National Park Service
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Natural Resource Stewardship and Science

Johnstown Flood National Memorial Natural Resource Condition Assessment

Natural Resource Report NPS/JOFL/NRR—2014/836

ON THIS PAGE
Train running through the dry lakebed of Lake Conemaugh.
Photograph by: NPS Park Staff

ON THE COVER
View of the dry bed of the former Lake Conemaugh from the Unger Farm hillside.
Photograph by: NPS Park Staff

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Executive Summary

Background and Context

Johnstown Flood National Memorial (JOFL) is located in Cambria County in southwestern Pennsylvania. The park commemorates the tragic Johnstown flood of May 31, 1889 and preserves the remains of the South Fork Dam and portions of the Lake Conemaugh bed, as well as historic structures associated with the Johnstown flood.

The South Fork Dam was originally constructed as a water source for the Pennsylvania Mainline Canal. Advances in railroad technology soon made the dam obsolete, it fell into disrepair and was later bought by the South Fork Fishing and Hunting Club who restored the dam and turned it into Lake Conemaugh, complete with stocked fish and resort houses along the shore to serve Pittsburgh industrialists, bankers, lawyers, and others who amassed great wealth during the Industrial Revolution. Farther downstream, Johnstown, housed the coal, iron, and steel factories, as well its workers and their families. Settled between two rivers with abundant natural resources in the surrounding hills, Johnstown owed much of its growth to its location. Unfortunately, the low-lying area and steep, narrow valley upstream also made the town prone to flooding.

This coupled with the dam's history of neglect and improper management caused Lake Conemaugh to rise to unprecedented levels during a period of heavy rains. Through the course of the morning and afternoon of May 31, 1889, the club's president Colonel Elias Unger coordinated several unsuccessful attempts to prevent flooding and sent numerous warnings to the residents of Johnstown, all of which went unheeded. The South Fork Dam failed at ~3:10 p.m. sending a huge flood wave down the narrow valley and devastating anything in its path. By the time it reached Johnstown the flood wave was amass with houses, trees, railcars and other debris, which piled up at the stone bridge on the Conemaugh River. By nightfall, fuel leaking from the debris was ignited and the massive inferno became a death trap for the people inside. The final deathtoll from the flood was estimated at 2,209 people. The disaster horrified the nation, and newspaper coverage, photographs, songs, and other paraphernalia surfaced to both pay homage to the tragic loss but also to debate the classic conflict of man versus nature and ask the question of how it could possibly have been prevented.

Johnstown Flood was designated a National Memorial on August 31, 1964 in order to commemorate the great loss of lives taken along the 15-mile flood path and instill the significance of the complex social and environmental factors that led to the destruction of the dam. The park is small, stretching across 178 acres and includes 1) the ruins of the South Fork Dam, 2) a small portion of the former lakebed, 3) the remains of South Fork Fishing and Hunting Club District, and 4) the Unger Farm, which includes the Unger House, the visitor center, the springhouse ruins, and the surrounding fields and orchard on the hillside above the dam. In addition, JOFL is significant in portraying the great sense of loss and providing visitors with a unique view of life before and after the flood through the museum collection of historical objects, the Clarke photo collection portraying life on the lake before the flood, the Morgue book containing a master list and descriptions of the deceased, and other archival collections.

Although this small park was established for the preservation of cultural resources, these resources are embedded within the natural resources of the park, including streams, wetlands, forested mountains, 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

JOFL 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 JOFL begins with a review of the region's mining and industrial history followed by a recount of the events leading up to and immediately following the flood. 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.

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	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low
	Condition Status Unknown; Consequently, Trend is also Unknown and Confidence is Low				

JOFL Management Objectives and Cultural Resources

Park-wide management objectives are (1) "to commemorate and interpret the tragic consequences of the flood…", (2) "to protect and maintain the natural diversity of plants and animals outside of areas managed for primarily cultural resources or developed areas" and (3) "to provide visitors a range of recreational opportunities which will enhance their appreciation of the story of the flood, the significance of geography and the relationship of natural resources, without impairing natural or cultural resource values or the atmosphere of quiet contemplation" (NPS 1992). Important cultural resources at JOFL include the following:

- South Fork Dam Ruins, including the dam abutments, the spillway and control tower foundation ruins, and the historic carriage road trace
- Dry Bed of Lake Conemaugh
- The Unger Farm, which includes the Unger House, springhouse, and replica barn (visitor center), and surrounding fields
- South Fork Fishing and Hunting Club Historic District, including the old Clubhouse, the Clubhouse Annex, the Brown Cottage, and the Moorhead Cottage.

Threats to JOFL

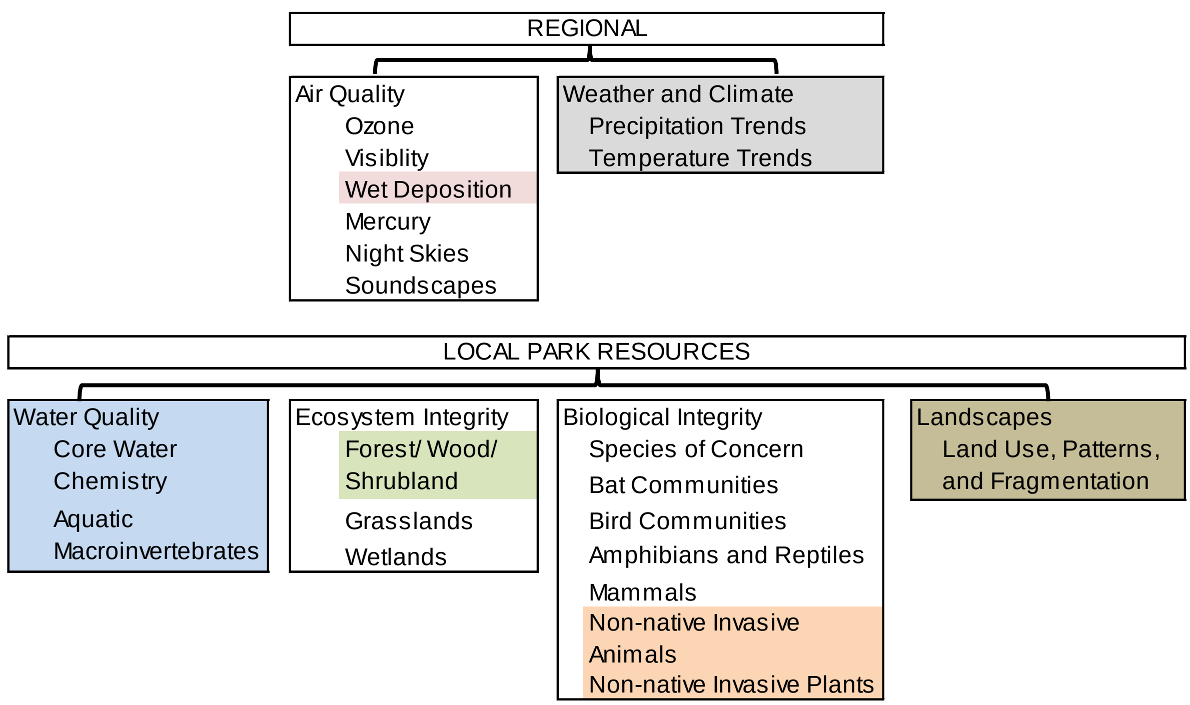
JOFL is a small park occurring mostly in an urban setting. As a result, the park's natural resources are under threat from fragmentation and invasive plant and animal species. The park implemented aggressive management controls to remove invasive plant species and, presently, is considered to be in good condition regarding this threat. Past land use activities, especially mining and industry have altered the air and water quality of the region and are largely beyond the park's ability to control. The South Fork Little Conemaugh River, which runs through the former lakebed, is impaired from abandoned mine drainage. Additional regional threats to the park include suburban development, Marcellus shale gas extraction and infrastructure, and wind turbines.

Current Condition of JOFL 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 JOFL or had very limited data where only heuristic or qualitative assessments were possible. The natural resources and indicators chosen for the JOFL NRCA are shown below. Indicators that correspond directly to the ERMN vital signs monitoring are shown in color. Those in white were included primarily because of their importance and relevance to JOFL.

JOFL NRCA RESOURCE & INDICATORS



Air Quality

Air quality, although beyond the ability of the park to control, is an important concern to JOFL, potentially affecting both cultural (e.g., eroding buildings) and natural (e.g., injuring sensitive plant species) resources. Important indicators include ozone, visibility, total wet deposition of nitrogen (N) and sulfur (S), and mercury (Hg). In addition, night skies and soundscapes are also important natural resources to the park. Overall air quality condition for JOFL was considered to be of *significant concern* with an *improving* trend. Ozone is considered to be of *moderate concern* with an *improving* regional trend (2006 – 2010 estimate for the interpolated 4th-highest daily maximum 8-hour ozone concentration = 72.3ppb). ERMN's risk assessment of ozone-induced foliar injury to sensitive plant species (Sum 06 & W126 indices) is of *moderate concern*. Visibility is an area of *significant concern* with no apparent (*unchanging*) trend in condition (2006 – 2010 interpolated visibility values = 11.4 dv). Wet S and N deposition are both considered to be of *significant concern* with an *improving* trend (Station PA13 estimates for nitrogen and sulfur wet deposition are N-(NH_4 + NO_2) = 6.3 kg/ha/yr and S – (SO_4) = 8.77 kg/ha/yr, respectively. Acidification risk is considered to be very high; nutrient enrichment risk is high. Condition rating for both metrics is *significant concern*. Mercury wet deposition is of *significant concern* with an *unchanging* trend (Hg concentrations from 1997 – 2011 have ranged from 7.06 to 9.37 ng/L with a 2011 estimate of 8.55 ng/L). Night skies are considered to be of *moderate concern* (region surrounding JOFL corresponds to a 4 on the Bortle Dark-Sky Scale). Desired condition for soundscapes at JOFL cannot be assessed due to lack of data.

We recommend continued monitoring, especially of wet nitrogen, sulfur, and mercury deposition. In addition, further monitoring of dry mercury deposition is highly encouraged, since this component may represent at least half of the total mercury entering the system.

