area, near the park boundary at Willow Bridge and the Incline 10 area of the Portage Trace Corridor. Water quality sampling (pH, specific conductance, dissolved oxygen, temperature, total alkalinity, nitrates, and total phosphates) were collected monthly; macroinvertebrate studies were done twice annually in the spring and the fall (but we could not find an appendix F with the macro data).

Sheeder and Tzilkowski (2006): A Level 1 water quality inventory was conducted for the Main Unit of ALPO. Eleven sites were sampled for a suite of 35 water quality parameters approximately every four weeks from April 2004 to November 2004. The core water quality parameters were among those measured and were considered for this assessment. In addition, stream discharge, fecal coliform bacteria, an extensive suite of metals, nutrients, alkalinity, acidity, and turbidity were also measured. Fish and macroinvertebrate samples were also collected during November 2004 and January 2005, respectively. Results for water quality and biological communities were similar and typical of forested watersheds with similar geologic characteristics, with the exception of two areas: (1) impairment of the Blair Gap Run headwaters, potentially from acid mine drainage and atmospheric pollution; and (2) high fecal coliform concentrations in the lower reaches of Blair Gap Run, probably from farming and malfunctioning septic systems.

Laubscher et al. (2007): A biological assessment for selected streams and watersheds within ALPO was conducted using three levels of assessment (Level 1 – landscape, Level – rapid, Level 3 – intensive; see Brooks et al. 2006 for details on the methodology). Sampling was conducted in June 2004, primarily in Blair Gap Run and in a tributary to Bradley Run. Sampling was not done in the Staple Bend Tunnel Unit. Core water chemistry parameters were measured (discrete), as well as macroinvertebrates and stream salamanders. The influence of abandoned mine discharge and/or acid-deposition was not apparent from the macroinvertebrate results for Blair Gap Run but was observed in the tributary to Bradley Run. Stream salamanders were more sensitive to atmospheric acidification than macroinvertebrates and rated all sites along both Blair Gap Run and the Bradley Run tributary as indicative of poor condition.

Tzilkowski and Sheeder (2006): In response to results from the Level 1 water quality inventory (above), an additional study was performed to assess the wild trout populations upstream of the Blair Gap Run confluence with Blair Run and determine the upstream limit of brown trout in the stream. Five sampled sites were located on a section of Blair Gap Run owned by the Altoona City Water Authority between Blair Gap Run sections that flow through park property. In addition, core water chemistry parameters were also collected prior to sampling.

Tzilkowski et al. (2010, 2011a, 2011b): The latest ERMN monitoring report (Tzilkowski et al. 2011b) contains water quality (point-in-time core parameters) and macroinvertebrate assessments conducted at permanent monitoring locations: Blair Gap Run below the confluence with Blair Run and in the Foot of Ten near the Level 10 Area of the Portage Trace Corridor, and along Millstone Run near Level 10 of the Portage Trace Corridor. Samples are collected annually in October or November; data used in this assessment were collected from 2008 – 2012 (water chemistry) and 2008 – 2010 (benthic macroinvertebrates). Continuous water quality monitoring (core parameters and turbidity) began at the Millstone Run location in March 2011 where multiprobes were installed from March through October to provide hourly measurements.

Kaktins and Carney (2002): To characterize water quality for the abandoned mine drainage crossing the park at the SBTU, an intensive water quality study was conducted biweekly by the University of Pittsburgh from May 2000 until April 2001. Because these drainages exist only as flows from abandoned mines and, therefore, would not be present as natural streams without the mines, they are not referred to as streams or tributaries of the Little Conemaugh.

Cravotta (2005): In addition to characterizing water quality for the abandoned mine drainage crossing the park at SBTU during periods of high flow, this study also evaluated the efficacy of limestone or steel slag for neutralization of the acid mine drainage and identified possible alternatives for passive or active treatment. Synoptic samples were collected twice in April 2004. Only the water quality characterization is used in this assessment.

Table A1. Descriptive statistics for pH and specific conductivity measured at the primary monitoring locations in the Blair Gap Run and Bradley Run watersheds of the Main Unit. NRCA Study IDs are as follows: Arnold = Arnold et al. 1997; PMD = Park Monitoring Data; EASI = Senior Ranger Program; Level 1 WQ = Sheeder and Tzilkowski 2006; ERMN = Tzilkowski et al. 2011a, 2011b.