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. 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. Precipitation and temperature trends indicate that JOFL 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 JOFL. Historical land use upstream in the watershed included surface and subsurface mining activities that resulted in severe AMD pollution of the South Fork Little Conemaugh River (SFLCR). Water quality results from two stations sampled along the SFLCR indicated *significant concern*. The macroinvertebrate community was severely depleted (MBII = 7.01 on a 0 to 100 scale with scores <49 indicating *significant concern*). These results are not surprising given the long-term impacts that AMD pollution has on macroinvertebrate communities. Low pH and high conductivity measurements are also consistent with AMD effects and support the biological condition results. This regional pollution detracts from the water quality and biological integrity of the park's resources. However, the three unnamed tributaries flowing through the park do not appear to be as affected by AMD as the SFLCR. Water pH values were higher, specific conductance was lower, and MBII scores, while still warranting *significant concern*, were also higher (average MBII score = 27.87) than in the SFLCR. While obviously affected by the connection to the SFLCR, it is likely that local stressors within and immediately surrounding JOFL influenced tributary scores. These include Rt. 219 (a four-lane divided highway) that follows the northwest border of the park and crosses the SFLCR just downstream of the park boundary. In addition an active railroad runs parallel to the SFLCR bisecting the park. Agricultural practices and urban development upstream in the watershed most likely affect JOFL water quality results, as well. As aquatic macroinvertebrates represent a more reliable and robust indicator of water quality than discrete water chemistry measurements, the overall water quality rating for JOFL is based primarily on the MBII results, which corresponds to *significant 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

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, including severe disturbances (e.g., extensive logging) followed by a long period of no physical land disturbance, coupled with increasing acid deposition from industrialization. As a result, the dominant fire-adapted trees species have been replaced with later successional, shade- and acid-tolerant species (e.g., red maple and striped maple). In JOFL, these factors, along with the disastrous flood of 1889 and surrounding land development, have shaped both forest species composition and vegetation structure in the park. The two forest associations within JOFL ranked *moderate concern* to *good* for floristic quality with an overall rating of *good* for the resource. Both associations, however, contain multiflora rose, Morrow's honeysuckle and Japanese barberry. We recommend continued vigilance of these non-native, invasive species to control and prevent their spread to other areas in of the park.

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 park's small area and surrounding urban development, along with encroaching shrubs in wetland habitats 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 patch around the visitor center and Unger House fields. 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.

Wetlands

Wetlands are an important resource at JOFL and occur throughout the former lakebed. Condition scores for JOFL wetland communities ranged in floristic quality from significant to moderate concern. The average FQI score was 27, while the average mean C score was 3; both equate to an average condition score of moderate concern. Lower rankings for floristic quality occurred either from the presence of non-native species or the presence of a high number of species with low conservatism values. Landscape metrics ranked wetlands in good condition with an overall rating of good for the resource. Individual landscape metric scores ranged between good condition and moderate concern. For example, landscape connectivity scored good for the combined length of all non-buffer segments but moderate concern for the proportion of non-riverine buffer as natural habitat. Buffer Index scores followed a similar pattern with buffer lenth and buffer width scoring as good condition and moderate concern, respectively. Surrounding Land Use Index was rated as good condition. Minimal information exists regarding wetlands within JOFL. The Perles et al. (2006) study and a recent wetland delineation conducted in the fall of 2009 are the only studies to formally sample wetlands. In order to properly address concerns for this critical resource, we recommend multi-year monitoring. This is especially important considering many of the wetlands throughout the park have been invaded by aggressive plant species. Of primary concern is the River Scour Vegetation area. This area contains two highly invasive species: Morrow’s honeysuckle and Japanese knotweed. Both of these were addressed by JOFL staff following the Perles et al. (2004) inventory; however, management efforts in this area remain challenging. Drastic year-to-year change from intermittent flood scouring is conducive to the establishment of weedy plants. Because the spread of knotweed to new sites is facilitated by disturbance (Beerling 1991), continued vigilance and control of knotweed in this area is critical to managing this species and curtailing its spread within the park.

Biological Integrity

The wildlife focused biological integrity indicators were rated across a variety of condition levels. Very little data (inventory or monitoring) was available for these species; therefore, in many cases condition was assigned based on the best professional judgment of JOFL’s Natural Resource Manager and the authors of this NRCA.

Species of Concern

Six species of concern were selected for JOFL due to their special status given by state or federal agencies. Appalachian blue violet is a Pennsylvania State imperiled and globally vulnerable plant species. Veiny-lined aster has no current legal status in Pennsylvania but is considered to be Tentatively Undetermined by the Pennsylvania Natural Heritage Program. Northern myotis (northern long-eared bat) is a federally Proposed Endangered bat species. The Golden-winged Warbler is currently under consideration for federal listing, while the Blackpoll Warbler is listed as PA Endangered and the smooth green snake is a Species of Special Concern in Pennsylvania. We did not assign condition to these last three species due to uncertainty of their status and/or lack of data. Appalachian blue violet was rated as moderate concern with a deteriorating trend, since only a small population was detected and little suitable habitat could be found within the park. A thriving colony of veiny-lined aster was documented within the park on both sides of the South Fork Little Conemaugh River; this species is considered to be in good condition but the trend is unknown. The northern myotis was considered to be of significant concern with a deteriorating trend, primarily due to the fact that park surveys were conducted prior to the detection of white-nosed syndrome, which has caused substantial population declines in this species.

Bat, Bird, Amphibian, Reptile, and Mammal Communities

The condition of bat, bird, amphibian, reptile, and mammal communities ranged from moderate concern to significant concern. No trends were determined due to limited data. In many instances, condition was assigned based on results from a single inventory. This makes it very difficult to determine condition and resulted in the low confidence and possibly lower condition ratings assigned to many of the indicators, especially considering the unlikelihood of detecting many of these species during a single survey. Overall the bat community at JOFL was considered to be of moderate concern. Although nine to eleven species were found to potentially occur within the park, these results were collected prior to white-nose syndrome. Present results may show a decline in the number of potential species. The condition of bird communities at JOFL warranted moderate concern (60% of points within the park had BCI scores between 40.1 and 52.0). Combined condition results for amphibians and reptiles indicated significant concern with 59% of expected amphibians and 44% of expected reptiles expected to occur within JOFL. Only 30% of expected mammal species occurred within the park warranting significant concern.

Non-native Invasive Animals and Plants

Five species of non-native invasive animals were included in the JOFL NRCA: gypsy moth, emerald ash borer, Asian longhorn beetle, viburnum leaf beetle, and non-native crayfish species. Although gypsy moth detections are presently at low levels, continuous monitoring is necessary due to the possibility of future outbreaks and warrants moderate concern. Emerald ash borer has been devastating native ash trees in several Pennsylvania counties; however, it has not been detected within JOFL during the ERMN early detection surveys. As a result, the species rated as good condition for the park but given the ability of emerald ash borer to decimate stands of healthy ash trees within a few years of infestation, this species should be monitored closely. The viburnum leaf beetle was first detected at JOFL in 2010. Rapid response measures failed to control populations, which have decimated native arrowwood shrubs in early successional woodlands of the park. Consequently, this species was considered to be of significant concern. Crayfish populations continue to show relatively high abundances of native species with no non-natives detected and were considered to be in good condition. Previous studies of non-native plants within JOFL identified a total of 54 species, of which 12 were considered to be moderate or serious threats by DCNR. In addition, four target non-native invasive plant species (garlic mustard, shrub honeysuckles, multiflora rose and knotweed) were identified in park surveys, all of which still occur within park boundaries.

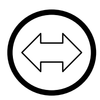
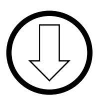
The overall condition ranking for non-native invasive plants, therefore, is moderate concern. Aggressive control and maintenance activities over the past decade have greatly reduced individual plants and curtailed a primary source of seed and propagules. Knotweed, in particular, which has been targeted for control since 2000, now poses a minor threat to park habitats. We recommend that control measures be continued to restrict the spread of target non-native invasive species. A management plan should be developed for each target 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. Park managers should 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.

Landscapes

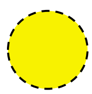
Landscape analyses were initially completed at four spatial scales; park boundary, park boundary +1 km buffer zone, park boundary +30 km buffer zone, and watershed catchment. After processing of the land cover data we focused work on the park boundary +1 km landscape and the catchment to keep our assessment 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. Land cover conditions differed inside the park boundary and within the 1-km buffer zone. Percent forest increased from 41.09% in 1992 to 55.44% in 2006 within the JOFL boundary but decreased from 59.31 % to 49.47 % inside the 1 km buffer surrounding the park. Core forest increased approximately 4% from 2.31% to 6.37% in the JOFL boundary. Despite the reduction in total forest cover in the 1-km buffer zone, core forest increased 3% from 6.89% in 1992 to 10.00% in 2006. Road density has remained relatively unchanged. Greater changes probably occurred prior to 1992 when the adjacent highway (Rt. 219) was constructed. Average condition score and trend results for landscapes was 83 indicating *good* condition with an *unchanging* trend. 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, despite forest increase within the park, 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.

Based on the summary results previously stated, the following State of the Park Summary Tables provide a broad overview of the state of JOFL's natural resources and include the overall condition status (green = *good*; yellow = *moderate concern*; red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging*, or *deteriorating* (downward arrow)), followed by the rationale for the determined result.

State of the Park Summary Tables

Priority Resource or Value	Condition Status/Trend	Rationale
Natural Resources		
Air Quality		Average condition score for air quality metrics was 20 indicating *significant concern* with an overall trend of *improving* condition. Estimated values for **ozone** were of *moderate concern* with an *improving* trend. Estimates for **visibility** warranted *significant concern* with an *unchanging* trend. Estimates of **wet deposition of nitrogen and sulfur** warranted *significant concern* with *improving* trends. Estimates of **wet mercury deposition** were of *significant concern* with an *unchanging* trend. **Night skies** were rated as *moderate concern* based on the Bortle Dark-Sky Scale.
Weather and Climate	 	Although **temperature trend** is *unchanged*, the lowest recorded temperature during the calendar year increased throughout the entire period of record, while the number of sub-zero days decreased. Overall results indicate JOFL has been experiencing milder winters with less snow cover. In accord with these milder temperatures, the growing season length has increased. Cumulative annual **precipitation** has remained unchanged but precipitation as snow, including annual snowfall, measurable snow days, moderate snow days, and heavy snow days, is decreasing.
Water Quailty		Water resources at JOFL include the South Fork Little Conemaugh River (SFLCR) and small unnamed tributaries (UNT). Wetlands are also an important resource but are not monitored for water quality. The ERMN monitors water quality using **benthic macroinvertebrates** (BMI) at one of the UNTs in the park. Due to the long history of AMD pollution to the SFLCR, the river was not monitored except for one year (2012). AMD watershed impacts affect the condition of JOFL's tributaries, but to a lesser degree than the SFLCR. BMI monitoring results confirmed impairment at both park (UNT) and regional (SFLCR) scales warranting *significant concern,* although the UNT was found to be in better condition than the SFLCR. **Core water chemistry** results for specific conductance supported the biological results, warranting *moderate concern* in the UNT and *significant concern* in the SFLCR.
Ecosystem Integrity		**Forests** occur south of the dam in JOFL's natural zone and consist primarily of Red Maple-Black Cherry Successional Forest/Woodland, which was considered to be in *good* condition for both floristic quality and conservatism. A Mosaic of Old Field/Red Maple-Black Cherry Successional Forest/Woodland is present to a lesser extent and warranted *moderate concern*. Early-successional **grasslands** occur within the Unger Farm fields surrounding the visitors center and warranted *moderate concern* based on minimum field size, perimeter:area ratio, and mowplan metrics. **Wetlands** occur throughout the former lakebed as a mosaic of early successional wetlands, grasslands, and shrubland and warranted *moderate* to *significant concern* for floristic quality and conservatism but scored higher for landscape condition ranging from *good* to *moderate concern*. The combined condition score for ecosystem integrity metrics was 71, indicating *good* condition.

State of the Park Summary Tables

Priority Resource or Value	Condition Status/Trend	Rationale
Natural Resources		
Biological Integrity		Very little data existed for biological integrity indicators necessitating best professional judgment for many of the associated condition assessments. **Species of concern** at JOFL include rare plant species (Appalachian blue violet and veiny-lined aster), northern myotis (northern long-eared bat), Golden-winged Warbler, Blackpoll Warbler, and smooth green snake. The suspected status of the Appalachian blue violet was *moderate concern* with a *deteriorating* trend (due to small population and lack of suitable habitat), while that of the veiny-lined aster was considered to be in *good* condition with thriving colonies on both sides of the river. Northern myotis warranted *significant concern* due to widespread species declines from white-nose syndrome. The remaining species were not assessed for condition due to their uncertain status and lack of suitable habitat within the park. **Bat communities** at JOFL warranted *moderate concern*, also due to regional declines from white-nose syndrome. **Streamside birds** are not monitored by the ERMN due to lack of sufficent stream length, but results from Yahner et al. 2001 revealed Bird Community Index scores warranting *moderate concern*. **Amphibians, reptiles,** and **mammals** warranted *significant concern*. **Non-native invasive animals** at JOFL include the gypsy moth (*moderate concern*), emerald ash borer (*good*), Asian longhorn beetle (*good*), viburnum leaf beetle (*significant concern*), and non-native crayfish (*good*). **Non-native invasive plants** include garlic mustard, shrub honeysuckle, multiflora rose and knotweed. JOFL condition assessment for these plant species was conducted using the ERMN monitoring data collected within the park's natural zone. Red Maple-Black Cherry Successional Forest/Woodland scored *good* for invasibility and % non-native species metrics; Mosaic Old Field and Red Maple-Black Cherry Successional Forest/Woodland scored *moderate concern* for each metric. The average condition score for all biological integrity indicators was 50 indicating *moderate concern.*
Landscapes		JOFL is a small park surrounded by a largely agricultural and urban matrix. This was reflected by differing land cover conditions inside the park vs. within a 1-km buffer zone surrounding the park. Percent forest has increased within the park from 1992 to 2006 but decreased within the buffer zone during that same time period. Due to the influence of the surrounding buffer, the park plus the 1-km buffer zone was the spatial scaled used for most of the landscape metrics, which showed percent forest warranted *moderate concern* with a *deteriorating* trend, percent core forest remained relatively unchanged, and road density was in *good* condition with an *unchanging* trend. Percent developed land in the catchment indicated *good* condition with *a deteriorating* trend. The average condition score and trend results for landscapes was 83 indicating *good* condition with an *unchanging* trend.

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 fora subset of important park natural resources and indicators

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

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

- are multi-disciplinary in scope, however, the breadth of natural resources and number/type of indicators evaluated will vary by park
- employ hierarchical indicator frameworks, which 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
- identify or develop logical reference condition data against. NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-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 an 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 planning7 and help parks report to government accountability measures. NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy (RSS) but study scope can be tailored to also work well as a post-RSS project. While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

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

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.

Johnstown Flood National Memorial (JOFL) 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 JOFL begins with a review of the natural and cultural history of the surrounding landscape. 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 small size, fragmented nature and urban/suburban setting of the park make JOFL extremely vulnerable to surrounding land use change. Thus, interpretation of the natural resource conditions in the park must be made within this context.

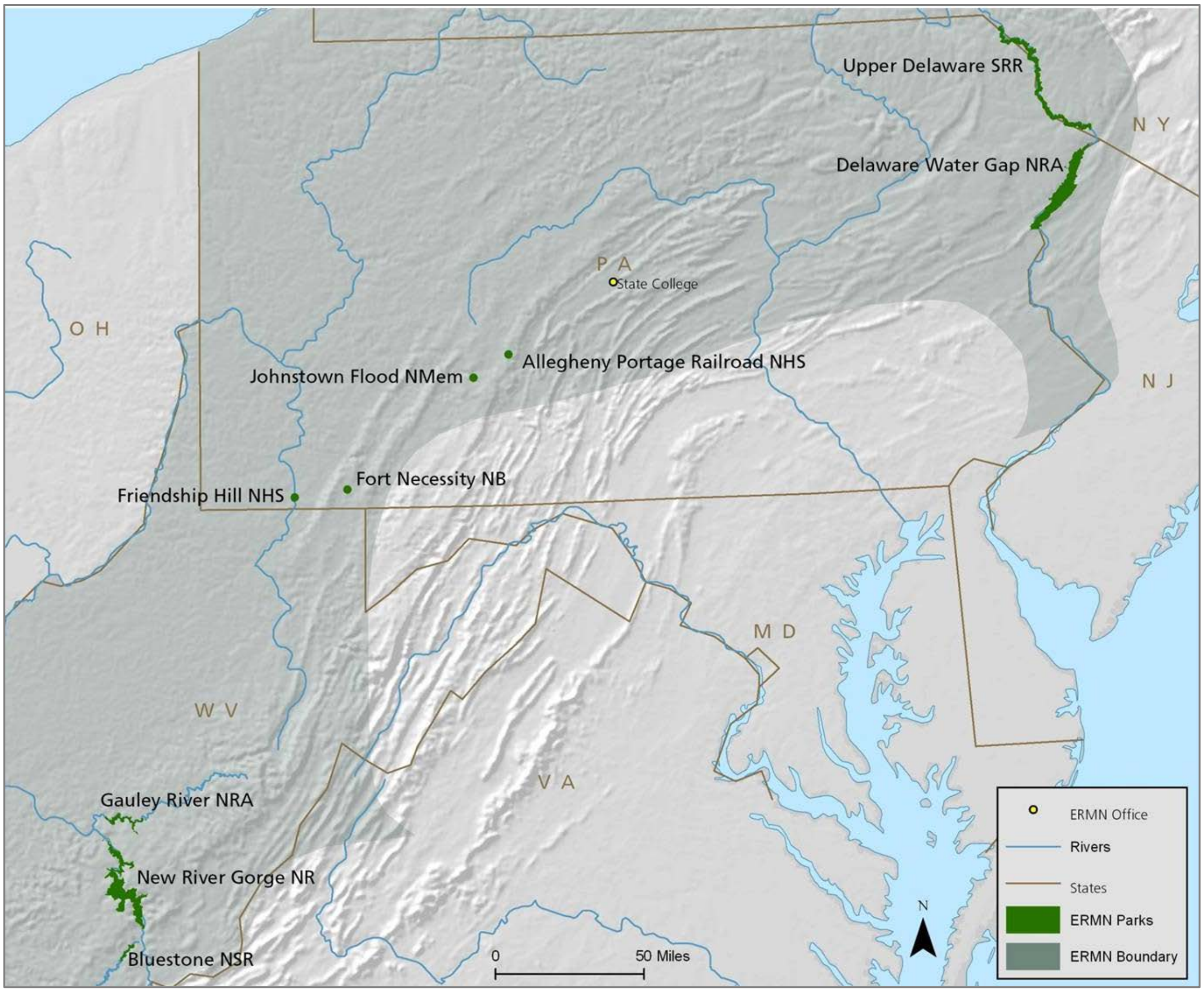


Figure 1. Locations of the Eastern Rivers and Mountains Network parks.

History

History of Johnstown

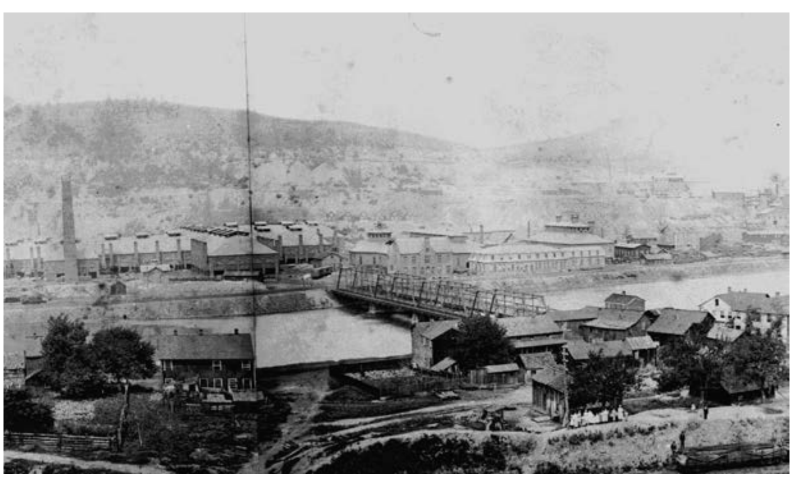
The steep topography of the Little Conemaugh valley discouraged settlement in the mid- to late-eighteenth century, leaving it largely uninhabited by both Native Americans and white settlers. However, the steep headwater streams were large enough to support grist mills and the hills contained the best quality timber, including the sugar tree (sugar maple), cherry, white walnut (butternut), hickory, chestnut, beech, poplar (tuliptree), ash, oak, cucumber, birch, hemlock and spruce. In addition, many of the low-lying areas were considered level enough for cultivation. Slowly, small clearings began to spring up along the stream valleys and more settlers began to crowd into the territory known as "The Conemaugh Country" until, eventually, Cambria County was carved out of the existing Huntingdon and Somerset counties by the Act of March 26, 1804 (McLaurin, 1890). Following the discovery of mineral wealth underground, however, the city of Johnstown and other small villages along the Little Conemaugh grew quickly.

Industrial History of Johnstown and Cambria County

Workers at a Cambria Iron blast furnace, circa 1870's. Image courtesy of JAHA.

As early as the 1760s, coal was used in village forges and blacksmith shops, especially in the western portions of Pennsylvania where soft, free-burning bituminous coal was readily available (Binder 1974). These early mines were small and served as local suppliers for home heating and cooking. As coal replaced charcoal in the iron making process, the coal industry in Cambria County grew. Transporting coal became much easier when the Pennsylvania Canal and Allegheny Portage Railroad opened in 1834 to transport boats over the Allegheny Front. Railroad expansion and technological advancement provided cheaper, bulk transportation to wider markets. The county's earliest commercially operated coal mines included the Myers brothers mine and Samuel Lemon's mine near the Summit (both 1845), Matthew Adam's mine near Summit Springs and the Dysart Shaft (both ca. 1840s) (JAHA 2013a). By 1860, Pennsylvania mined nearly half the bituminous coal produced in the country (Binder 1974).

As the demand for coke by iron and steel mills increased, so did the progression of Johnstown. By the 1870s, small, craft-organized factories were being replaced by integrated mills and organized industrial centers capable of mass production of steel and other commodities. Such large operations required railroad and river accessibility (Muller 2001). Johnstown provided both. By 1885, mines and mining communities spread from Johnstown up the Little Conemaugh corridor. The mines in Cambria County were producing more than a million tons of coal annually, with the largest portion mined by the Cambria Iron Company. During the second half of the 19th century the company's Cambria plant became a model for the iron and steel industry, advancing technology through invention and industrial design (JAHA 2013b).