		pH					Specific Conductivity (µS/cm)				
Site	**Study**	**n**	**Mean**	**SD**	**Max**	**Min**	**n**	**Mean**	**SD**	**Max**	**Min**
ALPO 1A	Arnold	4	6.0	0.8	6.8	4.9	4	317.8	141.3	432.0	112.0
	PMD	6	7.3	0.4	8.0	6.4	30	739.0	151.4	1116.0	468.0
ALPO 1B	PMD	20	4.5	1.0	7.4	3.6	20	242.3	106.9	409.0	130.0
ALPO 1	Arnold	3	6.7	0.3	7.1	6.4	3	282.3	49.7	338.0	243.0
	PMD	35	7.0	0.6	8.1	5.7	35	511.1	136.6	705.0	274.0
	Level 1 WQ	6	7.4	0.2	7.8	7.2	7	442.7	75.0	535.0	343.6
ALPO 2	Arnold	4	6.7	0.3	7.0	6.3	3	133.3	11.6	141.0	120.0
	PMD	33	7.3	0.7	9.1	5.9	33	185.9	45.8	262.0	105.0
	EASI	55	8.4	0.6	9.6	7.1	47	148.5	43.6	278.0	25.0
	Level 1 WQ	6	7.3	0.5	7.0	6.4	7	147.5	26.9	191.7	122.2
ALPO 3	Arnold	4	6.3	0.3	6.6	5.9	3	40.3	6.8	48.0	35.0
	PMD	33	6.7	0.6	7.8	5.4	33	55.5	11.6	77.0	42.0
	EASI	53	8.4	0.5	9.5	7.6	44	59.0	34.4	200.0	30.0
	Level 1 WQ	6	7.0	0.3	6.9	6.7	7	45.3	3.4	49.3	40.7
ALPO 4	PMD	17	6.8	0.4	7.2	6.0	17	107.4	25.0	168.0	69.0
	EASI	55	8.4	0.5	9.6	7.0	47	124.2	46.0	283.0	33.0
	Level 1 WQ	6	7.3	0.2	7.1	7.0	6	88.3	15.4	104.0	60.7
	ERMN	5	7.0	0.5	7.4	6.2	5	97.1	24.7	122.0	59.1
ALPO 5	Arnold	3	6.2	0.2	6.4	6.1	2	49.0	8.5	55.0	43.0
	PMD	33	6.8	0.5	7.6	5.6	33	77.2	17.3	123.0	48.0
	Level 1 WQ	6	6.9	0.3	7.5	6.6	6	75.4	8.7	91.0	65.3
	ERMN	5	7.1	0.3	7.4	6.6	5	77.7	16.0	95	56
ALPO 5A	Arnold	3	6.4	0.2	6.5	6.2	2	74.0	1.4	75.0	73.0
	PMD	22	6.4	0.5	7.3	5.0	22	117.9	35.0	220.0	60.0
ALPO 6	EASI	49	8.5	0.8	10.4	6.8	40	103.8	43.3	194.0	12.0
	Level 1 WQ	6	7.3	0.3	7.7	6.8	6	115.2	27.6	159.9	84.2
	ERMN	5	7.3	0.4	7.6	6.7	5	120.7	26.6	140	76.4

Table A2. Descriptive statistics for dissolved oxygen and temperature measured at the primary monitoring locations in the Blair Gap Run and Bradley Run watersheds of the Main Unit. NRCA Study IDs are as follows: PMD = Park Monitoring Data; EASI = Senior Ranger Program; Level 1 WQ = Sheeder and Tzilkowski 2006; ERMN = Tzilkowski et al. 2011a, 2011b.

		Dissolved Oxygen (mg/L)					Temperature (° C)				
Site	**Study**	**n**	**Mean**	**SD**	**Max**	**Min**	**n**	**Mean**	**SD**	**Max**	**Min**
ALPO 1A	PMD	30	9.3	2.3	13.0	3.3	30	9.4	5.6	17.8	0.1
ALPO 1B	PMD	20	9.5	1.7	12.4	6.7	20	10.8	5.4	18.3	2.4
ALPO 1	PMD	35	10.0	1.5	13.2	6.8	35	10.4	5.7	19.4	0.1
	Level 1 WQ	7	9.7	1	1.4	8.8	7	12.2	4.6	17.4	6.1
ALPO 2	PMD	32	10.2	1.1	12.6	8.2	33	11.2	5.4	19.4	0.0
	EASI	55	9.5	1.6	13.0	4.0	52	7.2	6.2	17.0	-9.0
	Level 1 WQ	7	10.3	0.6	11.3	9.4	7	11.6	3.3	15.7	7.7
ALPO 3	PMD	33	9.8	1.5	13.3	7.1	33	12.5	6.5	22.5	1.1
	EASI	53	9.3	1.7	14.0	5.0	48	7.4	6.4	20.0	-10.0
	Level 1 WQ	7	10	0.9	11.2	9.0	7	13.0	5.6	19.1	6.4
ALPO 4	PMD	17	9.6	1.7	11.7	4.7	17	13.0	6.3	22.8	3.6
	EASI	54	9.4	1.4	13.0	7.0	45	7.5	6.6	18.0	-10.0
	Level 1 WQ	7	10.1	0.9	11.6	8.8	7	12.4	4.4	17.2	7.3
	ERMN	5	10.6	0.7	11.2	9.4	5	10.1	2.9	14.0	6.0
ALPO 5	PMD	32	9.7	1.6	13.3	5.2	33	12.2	5.9	21.4	0.1
	Level 1 WQ	7	10	0.9	11.3	8.8	7	11.8	4.0	16.3	7.2
	ERMN	5	10.5	0.8	11.1	9.1	5	10.0	4.2	15.0	3.7
ALPO 5A	PMD	22	9.5	2.2	13.2	5.0	22	9.7	5.8	18.8	0.1
ALPO 6	EASI	49	9.6	1.8	13.0	5.0	45	8.3	8.2	23.0	-10.0
	Level 1 WQ	7	10.2	1.3	12.1	8.6	7	12.8	5.9	19.6	5.8
	ERMN	4	10.8	0.7	11.6	10.0	5	10.5	3.5	15.4	5.6

Table A3. Descriptive statistics for core water quality parameters (pH, dissolved oxygen, conductivity and temperature) measured at the primary monitoring locations in the Little Conemaugh watershed of the Staple Bend Tunnel Unit. Study IDs are as follows: Arnold = Arnold et al. 1997; K & C = Katkins and Carney 2001; Cravotta = Cravotta 2005.