A portion of Cambria City in 1876 (foreground). The Cambria Iron Works is across the river. Image courtesy of JAHA.

With this industrial advancement came a wave of immigrants, mostly from Southern and Eastern Europe, who settled next to the mills and mines where they worked (JAHA 2013b). Large operators typically built company stores, homes and other buildings to house workers and their families, creating several small towns or “coal patches” around the mines. One of the largest in Johnstown was created in 1877, when the Cambria Iron Company partnered with Dr. J. J. Gautier to manufacture wire and sundry steel. The principal works extended a mile up the Little Conemaugh at the base of Prospect Hill, and included barb-wire and merchant mills, warehouses, offices, and eight hundred tenement houses to rent to employees (McLaurin 1890). By 1890, more than 30,000 people resided in the city of Johnstown, the vast majority blue collar workers and their families (JAHA 2013b).

The South Fork Dam

The South Fork Dam was constructed in a narrow valley along South Fork Creek, now known as the South Fork Little Conemaugh River, (~2.25 miles from the mouth) to provide a feeder reservoir (Western Reservoir) in order to avoid drought situations along the Conemaugh River, which created problems for the Pennsylvania Mainline Canal’s Western Division whose eastern terminus was located downstream at Johnstown (Beale 1890, McLaurin 1890). Although this area was considered to be the safest location for a dam in the event of spring flooding, work was stopped between 1842 and 1851 and the dam was only half-completed. It is thought that this work stoppage caused damages to the South Fork Dam that led, in part, to its failure on May 31, 1889. In 1847, the half-completed South Fork Dam failed for the first time. By 1852, the Western Reservoir was finally dammed and both the Reservoir and the South Fork Dam were deemed ready for operation by 1853 (NPS 2013a). The dam’s embankment stretched across a deep gorge (1,000 ft in length and 90 ft high) 300 ft above the level of Johnstown and tapered in thickness from 280 ft at the base to 20 ft at the crown. The reservoir covered 600 acres and was calculated to hold 500 million cubic feet of water, enough to fill a row of barrels to girdle the earth (McLaurin 1890). Unfortunately, the Pennsylvania Mainline Canal went out of business only a year after the Dam’s completion, and both the dam and canal were abandoned in 1857, soon after their purchase by the Pennsylvania Railroad. In 1862, following heavy rains compounded by years of neglect, the South Fork Dam failed for the second time, raising the water in Johnstown by 2-3 feet. Pennsylvania Railroad employee and US Congressman John Reilly, bought the South Fork Dam in 1875 and proceeded to remove the five sluice pipes at the base of the dam, which aggravated the sag at the top of the dam, making it more susceptible to overtopping and limiting the ability to safely remove excess water. Reilly then sold the dam to Benjamin Ruff, President of the South Fork Fishing and Hunting Club in 1879 (NPS 2013a).

The South Fork Fishing and Hunting Club

To escape the smoke and dirt of the city, Benjamin Ruff formed the South Fork Fishing and Hunting Club in 1879, where Pittsburgh’s elite could hunt, fish, and enjoy the outdoors. The club consisted primarily of wealthy industrial tycoons, bankers, and lawyers, the aggregate wealth of which was estimated in the dozens of millions at the time of the original charter, which included sixteen men and grew to 61 by 1889 (McLaurin 1890, NPS 2013a). They envisioned the South Fork dam as the perfect location for a summer resort. After purchasing the dam, the club employed an impressive labor force of men to restore it, increasing the basin to a sheet of water roughly 3 miles long and 1 mile wide. By 1881, Lake Conemaugh was created, complete with a drive-way along the top of the dam 35 feet wide and up to 100 ft high. Sixteen cottages and a club house of 47 rooms were erected

Lake Conemaugh circa 1889. Photo from the Louis Semple Clarke collection (Courtesy of JAHA).

on the slopes bordering the lake. Fishermen came by train from Pittsburgh and Philadelphia to fish for black bass and trout along the South Fork (Trout Unlimited 2008).

Although it looked secure on the outside, in reality many of the changes made to accommodate the resort further weakened the structure of the South Fork Dam. These included 1) failure to patch holes from the 1862 break, 2) failure to replace the sluice pipes, 3) lowering the top of the dam to make it wider for carriages, and 4) putting fish screens over the spillway—screens which later clogged and prevented water from exiting over the spillway (NPS 2013a). Workers involved in repairing the dam were noted for stating that stumps, sand, loam, straw, and even leaves were used to fill the center of the dam (McLaurin 1890). Moreover, following the dam break, engineers investigating the cause of the dam failure noted that, although the original dam was designed and built by an able and experienced engineer, "at no time during the process of rebuilding the dam was any engineer engaged on or consulted as to the work" (Beale 1890).

<u>The Flood</u>

Settled between two rivers with abundant natural resources in the surrounding hills, Johnstown owed much of its growth to its location. The Little Conemaugh River flowed through the center of town and merged with the Stony Creek River to form the Conemaugh River at the western end of town (Figure 2). Unfortunately, being located in a narrow floodplain of a river confluence draining a large watershed (657 square miles) with steep, narrow valleys also made the town prone to flooding (McLaurin 1890, NPS 2013b). This was compounded by borough ordinances and agreements with the Cambria Iron Company to fix the widths of Stony Creek, the Little Conemaugh,

The ruins of the South Fork Dam and Lake Conemaugh. The previous elevation of the dam is depicted by the line at the top. Image courtesy of JAHA.

and the Conemaugh River, which left no outlet for flood waters except streets and buildings. Thus, the residents of Johnstown were quite used to spring floods. Many of the survivors commented on their lack of alarm prior to the dam break. As the waters rose around them, carpets were taken up, valuables were elevated and families settled in to wait out the flood (Beale 1890).

During the last week of May 1889, the region experienced extraordinary rainfall, increasing water levels in the streams and Lake Conemaugh to unprecedented levels. Previous floods, including the flood of June 1887, which was considered exceptional, had not done any great damage, but these were created from either the Stony Creek or the Little Conemaugh, with one or the other discharging its floodwaters before its confluence near the Stone Bridge. None could recall both streams rising simultaneously, as they did the morning of May 31, 1889 (Beale 1890).

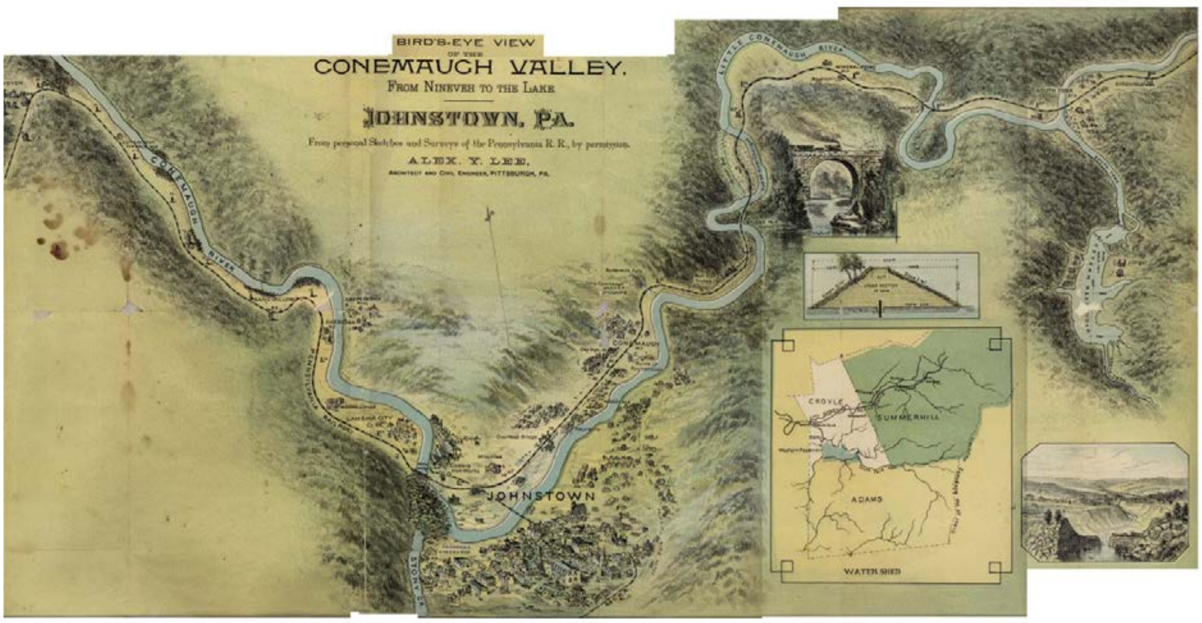


Figure 2. Map of the region, published shortly after the flood. The square outlines the lake area where the South Fork Dam was located. Used with permission from the Johnstown Area Heritage Association (JAHA) (www.jaha.org).

Through the course of the morning and afternoon of May 31, 1889 at the South Fork Dam, the club's president Colonel Elias Unger coordinated several unsuccessful attempts to prevent flooding and sent numerous warnings to the residents of Johnstown, all of which went unheeded. At 2:50 pm the stones along the lower half of the wall crumbled and at ~3:10 pm the dam burst, creating an opening more than 300 feet wide and down to the bottom, sending a 23 m (76 ft) high wall of 450,000,000 cubic feet of water rushing (60 km/hr, 40 mph) down the narrow valley toward the communities of South Fork, Mineral Point, East Conemaugh/Franklin, Woodvale, and Johnstown and unleashing one of the most destructive floods in history (Beale 1890, McLaurin 1890, Penrod et al. 2005). The horror and devastation that followed cannot be overstated. At South Fork, the Conemaugh Bridge and several


The Stone Bridge (visible in the background) blocked acres of debris in the 1889 Johnstown flood. This photo was taken a few days later, after a tragic fire that killed dozens trapped in the debris.

freight trains were washed away. The viaduct, just below the river bend, slowed the flood down momentarily but also served to accumulate more debris, which piled up 125 feet above the stream bed before eventually plunging further downstream and completely wiping out the small mining towns in its path (Beale 1890).

By the time it reached Johnstown the flood wave was a wall of debris 30 or 40 feet high and moving with a force and velocity greater than that of Niagra Falls (Beale 1890, JAHA 2013c). This 'inextricable mass' piled up at the Stone Bridge on the Conemaugh River and was described by a survivor as follows: "It's spoil consisted of (1) every tree the flood had touched in its whole course, with trifling exceptions, including hundreds of large trees, all of which were stripped of their bark and small limbs almost at once; (2) all the houses in a thickly settled town three miles long and one-fourth to one-half mile wide; (3) half the human beings and all the horses, cows, cats, dogs and rats that were in the houses; (4) many hundreds of miles of telegraph wire that was on strong poles in use, and many times more than this that was in stock in the mills; (5) perhaps fifty miles of track and track material, rails and all; (6) locomotives, pig-iron, brick, stone, boilers, steam engines, heavy machinery and other spoil of a large manufacturing town" (Beale 1890). Engineers estimate the flood took twenty minutes from the break to the Stone Bridge, where the debris ignited, creating a massive inferno that became a death trap for the people inside. The flood killed 2,209 people, destroyed 1600 homes, and left over $17,000,000 in property damage (Beale 1890, NPS 2013a, 2013b).