		pH					Dissolved Oxygen (mg/L)					Specific Conductivity (µS/cm)					Temperature (°C)				
Site	**Study**	**n**	**Mean**	**SD**	**Max**	**Min**	**n**	**Mean**	**SD**	**Max**	**Min**	**n**	**Mean**	**SD**	**Max**	**Min**	**n**	**Mean**	**SD**	**Max**	**Min**
ALPO 7	Arnold	2	6.3	0.2	6.5	6.2	*					1	166	*	166	166	*				
1U	K&C	24	3.0	0.2	3.4	2.7	24	9.6	0.4	10.4	9.6	24	1338	68	2200	740	24	8.8	0.5	11.5	3.0
	Cravotta	1	2.9	*	2.9	2.9	1	10.3	*	10.3	10.3	1	1340	*	1340	1340	1	10.9	*	10.9	10.9
1	K&C	25	3.0	0.4	4.2	2.3	25	10.9	1.2	13.7	9.0	24	1390	223	1850	960	25	9.2	2.9	13.0	2.0
	Cravotta	2	3.0	0.5	2.7	3.4	2	10.8	0.6	10.4	11.2	2	1166	243	994	1337	2	10.6	0.9	10.0	11.3
1Fe	K&C	25	3.3	0.3	3.6	2.5	25	1.5	0.8	4.2	0.8	24	1433	247	1900	1125	25	9.4	2.3	12.0	3.0
	Cravotta	2	3.0	0.4	2.8	3.3	2	1.4	0.6	1.0	1.8	2	1424	124	1337	1512	2	9.4	0.4	9.2	9.7
2	K&C	25	2.9	0.2	3.2	2.5	25	10.4	1.2	12.3	8.2	24	1840	342	2540	1300	25	9.3	5.2	18.0	1.0
	Cravotta	1	2.3	*	2.3	2.3	1	9.7	*	9.7	9.7	1	2029	*	2029	2029	1	10.7	*	10.7	10.7
2Fe	K&C	25	3.6	0.3	3.9	2.7	25	1.4	0.8	4.0	0.4	24	1605	246	2020	1250	25	10.3	1.0	12.0	7.5
	Cravotta	2	3.8	0.2	3.6	3.9	2	1.0	0.4	0.7	1.2	2	1708	138	1611	1806	2	10.8	0.1	10.7	10.8
3	K&C	25	3.2	0.2	3.7	2.9	25	7.6	1.4	10.0	4.6	25	1608	227	2000	1220	25	8.9	3.9	15.0	2.0
	Cravotta	2	4.2	0.6	3.8	4.7	2	10.4	0.2	10.2	10.5	2	1356	154	1247	1465	2	10.9	0.4	10.6	11.2
3A	K&C	25	3.1	0.2	3.5	2.5	25	8.4	1.2	11.4	5.7	25	1615	258	2100	1120	25	9.9	3.3	14.0	3.0
	Cravotta	1	3.2	*	3.2	3.2	1	8.8	*	8.8	8.8	1	1303	*	1303	1303	1	9.6	*	9.6	9.6
3B	K&C	25	3.1	0.2	3.5	2.8	25	10.3	1.1	12.5	8.8	25	1603	228	2050	1180	25	9.9	3.4	15.0	3.0
	Cravotta	2	3.3	0.3	3.1	3.5	2	9.8	0.2	9.6	9.9	2	1308	122	1222	1394	2	11.6	0.3	11.4	11.8
4	K&C	25	4.6	1.2	7.4	3.3	25	4.7	2.7	10.2	1.6	25	1134	463	1830	460	25	9.8	5.8	19.0	0.0
	Cravotta	2	5.6	1.3	4.7	6.5	1	10.5	*	10.5	10.5	1	1237	*	1237	1237	1	9.4	*	9.4	9.4
5	K&C	25	3.5	0.4	4.3	2.8	25	10.8	1.0	13.3	8.7	25	1430	289	1125	1910	25	9.5	3.7	15.0	1.0
	Cravotta	2	5.6	1.3	4.7	6.5	2	10.9	0.2	10.7	11.0	2	1085	148	980	1189	2	10.3	0.3	10.1	10.5
6	K&C	25	3.1	0.2	3.8	2.7	25	10.8	0.8	12.5	9.6	25	1404	218	2100	1040	25	9.9	1.9	13.0	7.0
	Cravotta	2	3.2	0.1	3.1	3.3	2	11.2	0.1	11.1	11.2	2	1270	108	1193	1346	2	6.8	0.5	6.5	7.2
7	K&C	25	3.0	0.2	3.7	2.7	25	10.7	0.8	12.6	9.2	25	1700	237	2350	1275	25	10.3	3.3	15.0	2.0
	Cravotta	2	3.2	0.3	3.0	3.4	2	10.6	0.1	10.5	10.7	2	1430	158	1318	1542	2	10.8	0.5	10.4	11.1
8	Cravotta	2	7.4	0.5	7.1	7.8	2	11.4	0.6	11.0	11.9	2	716	80	660	773	2	7.6	2.5	5.9	9.4
POND 1	Cravotta	6	3.5	0.2	3.2	3.8	6	10.4	0.9	9.3	11.4	7	695	247	219	1040	8	9.3	1.5	7.1	11.2
POND 2	Cravotta	3	3.8	0.2	3.6	4.0	3	8.4	2.3	7.0	11.1	3	719	18	700	735	3	10.4	3.5	6.3	12.7

Appendix B: Bird Community Information

Table B1. List of bird species detected during the 1997 spring migration and breeding surveys (Yahner and Keller 2000) and the 1999/2001 spring surveys (Yahner et al. 2001).