The disaster horrified the nation, but also demonstrated the resilience and compassion of its people. The post-flood recovery efforts provided a national model for disaster recovery. Pittsburgh received news of the flood's destruction on the morning of June 1st, and by 4 o'clock that afternoon, a train of nearly twenty cars packed with volunteers was headed down the Pennsylvania Railroad toward the Conemaugh Valley. The Pittsburgh Relief Committee and Ladies Committee spearheaded the nation's efforts to forward and distribute supplies and contributions for the flood victims. Monetary donations and other aid arrived from Philadelphia, New York, Baltimore, Boston, and other cities (Beale 1890). The Philadelphia Red Cross provided medical relief, while the American Red Cross, led by Clara Barton, provided furniture and supplies. The Johnstown flood represented the organization's first non-battlefield relief effort and established the American Red Cross as the premiere entity for disaster relief (www.jaha.org/FloodMuseum/RedCross.html).

Newspaper coverage, photographs, songs, and other paraphernalia surfaced to both pay homage to the tragic loss but also to ask the question of how it could possibly have been prevented. Engineers brought in to survey the damage concluded the dam failed primarily due to (1) an insufficient spill-way, which had been screened to keep the fish in the lake, and (2) excessive phenomenal rainfall, which began May 30th after several days of moderate prior rains and continued almost until the dam gave way. Although the stability of the dam had been questioned repeatedly, and even declared 'unsafe' by a superintendent of the Pennsylvania Railroad years earlier, on the whole it was decided that the flow of water over the top of the dam (caused primarily by the inability of the spillway to handle the overflow) was the cause of the disaster and that any negligence in repairing the dam was of minor importance (Beale 1890). Attempts to assign responsibility culminated in national laws holding industry liable for damage and loss of life (NPS 2013b).

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).

Johnstown Flood was designated a National Memorial on August 31, 1964 in order to commemorate the great loss of lives taken along the 15-mile flood path and instill the significance of the complex social and environmental factors that led to the destruction of the dam (Public Law 88-546). The park is small, stretching across 0.72 sq km (178 ac) and includes 1) the ruins of the South Fork Dam, 2) a small portion of the former lakebed, 3) the remains of South Fork Fishing and Hunting Club District, and 4) the Unger Farm, which includes the Unger House, the visitor center, the springhouse ruins, and the surrounding fields and orchard on the hillside above the dam. In addition, JOFL is significant in portraying the great sense of loss and providing visitors with a unique view of life before and after the flood through the museum collection of historical objects, the Clarke photo collection portraying life on the lake before the flood, the Morgue book containing a master list and descriptions of the deceased, and other archival collections.

People standing on rooftops, most likely sightseers who came to view the flood's destruction. Image courtesy of JAHA.

Park-wide management goals, as stated in the General Management Plan (NPS 1980) fall under three main categories:

1) Interpretation and Visitor Services – "To interpret the causes and significance of the Johnstown Flood in the nation's economic, social, and technological history and to foster an awareness of its relationship to contemporary American society";
2) Natural Resource Management – "To perpetuate natural ecological communities in the park's natural zone and to enhance the value of these lands as aesthetic buffers around significant resources";
3) Cultural Resource Management – "To identify, evaluate, protect, maintain and interpret the park's cultural resources…..and…..To preserve and maintain the cultural resources and the setting of the South Fork Dam to approximate conditions in 1889."

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. Although parkwide management objectives are "to commemorate and interpret the tragic consequences of the flood…", parkwide management objectives also specify "to protect and maintain the natural diversity of plants and animals outside of areas managed for primarily cultural resources or developed areas" and "to provide visitors a range of recreational opportunities which will enhance their appreciation of the story of the flood, the significance of geography and the relationship of natural resources, without impairing natural or cultural resource values or the atmosphere of quiet contemplation" (NPS 1992). Thus, we begin with a brief description of the important cultural resources managed within the park.

<u>Cultural Resources</u>

South Fork Dam Ruins

This includes the dam abutments (ruins of the dam) and spillway (sluiceway) ruins that constitute the remainder of the South Fork Dam, as well as the control tower foundation ruins, and the historic carriage road that crossed the top of the dam abutments and continued upslope through the woods and on to the Clubhouse.

View of the north dam abutment and spillway in 2007(left photo). Photo by NPS staff. The sluice gate remains of the South Fork Dam, taken after the May 31, 1889 break (right photo). Photo courtesy of JAHA

The Carriage Road Nature Trail winds through the woods and contains educational markers of important tree species. Photo by S. Yetter.

The north abutment borders the fields of the Unger Farm. The south abutment is adjacent to the park's natural zone, which consists primarily of a forested slope. The carriage road trace goes through this forest, and a picnic area and maintenance buildings are located near the top of this forested slope. Walking paths provide an educational tour through the lakebed and surrounding woods.

Dry Bed of Lake Conemaugh

Although the former bed of Lake Conemaugh extends well beyond park boundaries (most of the towns of St. Michael, Creslo, and part of Sidman are located in the historic lake), the lakebed area of the park consists of the land below the 1,600-foot contour of the lake, including the South Fork Little Conemaugh River, wetlands, and vegetated slopes. An important management objective is "to encourage preservation of the Lake Conemaugh Area and the path of the flood….in a way that maintains a visual impression of these areas as they were at the time of the flood…." (NPS 1992). The park tries to interpret the size and magnitude of the former Lake by cutting most of the former lakebed area within the park.

View of the lakebed in winter. To the right is the forested slope natural zone. The South Fork Little Conemaugh River and modern railroad tracks run through the approximate center of the lakebed area. Photo by NPS staff.

The Unger Farm

The Unger Farm comprises the Unger House where Colonel Elias Unger (the president of the South Fork Fishing and Hunting Club in 1889) lived, the visitor center (a replica of the historic barn), the springhouse ruins, and the fields and orchard on the hillside above the North Abutment of the South Fork Dam. Management objectives for this area are "to maintain the character of the Unger House, spring house, barn-form of the visitor center, and the surrounding landscape on the north abutment area at about 1889, to convey to visitors the events at the dam on the fateful day of the flood" (NPS 1992).

The left photo is a view of the Unger Farm, including replicas of the spring house and barn (visitors center) taken from the former lakebed. The house between the replica structures is the historic Unger House (photo by NPS staff); the photo on the right is of the same view taken prior to the dam break (from the Louis Semple Clarke collection courtesy of JAHA).

South Fork Fishing and Hunting Club Historic District

Following the dam break, the Clubhouse and resort buildings fell into disrepair. Initially, they were inhabited by a group of homeless known as the “Johnstown Colony.” Eventually they were sold at public auction and, in 2006, several structures in the St. Michael Historic District were donated to NPS, including the 1889 Clubhouse, the Clubhouse Annex, the Brown Cottage, and the Moorhead Cottage (www.nps.gov/jofl/historyculture/). Management objectives for this area are “to encourage a representation of the setting at the South Fork Fishing and Hunting Club, 1878-1889” (NPS 1992).

The left photo is a view of Lake Conemaugh from the Clubhouse prior to May 31, 1889 (from the Louis Semple Clarke collection courtesy of JAHA); the photo on the right is the Clubhouse today (photo by S. Yetter). The town of St. Michael partially occupies the former lakebed of Lake Conemaugh.

Geographic Setting

JOFL is located in the Appalachian Mountain section of southwestern Pennsylvania, approximately 16 km (10 mi) northeast of Johnstown and encompasses 75 ha (187 ac). The entire park is located in Cambria County, which is 1782.8 sq km (688.35 sq mi) 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. (http://quickfacts.census.gov/qfd/states/).

Visitation Statistics

From 1969 to 2012 JOFL has had 4,282,029 recreational visitors to the park. Yearly visitation was lowest in 1969 with 19,700 visitors and highest in during the centennial anniversary year of the flood (1989) when 333,283 visitors came to the park. Since that time yearly visitation has ranged between 100,000 and 160,000 people per year (Figure 3). Visitation occurs primarily during warmer months (April through October) and drops off in winter. In 2012, 97,466 people visited the park between April and October, representing >79% of total visitors for the year (http://irma.nps.gov/Stats/Reports/ReportList).

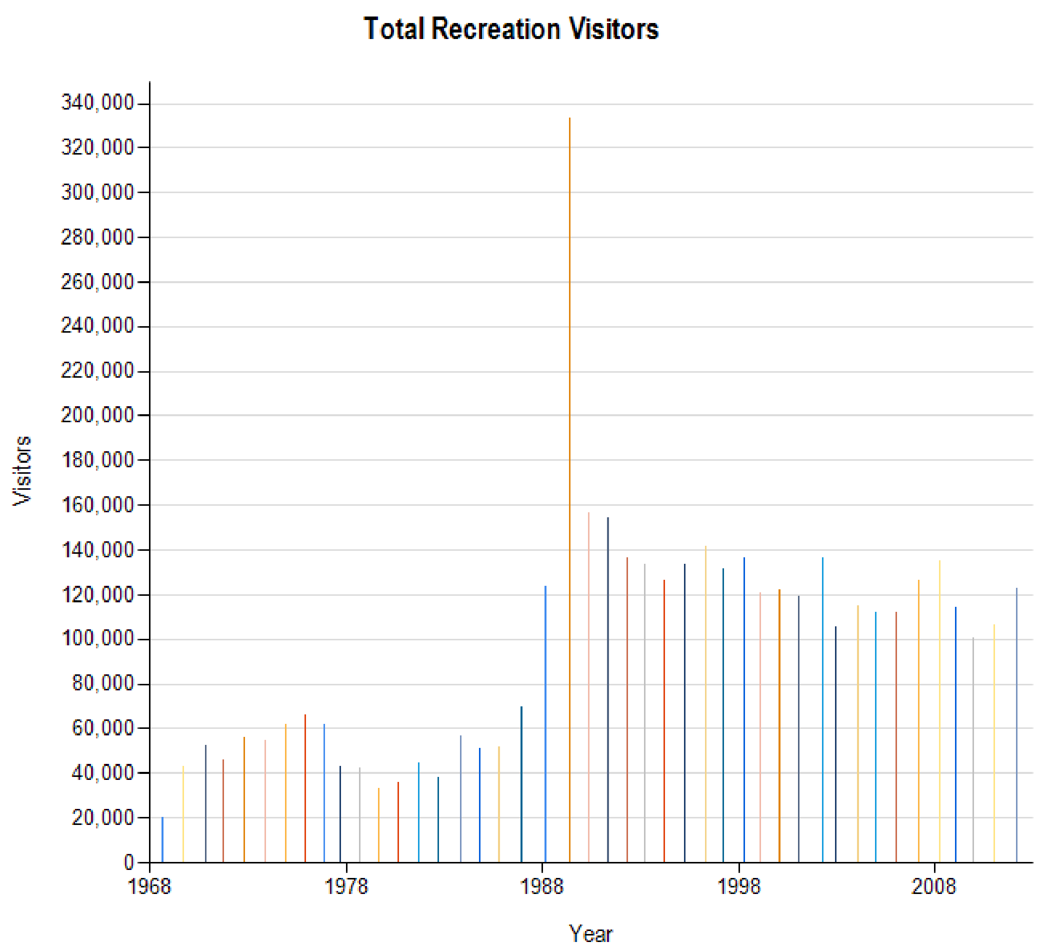


Figure 3. Total Recreation Visitors per year for JOFL (http://irma.nps.gov/Stats/Reports/)

Natural Resources

Physical Setting of JOFL

Climate

JOFL 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. 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. 2011). Flooding is usually associated with extremely high and intense rainfall amounts and can occur at any time during the year, although the major historic floods in Pennsylvania have occurred primarily in the summer (Aron 1999). In the immediate JOFL area, the three major Johnstown floods occurred on May 31, 1889; March 17, 1936 and July 20, 1977.