COMMON NAME	SCIENTIFIC NAME	CODE	1997 Spring Migration	1997 Spring Breeding	May 1999 - May 2001 Survey
Acadian Flycatcher	*Empidonax virescens*	ACFL	X	X	X
American Crow	*Corvus brachyrhynchos*	AMCR	X	X	X
American Goldfinch	*Spinus tristis*	AMGO	X	X	X
American Redstart	*Setophaga ruticilla*	AMRE	X	X	X
American Robin	*Turdus migratorius*	AMRO	X	X	X
American Tree Sparrow	*Spizella arborea*	ATSP			X
American Woodcock	*Scolopax minor*	AMWO			X
Baltimore Oriole	*Icterus galbula*	BAOR	X		X
Bay-breasted Warbler	*Dendroica castanea*	BBWA	X		X
Belted Kingfisher	*Ceryle alcyon*	BEKI			X
Black-and-white Warbler	*Mniotilta varia*	BAWW	X	X	X
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BBCU			X
Black-capped Chickadee	*Poecile atricapillus*	BCCH	X	X	X
Blackburnian Warbler	*Dendroica fusca*	BLBW	X		X
Blackpoll Warbler	*Dendroica striata*	BLPW	X		X
Black-throated Blue Warbler	*Dendroica caerulescens*	BTBW	X		X
Black-throated Green Warbler	*Dendroica virens*	BTNW	X	X	X
Blue Jay	*Cyanocitta cristata*	BLJA	X	X	X
Blue-gray Gnatcatcher	*Polioptila caerulea*	BGGN	X	X	X
Blue-headed Vireo	*Vireo solitarius*	BHVI	X	X	X
Blue-winged Warbler	*Vermivora pinus*	BWWA			X
Broad-winged Hawk	*Buteo platypterus*	BWHA	X	X	X
Brown Creeper	*Certhia americana*	BRCR	X		X
Brown Thrasher	*Toxostoma rufum*	BRTH			X
Brown-headed Cowbird	*Molothrus ater*	BHCO	X	X	X
Canada Goose	*Branta canadensis*	CANG			X
Canada Warbler	*Wilsonia canadensis*	CAWA	X		X
Cape May Warbler	*Dendroica tigrina*	CMWA	X		X
Carolina Wren	*Thryothorus ludovicianus*	CARW	X		X
Cedar Waxwing	*Bombycilla cedrorum*	CEDW		X	X
Cerulean Warbler	*Dendroica cerulea*	CERW			X
Chestnut-sided Warbler	*Dendroica pensylvanica*	CSWA	X	X	X
Chimney Swift	*Chaetura pelagica*	CHSW	X		X
Chipping Sparrow	*Spizella passerina*	CHSP	X	X	X
Common Grackle	*Quiscalus quiscula*	COGR		X	X
Common Raven	*Coruvs corax*	CORA	X	X	X
Common Redpoll	*Carduelis flammea*	CORE			X
Common Yellowthroat	*Geothlypis trichas*	COYE	X	X	X
Cooper's Hawk	*Accipiter cooperii*	COHA	X		X
Dark-eyed Junco	*Junco hyemalis*	DEJU			X
Downy Woodpecker	*Picoides pubescens*	DOWO	X	X	X
Eastern Bluebird	*Sialia sialis*	EABL			X
Eastern Kingbird	*Tyrannus tyrannus*	EAKI			X
Eastern Meadowlark	*Sturnella magna*	EAME			X
Eastern Phoebe	*Sayornis phoebe*	EAPH	X	X	X
Eastern Screech-owl	*Ottus asio*	EASO			X
Eastern Towhee	*Pipilo erythrophthalmus*	EATO	X	X	X
Eastern Wood-Pewee	*Contopus virens*	EAWP	X	X	X
European Starling	*Sturnus vulgaris*	EUST			X
Field Sparrow	*Spizella pusilla*	FISP		X	X

Table B1 (cont'd). List of bird species detected during the 1997 spring migration and breeding surveys (Yahner and Keller 2000) and the 1999/2001 spring surveys (Yahner et al. 2001).

COMMON NAME	SCIENTIFIC NAME	CODE	1997 Spring Migration	1997 Spring Breeding	May 1999 - May 2001 Survey
Fish Crow	*Corvus ossifragus*	FICR			X
Golden-crowned Kinglet	*Regulus satrapa*	GCKI			X
Gray Catbird	*Dumetella carolinensis*	GRCA	X	X	X
Great Blue Heron	*Ardea herodias*	GBHE			X
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL			X
Great Horned Owl	*Bubo virginianus*	GHOW			X
Hairy Woodpecker	*Picoides villosus*	HAWO		X	X
Hermit Thrush	*Catharus guttatus*	HETH			X
Hooded Warbler	*Wilsonia citrina*	HOWA		X	X
House Finch	*Carpodacus mexicanus*	HOFI			X
House Wren	*Troglodytes aedon*	HOWR	X	X	X
Indigo Bunting	*Passerina cyanea*	INBU	X	X	X
Kentucky Warbler	*Oporornis formosus*	KEWA	X	X	
Least Flycatcher	*Empidonax minimus*	LEFL	X	X	X
Louisiana Waterthrush	*Parkesia motacilla*	LOWA	X	X	X
Magnolia Warbler	*Dendroica magnolia*	MAWA	X		X
Mallard	*Anas platyrhynchos*	MALL	X		X
Mourning Dove	*Zenaida macroura*	MODA			X
Mourning Warbler	*Geothlypis philadelphia*	MOWA	X		
Nashville Warbler	*Vermivora ruficapilla*	NAWA	X	X	X
Northern Cardinal	*Cardinalis cardinalis*	NOCA	X	X	X
Northern Flicker	*Colaptes auratus*	NOFL	X	X	X
Northern Parula	*Parula americana*	NOPA	X	X	X
Northern Saw-whet Owl	*Aegolius acadicus*	NSWO			X
Northern Waterthrush	*Parkesia noveboracensis*	NOWA	X		X
Ovenbird	*Seiurus aurocapilla*	OVEN	X	X	X
Philadelphia Vireo	*Vireo philadelphicus*	PHVI	X		X
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	X	X	X
Pine Warbler	*Dendroica pinus*	PIWA			X
Purple Finch	*Carpodacus purpureus*	PUFI			X
Red-bellied Woodpecker	*Melanerpes carolinus*	RHWO	X		X
Red-Eyed Vireo	*Vireo olivaceus*	REVI	X	X	X
Red-shouldered Hawk	*Buteo lineatus*	RSHA			X
Red-tailed Hawk	*Buteo jamaicensis*	RTHA			X
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL			X
Rock Dove	*Columba livia*	ROPI			X
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	X	X	X
Ruby-crowned Kinglet	*Regulus calendula*	RCKI	X		X
Ruby-throated Hummingbird	*Archilochus colubris*	RTHU			X
Ruffed Grouse	*Bonasa umbellus*	RUGR		X	X
Savannah Sparrow	*Passerculus sandwichensis*	SAVS			X
Scarlet Tanager	*Piranga olivacea*	SCTA	X	X	X
Song Sparrow	*Melospiza melodia*	SOSP	X	X	X
Swainson's Thrush	*Catharus ustulatus*	SWTH	X		X
Swamp Sparrow	*Melospiza georgiana*	SWSP			X
Tree Swallow	*Tachycineta bicolor*	TRES	X	X	X
Tufted Titmouse	*Baeolophus bicolor*	TUTI	X	X	X
Tundra Swan	*Cygnus columbianus*	TUSW			X
Turkey Vulture	*Cathartes aura*	TUVU		X	X

Table B1 (cont'd). List of bird species detected during the 1997 spring migration and breeding surveys (Yahner and Keller 2000) and the 1999/2001 spring surveys (Yahner et al. 2001).

COMMON NAME	SCIENTIFIC NAME	CODE	1997 Spring Migration	1997 Spring Breeding	May 1999 - May 2001 Survey
Veery	*Catharus fuscescens*	VEER		X	X
Vesper Sparrow	*Pooecetes gramineus*	VESP			X
Warbling Vireo	*Vireo gilvus*	WAVI	X		
White-breasted Nuthatch	*Sitta carolinensis*	WBNU		X	X
White-eyed Vireo	*Vireo griseus*	WEVI			X
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	X		X
Wild Turkey	*Meleagris gallopavo*	WITU			X
Willow Flycatcher	*Empidonax traillii*	WIFL			X
Winter Wren	*Troglodytes hiemalis*	WIWR			X
Wood Thrush	*Hylocichla mustelina*	WOTH	X	X	X
Worm-eating Warbler	*Helmitheros vermivorus*	WEWA	X		X
Yellow Warbler	*Dendroica petechia*	YWAR	X		X
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA			X
Yellow-billed Cuckoo	*Coccyzus americanus*	YBCU		X	X
Yellow-breasted Chat	*Icteria virens*	YBCH			X
Yellow-rumped Warbler	*Dendroica coronata*	YRWA	X		X
Yellow-throated Vireo	*Vireo flavifrons*	YTVI			X

Table B2. List of bird species detected during the ERMN streamside bird surveys (2007-2012) (Marshell et al. 2013).

COMMON NAME	SCIENTIFIC NAME	CODE	TOTAL DETECTIONS
Broad-winged Hawk	*Buteo platypterus*	BWHA	1
Red-tailed Hawk	*Buteo jamaicensis*	RTHA	1
Mourning Dove	*Zenaida macroura*	MODA	3
Yellow-billed Cuckoo	*Coccyzus americanus*	YBCU	2
Chimney Swift	*Chaetura pelagica*	CHSW	5
Ruby-throated Hummingbird	*Archilochus colubris*	RTHU	7
Red-bellied Woodpecker	*Melanerpes carolinus*	RHWO	56
Downy Woodpecker	*Picoides pubescens*	DOWO	28
Hairy Woodpecker	*Picoides villosus*	HAWO	2
Northern Flicker	*Colaptes auratus*	NOFL	11
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	20
Eastern Wood-Pewee	*Contopus virens*	EAWP	33
Acadian Flycatcher	*Empidonax virescens*	ACFL	58
Eastern Phoebe	*Sayornis phoebe*	EAPH	11
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL	3
Yellow-throated Vireo	*Vireo flavifrons*	YTVI	1
Blue-headed Vireo	*Vireo solitarius*	BHVI	17
Red-Eyed Vireo	*Vireo olivaceus*	REVI	283
Blue Jay	*Cyanocitta cristata*	BLJA	37
American Crow	*Corvus brachyrhynchos*	AMCR	45
Common Raven	*Coruvs corax*	CORA	2
Black-capped Chickadee	*Poecile atricapillus*	BCCH	23
Tufted Titmouse	*Baeolophus bicolor*	TUTI	62
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	37
Carolina Wren	*Thryothorus ludovicianus*	CARW	9
Winter Wren	*Troglodytes hiemalis*	WIWR	2
Blue-gray Gnatcatcher	*Polioptila caerulea*	BGGN	3
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	2
Eastern Bluebird	*Sialia sialis*	EABL	1
Wood Thrush	*Hylocichla mustelina*	WOTH	77
American Robin	*Turdus migratorius*	AMRO	57
Gray Catbird	*Dumetella carolinensis*	GRCA	24
European Starling	*Sturnus vulgaris*	EUST	1
Cedar Waxwing	*Bombycilla cedrorum*	CEDW	12
Northern Parula	*Parula americana*	NOPA	5
Chestnut-sided Warbler	*Dendroica pensylvanica*	CSWA	1
Black-throated Blue Warbler	*Dendroica caerulescens*	BTBW	1
Black-throated Green Warbler	*Dendroica virens*	BTNW	36
Blackburnian Warbler	*Dendroica fusca*	BLBW	1
American Redstart	*Setophaga ruticilla*	AMRE	27
Ovenbird	*Seiurus aurocapilla*	OVEN	130
Louisiana Waterthrush	*Parkesia motacilla*	LOWA	50
Common Yellowthroat	*Geothlypis trichas*	COYE	58
Hooded Warbler	*Wilsonia citrina*	HOWA	3
Eastern Towhee	*Pipilo erythrophthalmus*	EATO	62
Field Sparrow	*Spizella pusilla*	FISP	9
Song Sparrow	*Melospiza melodia*	SOSP	16
Scarlet Tanager	*Piranga olivacea*	SCTA	126
Northern Cardinal	*Cardinalis cardinalis*	NOCA	36
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	28
Indigo Bunting	*Passerina cyanea*	INBU	43
Common Grackle	*Quiscalus quiscula*	COGR	7
Brown-headed Cowbird	*Molothrus ater*	BHCO	10
Baltimore Oriole	*Icterus galbula*	BAOR	1
American Goldfinch	*Spinus tristis*	AMGO	10
unknown bird		UNBI	5
unknown woodpecker		UNWO	3