Geology and Topography

The park lies along the western edge of the Allegheny Mountains near the Pittsburgh Low Plateau section within the Allegheny Plateau physiographic province in southwestern Pennsylvania (Figure 4). JOFL's cultural and natural resources are largely a product of the surrounding geology. Geologic processes are the underlying determinant of landscape configurations, which played an important role in the region's history. Even the historical use of the lake for recreation was due in part to the surrounding landscape, which prompted the original location of the reservoir. The South Fork Dam was built primarily because of the topography of the area (i.e. a steep gorge along the South Fork Little Conemaugh River) and geographic location (i.e. near the Johnstown canal basin). The Allegheny Front is characterized by steep slopes and narrow valleys and is prone to landslides, slumps, and rockfalls. Topography of the Allegheny Mountains is characterized by rolling hills and ridges composed of resistant Paleozoic sandstone and valleys underlain by less resistant carbonates and shales. 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 2008). The large watershed and narrow valleys make the area prone to flooding, especially during the spring, factors which are thought to have aggravated the 1889 flood, causing the reservoir to rise quickly and increase rapidly in speed and volume as it moved downstream (Aron 1999, Thornberry-Ehrlich 2008, K. Penrod, pers. comm., 2013). Presently, the major issues from flooding are mostly due to erosion from the flood-prone river (Thornberry-Ehrlich 2008).

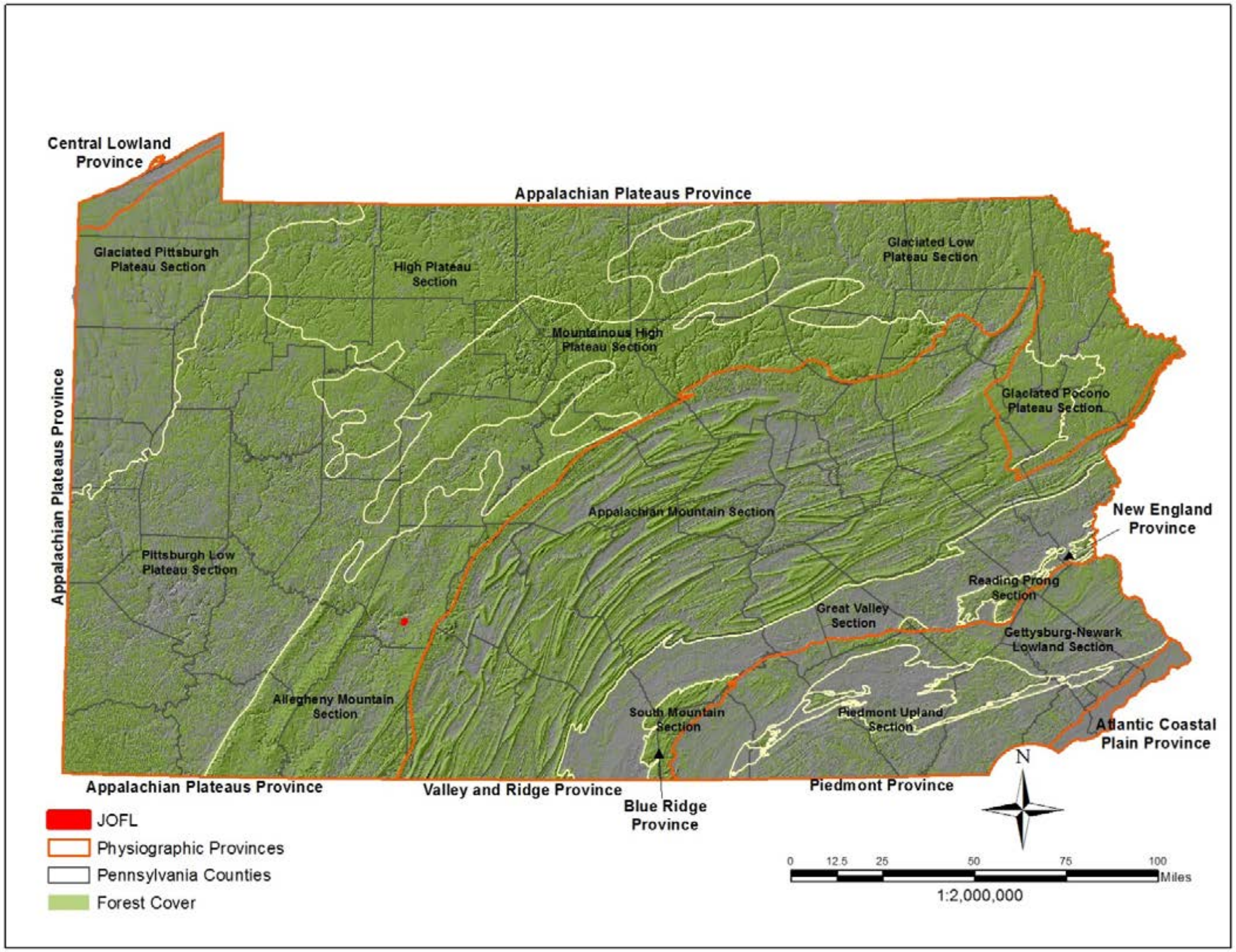


Figure 4. Map of Pennsylvania showing the physiographic provinces and the location of JOFL. The park is located in Cambria County in the Pittsburgh Low Plateau section of the Allegheny Mountain Province, just west of the Allegheny Front. The shaded relief used for the map helps to illustrate Pennsylvania's diverse topography. As you move from southeast to northwest across Pennsylvania the topography changes 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).

Bedrock geology in the park varies from the Glenshaw Formation in the former lakebed to the Casselman Formation in the higher elevations. Both are marine-derived sediments of Pennsylvania age composed of abundant sandstone and siltstone with limited amounts of shale, limestone and coal. They also contain fossiliferous remains of historic marshy peat swamps and wetlands (Thornberry-Erhlich 2008). Elevation at JOFL ranges from 470 – 565 m (1,540 – 1,855 ft).

Soil types immediately surrounding the South Fork Little Conemaugh River include Atkins silt loam and Philo silt loam, both moderately well-drained floodplain soils. The lakebed also contains a combination of well-drained soil (Laidig loam) and poorly-drained soil (Brinkerton silt loam).

Figure 5 provides a close-up of the geologic formations underlying JOFL. Compare this with Figure 6, which superimposes the elevation of Lake Conemaugh (circa 1889) with the park boundary and an elevation and aerial map. Figure 6 is useful for comparing the historical pre-flood with the current post-flood country side, as well as imparting the knowledge that only a small part of the former Lake Conemaugh resides within the park.

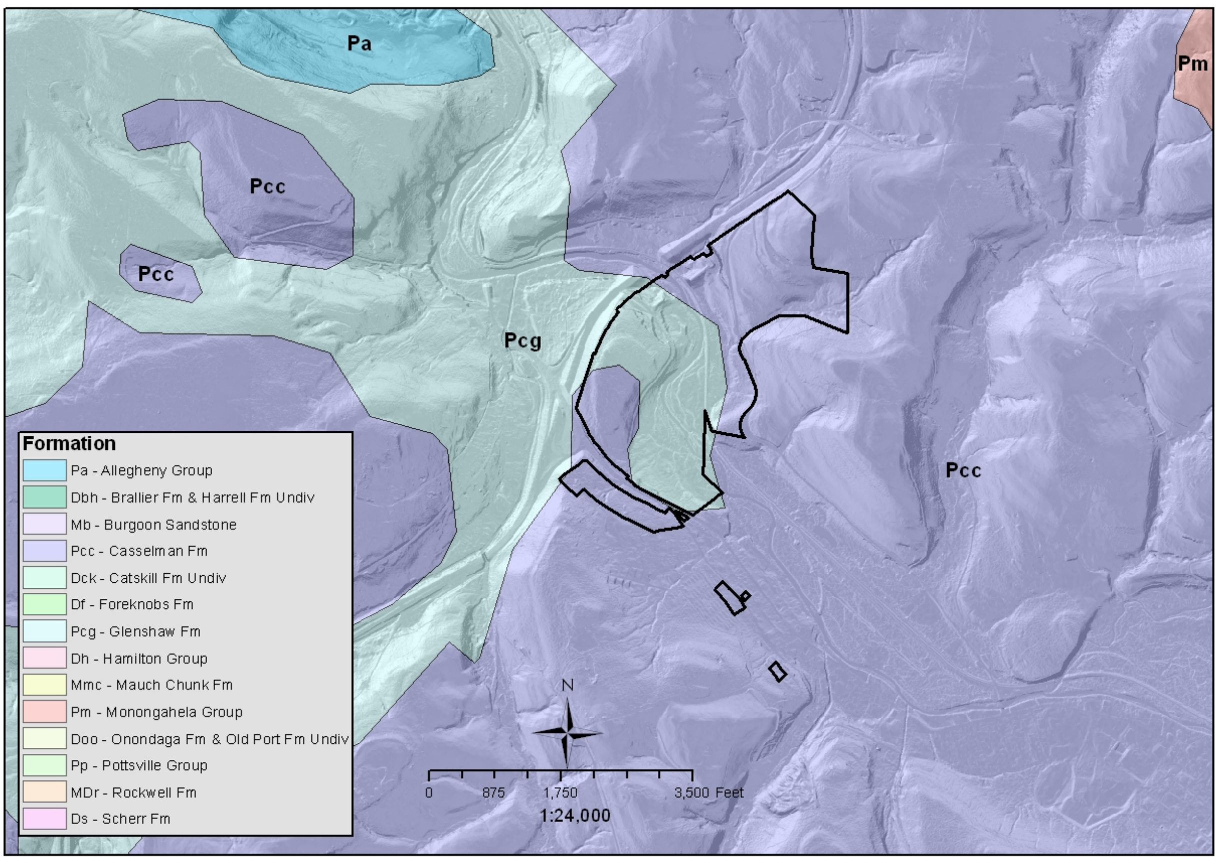


Figure 5. This map shows Pennsylvania's Surface Geology for JOFL. The high resolution (1 m x 1 m) shaded relief depicts the topographic changes that occur as you move from the former lakebed to the surrounding ridges of the Appalachian Plateau. The black borders represent JOFL boundary lines. Spatial data source: PA DCNR, Bureau of Topographic and Geologic Survey.

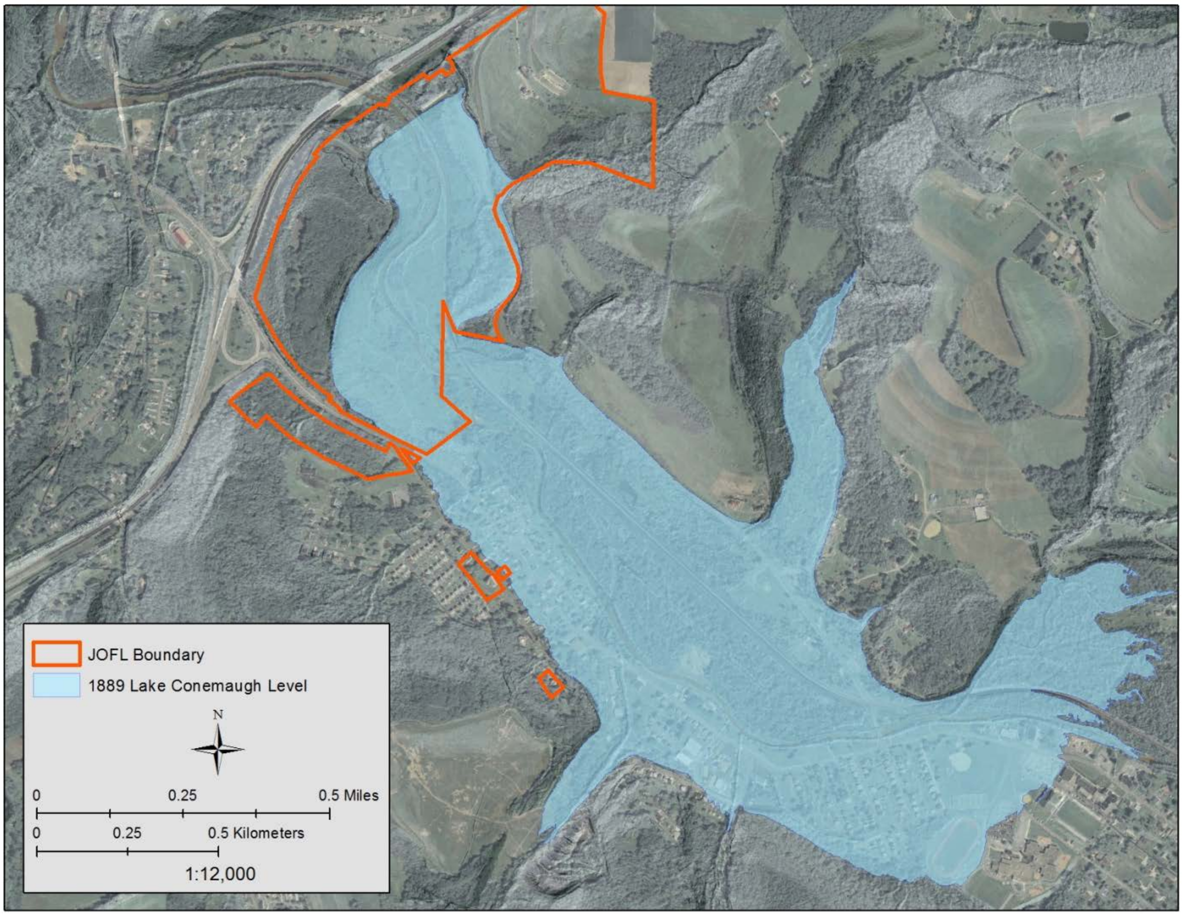


Figure 6. Map of JOFL showing the area of Lake Conemaugh at pre-flood level superimposed on a shaded relief and aerial background. This map was provided to illustrate 1) the small portion of the former lakebed located within park boundaries, 2) the contrast in elevation between the lakebed and the steep slopes on both sides, and 3) the large area of former lakebed that has since become a series of roads and small towns. Spatial data source: PA DCNR, Bureau of Topographic and Geologic Survey.

Resource Descriptions and Ecological Units

Water Resources

JOFL contains a variety of important water resources, including streams and wetlands (Figure 7). The main water resource at JOFL is the South Fork Little Conemaugh River which bisects the park. Several small tributaries join the river from the east and flow through park property (Figures 7 and 8). The South Fork Little Conemaugh River flows into the Little Conemaugh River near the town of South Fork, then joins with the Stonycreek River to form the Conemaugh River at Johnstown, then to the Kiskiminetas, Allegheny and Ohio Rivers. JOFL is located just two miles upstream of the confluence of the South Fork Little Conemaugh River with the Little Conemaugh River. Thus the drainage area of the streams running through the park is quite large (~ 137 km^2 [53 mi^2] in size and containing ~164 km [102 miles] of streams) (Figure 8). Most of this area is woodland, but abandoned mine lands occur throughout the watershed, mostly to the south and east of the park, as well as scattered agricultural and urban lands.

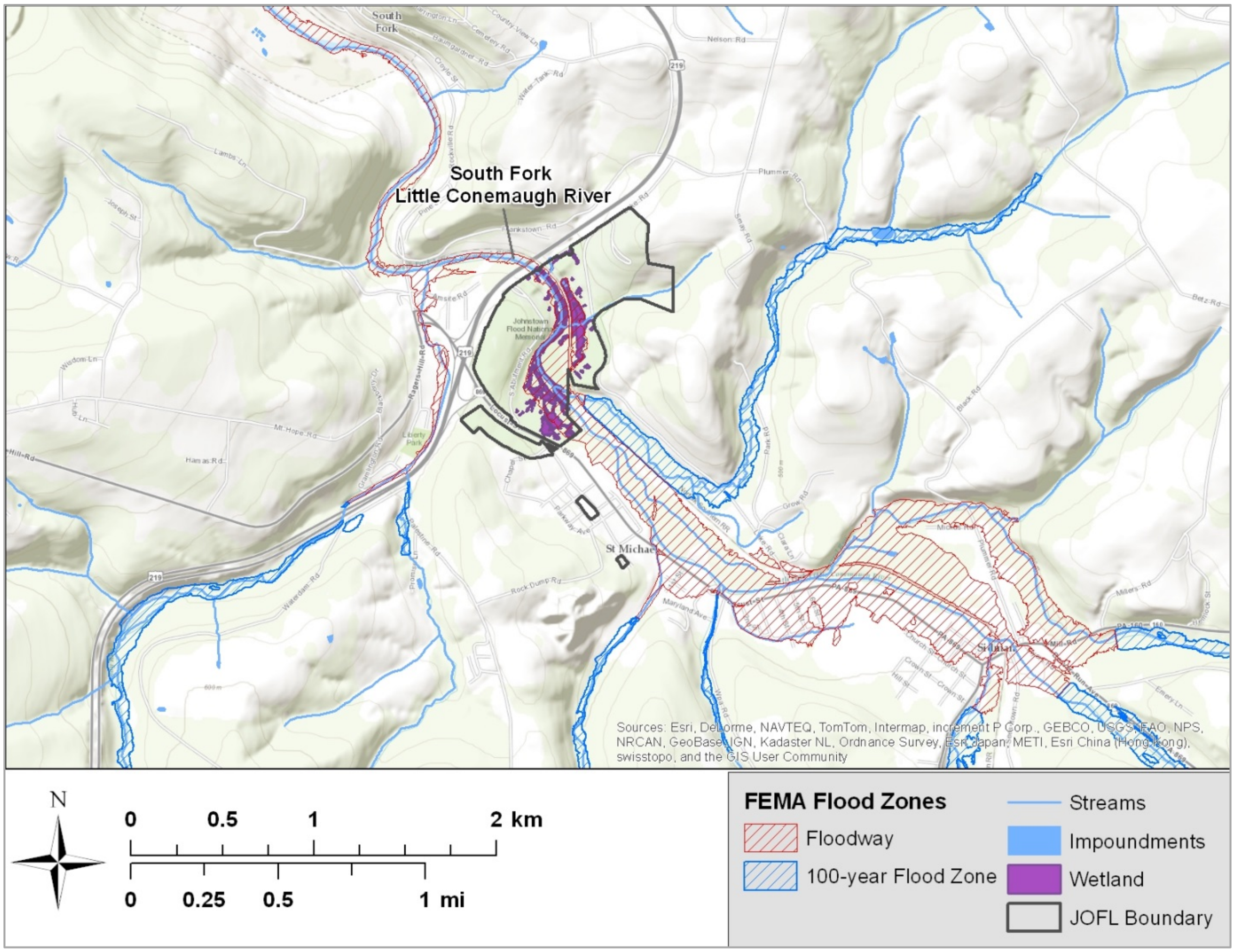


Figure 7. Water resources at JOFL including streams, impoundments, and wetlands within the surrounding landscape. Park boundaries are indicated by black outlines.

Streams flowing through the park have been designated "cold water fisheries" but none are considered 'high quality' waters (Sheeder et al. 2004, PA DEP 2009a). The entire length of the South Fork Little Conemaugh River running through the park is listed as impaired by pH and metals from abandoned mine drainage (AMD) by the Pennsylvania 303d list (PA DEP 2012). Other stream segments in the watershed upstream of the park are also impaired from AMD (Figure 8) (see section 2.2.3 Potential Threats and Stressors for more information).