Table B3. BCI scores for Breeding Bird Atlas (BBA) blocks located within a 30-km radius of ALPO's Main Unit and SBTU. BCI_1 = 1983-89 survey scores; BCI_2 = 2004-09 survey scores. Trends were determined by the difference in condition rating between the 1983-89 survey and the 2004-09 survey for each block.

BLOCK_ID	BBA_ID	BCI_1	Integrity_BCI_1	BCI_2	Integrity_BCI_2	Trend
510	73B51	56.0	High	55.0	High	Unchanging
941	73A75	53.5	High	39.5	Low	Deteriorating
1062	60C34	53.0	High	51.0	Medium	Deteriorating
1159	60C45	53.0	High	43.0	Medium	Deteriorating
1162	61C46	56.5	High	52.0	Medium	Deteriorating
1059	60D32	52.5	High	46.0	Medium	Deteriorating
929	73B62	59.0	High	51.5	Medium	Deteriorating
937	73B71	56.5	High	48.0	Medium	Deteriorating
738	74D12	56.0	High	50.0	Medium	Deteriorating
940	73B72	33.5	Low	53.0	High	Improving
1083	74B41	39.0	Low	59.5	High	Improving
1046	60C25	32.5	Low	39.5	Low	Unchanging
1002	60D11	36.5	Low	36.5	Low	Unchanging
1048	60D12	35.0	Low	32.0	Low	Unchanging
1049	60D21	28.5	Low	33.0	Low	Unchanging
1050	60D22	36.5	Low	36.5	Low	Unchanging
991	60D13	36.5	Low	34.5	Low	Unchanging
990	60D14	35.5	Low	34.0	Low	Unchanging
992	60D23	36.5	Low	38.0	Low	Unchanging
1000	60D24	33.0	Low	37.0	Low	Unchanging
1106	61D44	35.0	Low	33.5	Low	Unchanging
1108	61D53	37.0	Low	34.0	Low	Unchanging
950	59D65	35.0	Low	31.5	Low	Unchanging
987	60D15	35.0	Low	37.0	Low	Unchanging
984	60D25	34.5	Low	32.5	Low	Unchanging
1101	61D46	37.0	Low	31.5	Low	Unchanging
986	74A11	34.5	Low	36.0	Low	Unchanging
995	74A22	36.0	Low	32.0	Low	Unchanging
1102	74A41	28.5	Low	32.0	Low	Unchanging
954	73A64	38.5	Low	39.5	Low	Unchanging
953	73A73	37.0	Low	32.0	Low	Unchanging
1081	75A44	34.0	Low	28.5	Low	Unchanging
1096	75A53	35.5	Low	29.0	Low	Unchanging
1099	75A63	38.5	Low	35.5	Low	Unchanging
1136	75A64	32.0	Low	35.5	Low	Unchanging
971	74A16	40.0	Low	36.0	Low	Unchanging
962	74A25	36.5	Low	35.5	Low	Unchanging
980	74A26	37.5	Low	37.0	Low	Unchanging
1082	75A46	32.5	Low	39.0	Low	Unchanging
1098	75A65	36.5	Low	39.0	Low	Unchanging
933	73B52	38.0	Low	35.5	Low	Unchanging
935	73B61	27.5	Low	36.5	Low	Unchanging
963	74B12	33.5	Low	32.0	Low	Unchanging

Table B3 (cont'd). BCI scores for Breeding Bird Atlas (BBA) blocks located within a 30-km radius of ALPO's Main Unit and SBTU. BCI_1 = 1983-89 survey scores; BCI_2 = 2004-09 survey scores. Trends were determined by the difference in condition rating between the 1983-89 survey and the 2004-09 survey for each block.

BLOCK_ID	BBA_ID	BCI_1	Integrity_BCI_1	BCI_2	Integrity_BCI_2	Trend
974	74B22	32.5	Low	34.0	Low	Unchanging
977	74B31	33.5	Low	38.0	Low	Unchanging
1086	75B42	25.5	Low	36.5	Low	Unchanging
1092	75B52	40.0	Low	40.0	Low	Unchanging
1080	75B61	32.5	Low	38.0	Low	Unchanging
931	73B54	36.0	Low	39.5	Low	Unchanging
932	73B63	38.0	Low	29.0	Low	Unchanging
939	73B74	36.5	Low	33.5	Low	Unchanging
964	74B14	29.0	Low	27.5	Low	Unchanging
967	74B23	39.5	Low	40.0	Low	Unchanging
1084	74B43	32.0	Low	36.0	Low	Unchanging
1085	75B44	38.0	Low	32.5	Low	Unchanging
1091	75B53	37.5	Low	32.5	Low	Unchanging
733	73B75	39.5	Low	36.5	Low	Unchanging
737	73B76	36.5	Low	39.0	Low	Unchanging
697	74B15	40.0	Low	39.0	Low	Unchanging
758	74B16	39.5	Low	38.0	Low	Unchanging
880	75B46	37.5	Low	33.0	Low	Unchanging
872	75B55	26.5	Low	24.5	Low	Unchanging
887	75B65	35.5	Low	38.0	Low	Unchanging
734	73C71	35.5	Low	30.5	Low	Unchanging
736	74C11	32.0	Low	32.5	Low	Unchanging
759	74C12	35.5	Low	33.0	Low	Unchanging
619	74C32	30.0	Low	24.0	Low	Unchanging
879	75C42	34.0	Low	29.0	Low	Unchanging
882	75C52	38.0	Low	33.5	Low	Unchanging
717	73C64	38.0	Low	37.0	Low	Unchanging
730	73C74	39.0	Low	35.0	Low	Unchanging
766	74C33	38.5	Low	35.0	Low	Unchanging
761	74C34	36.0	Low	29.0	Low	Unchanging
874	74C43	38.0	Low	37.5	Low	Unchanging
875	75C44	33.0	Low	38.5	Low	Unchanging
764	74C35	37.0	Low	38.5	Low	Unchanging
715	74D11	28.5	Low	39.5	Low	Unchanging
746	74D22	36.0	Low	38.5	Low	Unchanging
1053	60C23	39.5	Low	41.0	Medium	Improving
1054	60C24	38.5	Low	42.5	Medium	Improving
1166	60C43	38.0	Low	42.5	Medium	Improving
1167	61C44	39.5	Low	42.0	Medium	Improving
1047	60C16	30.0	Low	40.5	Medium	Improving
1045	60C26	37.5	Low	46.0	Medium	Improving
1058	60C35	32.0	Low	48.0	Medium	Improving
1056	60C36	33.0	Low	46.0	Medium	Improving

Table B3 (cont'd). BCI scores for Breeding Bird Atlas (BBA) blocks located within a 30-km radius of ALPO's Main Unit and SBTU. BCI_1 = 1983-89 survey scores; BCI_2 = 2004-09 survey scores. Trends were determined by the difference in condition rating between the 1983-89 survey and the 2004-09 survey for each block.

BLOCK_ID	BBA_ID	BCI_1	Integrity_BCI_1	BCI_2	Integrity_BCI_2	Trend
1057	60D31	40.0	Low	47.5	Medium	Improving
1160	61D42	37.0	Low	48.0	Medium	Improving
1172	61D52	41.0	Low	41.0	Medium	Improving
1113	61D54	33.5	Low	42.5	Medium	Improving
956	59D66	40.0	Low	41.5	Medium	Improving
985	60D16	39.0	Low	43.0	Medium	Improving
1111	61D56	38.5	Low	49.5	Medium	Improving
1109	61D65	39.0	Low	47.0	Medium	Improving
951	73A62	38.0	Low	40.5	Medium	Improving
996	74A31	35.5	Low	41.0	Medium	Improving
1104	75A42	35.0	Low	42.5	Medium	Improving
1100	75A51	38.0	Low	50.0	Medium	Improving
1112	75A61	38.0	Low	45.5	Medium	Improving
1134	75A62	39.5	Low	47.0	Medium	Improving
973	74A23	38.5	Low	43.0	Medium	Improving
961	74A24	39.0	Low	40.5	Medium	Improving
981	74A33	36.5	Low	49.5	Medium	Improving
942	73A76	36.5	Low	45.0	Medium	Improving
970	74A15	34.0	Low	46.0	Medium	Improving
979	74A35	36.5	Low	49.0	Medium	Improving
982	74A36	36.5	Low	51.5	Medium	Improving
1088	74A45	31.0	Low	42.5	Medium	Improving
1095	75A55	35.5	Low	43.0	Medium	Improving
966	74B11	27.5	Low	40.0	Medium	Improving
968	74B21	33.0	Low	40.5	Medium	Improving
925	74B32	38.5	Low	52.0	Medium	Improving
1089	75B51	38.0	Low	44.0	Medium	Improving
938	73B73	36.5	Low	42.5	Medium	Improving
965	74B13	34.0	Low	44.0	Medium	Improving
1090	75B54	32.5	Low	48.0	Medium	Improving
1093	75B63	32.5	Low	41.0	Medium	Improving
618	73B56	40.0	Low	42.0	Medium	Improving
753	74B25	38.5	Low	42.5	Medium	Improving
771	74B36	37.5	Low	47.5	Medium	Improving
888	75B56	35.0	Low	40.5	Medium	Improving
735	73C72	36.5	Low	48.5	Medium	Improving
768	74C22	40.0	Low	41.5	Medium	Improving
727	73C73	36.5	Low	42.5	Medium	Improving
755	74C16	32.0	Low	45.5	Medium	Improving
743	74D21	38.5	Low	44.5	Medium	Improving
731	74C15	36.0	Low	N/A	N/A	*
1114	61D63	40.5	Medium	54.0	High	Improving
767	74B26	47.5	Medium	55.0	High	Improving

Table B3 (cont'd). BCI scores for Breeding Bird Atlas (BBA) blocks located within a 30-km radius of ALPO's Main Unit and SBTU. BCI_1 = 1983-89 survey scores; BCI_2 = 2004-09 survey scores. Trends were determined by the difference in condition rating between the 1983-89 survey and the 2004-09 survey for each block.

BLOCK_ID	BBA_ID	BCI_1	Integrity_BCI_1	BCI_2	Integrity_BCI_2	Trend
770	74B35	51.0	Medium	54.5	High	Improving
725	73C61	46.5	Medium	56.0	High	Improving
757	74C23	41.5	Medium	62.5	High	Improving
1164	61C55	45.5	Medium	39.5	Low	Deteriorating
999	60D33	43.5	Medium	37.0	Low	Deteriorating
998	60D35	49.0	Medium	35.0	Low	Deteriorating
993	60D36	49.0	Medium	39.0	Low	Deteriorating
1103	60D45	43.0	Medium	39.5	Low	Deteriorating
927	73A72	40.5	Medium	40.0	Low	Deteriorating
988	74A21	43.5	Medium	38.0	Low	Deteriorating
946	73A63	44.5	Medium	29.5	Low	Deteriorating
955	73A74	41.5	Medium	40.0	Low	Deteriorating
1094	75A56	41.5	Medium	39.0	Low	Deteriorating
1121	75A66	45.0	Medium	40.0	Low	Deteriorating
978	74B34	45.0	Medium	34.5	Low	Deteriorating
769	74C31	40.5	Medium	27.5	Low	Deteriorating
876	74C41	48.0	Medium	31.0	Low	Deteriorating
878	75C51	41.5	Medium	35.5	Low	Deteriorating
732	74C13	43.5	Medium	36.0	Low	Deteriorating
754	74C14	42.0	Medium	38.5	Low	Deteriorating
762	74C24	44.0	Medium	36.5	Low	Deteriorating
729	73C75	51.5	Medium	37.0	Low	Deteriorating
728	73C76	41.5	Medium	38.0	Low	Deteriorating
763	74C26	41.5	Medium	39.5	Low	Deteriorating
698	73D72	40.5	Medium	36.5	Low	Deteriorating
1061	60C33	43.5	Medium	43.5	Medium	Unchanging
1018	59D72	41.0	Medium	41.5	Medium	Unchanging
1161	60D41	40.5	Medium	41.5	Medium	Unchanging
1163	61D51	42.5	Medium	43.5	Medium	Unchanging
960	59D73	42.5	Medium	45.5	Medium	Unchanging
926	59D74	42.5	Medium	44.5	Medium	Unchanging
1001	60D34	52.0	Medium	41.0	Medium	Unchanging
1107	60D43	43.5	Medium	41.0	Medium	Unchanging
959	59D75	40.5	Medium	46.0	Medium	Unchanging
958	59D76	43.5	Medium	45.5	Medium	Unchanging
994	60D26	42.5	Medium	42.5	Medium	Unchanging
1105	61D55	42.0	Medium	47.0	Medium	Unchanging
944	73A52	42.0	Medium	44.0	Medium	Unchanging
947	73A61	41.5	Medium	51.5	Medium	Unchanging
952	73A71	47.5	Medium	41.5	Medium	Unchanging
989	74A12	41.5	Medium	41.0	Medium	Unchanging
997	74A32	42.0	Medium	40.5	Medium	Unchanging
1110	75A52	44.5	Medium	49.5	Medium	Unchanging

Table B3 (cont'd). BCI scores for Breeding Bird Atlas (BBA) blocks located within a 30-km radius of ALPO's Main Unit and SBTU. BCI_1 = 1983-89 survey scores; BCI_2 = 2004-09 survey scores. Trends were determined by the difference in condition rating between the 1983-89 survey and the 2004-09 survey for each block.

BLOCK_ID	BBA_ID	BCI_1	Integrity_BCI_1	BCI_2	Integrity_BCI_2	Trend
945	73A54	43.5	Medium	49.5	Medium	Unchanging
969	74A13	41.5	Medium	44.5	Medium	Unchanging
972	74A14	42.0	Medium	45.5	Medium	Unchanging
983	74A34	44.5	Medium	51.0	Medium	Unchanging
1087	74A43	42.0	Medium	46.0	Medium	Unchanging
1097	75A54	43.0	Medium	43.0	Medium	Unchanging
518	73A55	44.0	Medium	41.5	Medium	Unchanging
934	73A56	46.0	Medium	43.0	Medium	Unchanging
936	73A65	42.0	Medium	45.0	Medium	Unchanging
928	73A66	43.5	Medium	49.5	Medium	Unchanging
514	73B53	41.0	Medium	44.0	Medium	Unchanging
930	73B64	52.0	Medium	48.0	Medium	Unchanging
976	74B24	40.5	Medium	47.5	Medium	Unchanging
975	74B33	41.0	Medium	51.5	Medium	Unchanging
723	73B65	48.0	Medium	50.0	Medium	Unchanging
716	73B66	46.5	Medium	46.5	Medium	Unchanging
877	74B45	46.5	Medium	41.5	Medium	Unchanging
724	73C52	43.0	Medium	50.0	Medium	Unchanging
726	73C62	40.5	Medium	48.0	Medium	Unchanging
760	74C21	44.0	Medium	49.0	Medium	Unchanging
722	73C63	46.0	Medium	43.0	Medium	Unchanging
721	73C66	46.0	Medium	44.0	Medium	Unchanging
756	74C25	46.5	Medium	46.5	Medium	Unchanging
765	74C36	43.5	Medium	42.0	Medium	Unchanging

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