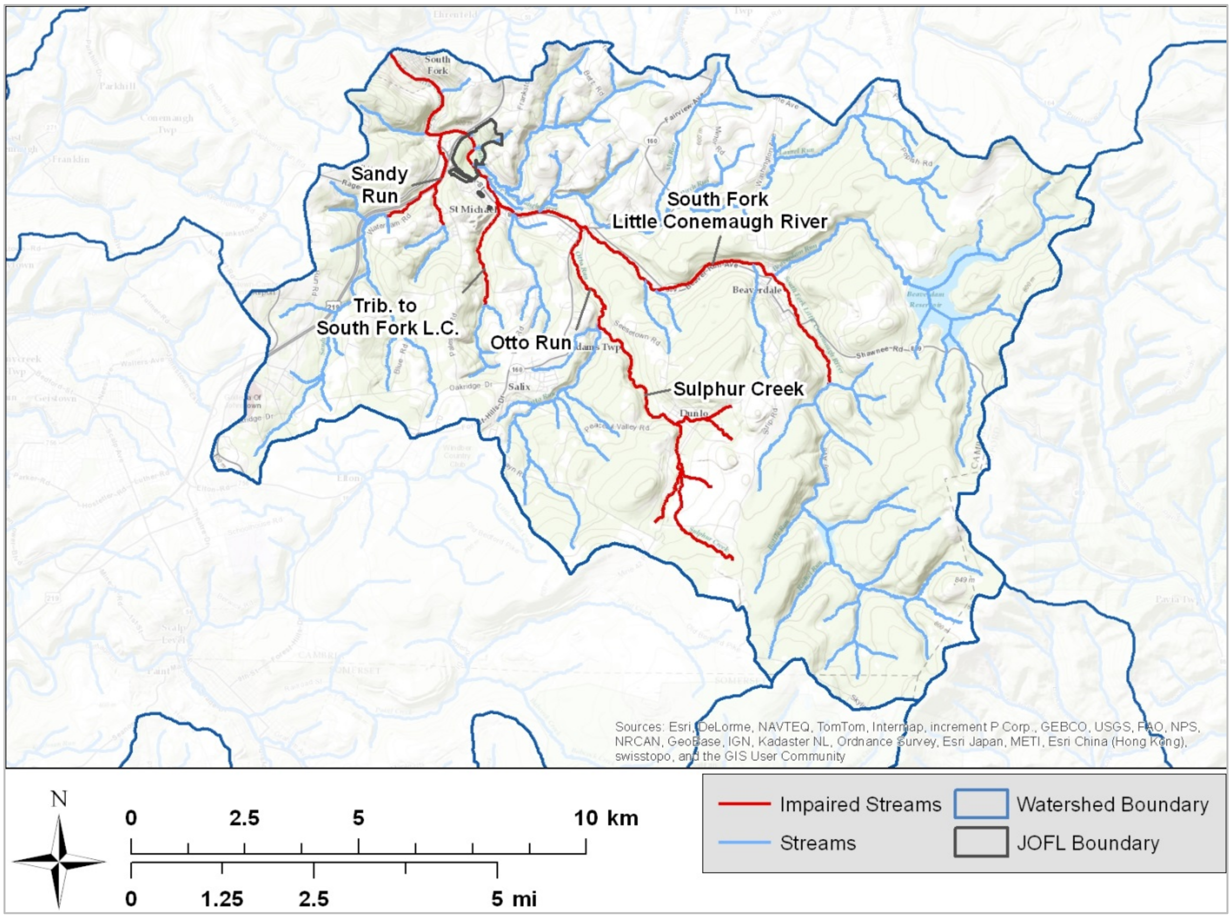
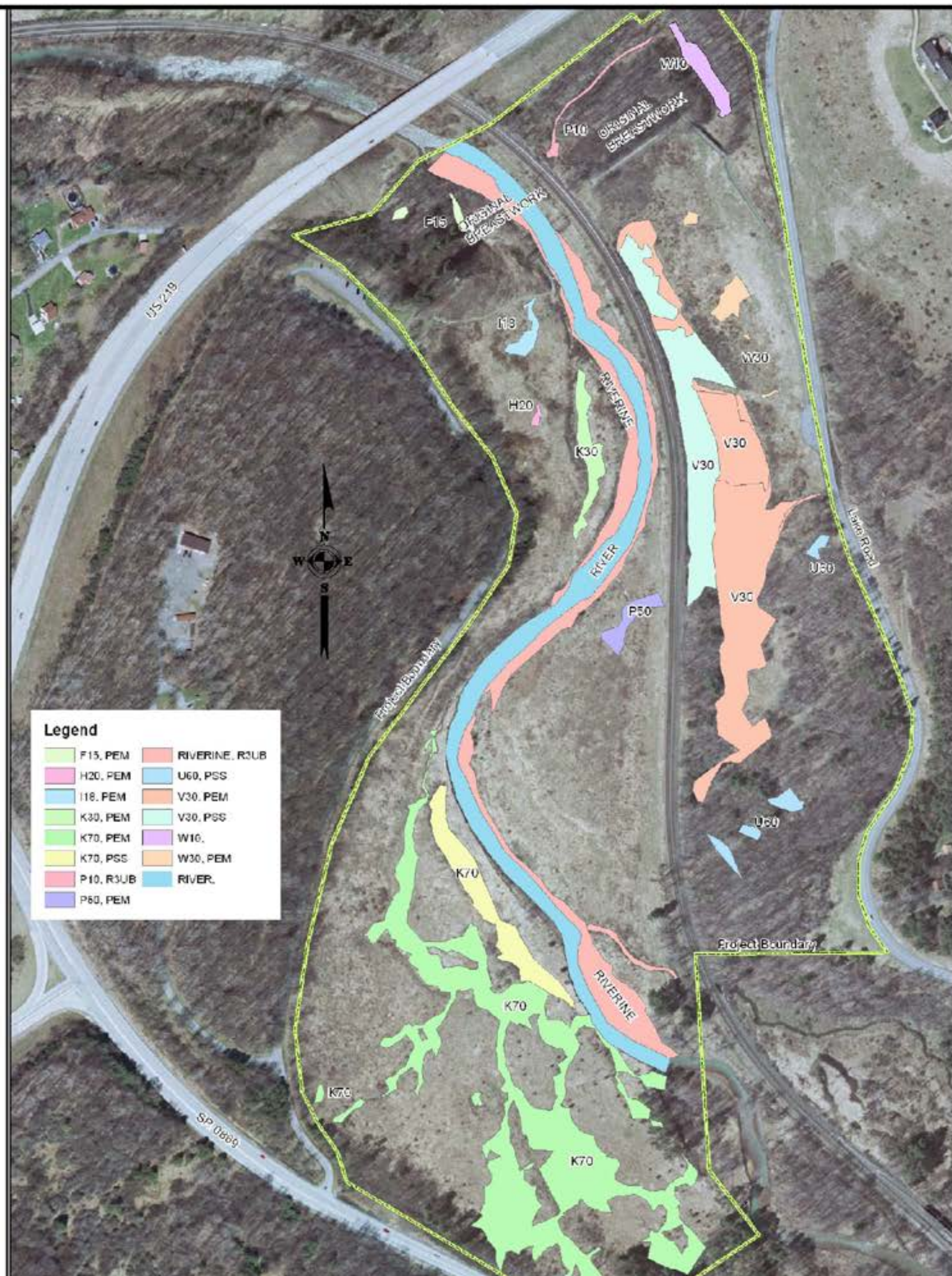


Figure 8. South Fork of the Little Conemaugh River watershed showing location of the JOFL boundary and location of impaired stream segments within the watershed (obtained from PASDA's Stream's Integrated List of Nonattaining Stream Segments published by PADEP Office of Water Management, July 2013).

Currently, the ERMN monitors water quality within the park annually (fall sampling) at one location along an unnamed tributary to the South Fork Little Conemaugh River (Tzilkowski et al. 2010, 2011a, 2011b). Wetlands are not monitored for water quality.

Wetlands are an important resource of the park and occur throughout the lakebed (Figure 9). Bowersox (1986) mapped seven acres of wetland along the railroad berm near the north abutment. A 2009 wetland delineation by Keller Engineers delineated 15.43 acres of wetland in JOFL, most of which were within the former lakebed area. Two small wetlands were also delineated outside the lakebed below the dam abutments (north of the dam) (K. Penrod, pers. comm., 2013). Palustrine emergent wetlands covered the largest wetland area, while the remaining area was represented by palustrine scrub shrub wetlands and riverine unconsolidated bottom wetlands along the river (Keller Engineers, Inc. 2009).



	V30	W30	W10	P50	U60	K70	K30	H20	I18	F15	P10	Unnamed tributaries	Riverine wetland	TOTAL
PEM	3.29	0.19	0.2	0.19		5.25	0.34	0.02	0.12	0.07				9.67
PSS	1.71		0.06		0.23	0.82								2.82
R3UB											0.09	0.11	2.74	2.94

PEM - Palustrine emergent
PSS-Palustine scrub shrub
R3UB-Riverine, upper perenial, unconsolidated bottom

PROJECT NO.:	1713–6
FILE NAME:	P\1713–6\dwg\wetland
DATE:	7/14/09
DESIGNED BY:	RGK
DRAWN BY:	RGK
CHECKED BY:	PEK
PAGE NO.:	1

SCALE: 1"=250'
250' 0' 250'

WETLAND MAP

JOHNSTOWN FLOOD NATIONAL MEMORIAL

ADAMS & CROYLE TOWNSHIP, CAMBRIA COUNTY
PENNSYLVANIA

KELLER ENGINEERS, INC.
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FAX: 814-696-0150

KELLER ENGINEERS
HOLLIDAYSBURG • STATE COLLEGE • HAGERSTOWN

Figure 9. Wetland delineation map depicting the various wetland types found at JOFL (Keller Engineers, Inc. 2009).

Several wetland associations were identified in the vegetation classification and mapping report and include (1) Silky Willow Shrub Swamp and (2) Cattail Marsh, which both occur mostly in the impounded areas along the railroad berm; (3) Old Field (Wet Meadow subtype), which is interspersed throughout the lakebed with the other Old field subtypes, occurring in seasonally saturated areas of the lakebed; and (4) Riverine Scour Vegetation, which occurs in areas along the river that are underwater for a significant portion of the year and are subject to high flood velocities and scour (Perles et al. 2006).

Terrestrial Resources

The region surrounding JOFL was historically forested. Tree species included sugar tree (sugar maple), cherry, white walnut (butternut), hickory, chestnut, ash, oak, cucumber, hemlock and spruce (McLaurin 1890). Presently, some forested area occurs near the Picnic and Maintenance areas southwest of the dam and represent the only Natural Zone in the park (JOFL Natural Resource Manager, pers. comm.). These forests are typical of contemporary forest composition and include many northern hardwood species, such as sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), and black cherry (*Prunus serotina*). Perles et al. (2006) provides extensive detail on current habitat associations within JOFL, their extent and characteristic species. The most common forest type at JOFL is Red Maple-Black Cherry Successional Forest/Woodland; it occurs on moderate to somewhat steep slopes. Eastern Hemlock-Northern Hardwood Forest can be found on the north-facing slopes, primarily near the south abutment (Perles et al. 2006).

The former lakebed constitutes much of the park's acreage and represents the most important feature. Little is known regarding lakebed management in the first few decades. In 1986, a description of vegetation communities characterized the lakebed as consisting largely of planted stands of Scotch pine (*Pinus sylvestris*), eastern white pine, and red pine (*P. resinosa*), as well as mixed conifer-hardwood and northern hardwood communities (Bowersox 1986). Today the lakebed is managed primarily as a mosaic of wetlands, grasslands, and shrubland. This early-successional habitat accounts for 43% (27 ha) of the park area (Yahner and Keller 2000). Two abundant shrub/small tree species are speckled alder (*Alnus rugosa*) and European alder (*A. glutinosa*). The latter is a non-native which park management intends to remove. In addition, a 15.2-m (50-ft) forested riparian buffer strip is being allowed to re-grow on either side of the South Fork Little Conemaugh River (K. Penrod, pers. comm., 2013). A few patches of conifer plantations were allowed to remain in the lakebed near the south end (Perles et al. 2006).

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. Herbaceous habitat accounts for 23% (15ha) of the park area (Yahner and Keller 2000). 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 (*Dactylisglomerata*) and goldenrods (*Solidago spp.*). Although strict grassland management was not possible in the former lakebed, much of the area surrounding the Unger Farm and the park's visitor center is mowed annually and classified as Old Field (Herbaceous subtype). Dominant species are patchy in their distribution and include wrinkleleaf goldenrod (*Solidago rugosa*), timothy (*Phleum pretense*), shiny wedgescale (*Sphenopholis nitida*), sweet vernalgrass (*Anthoxanthum odoratum*), flat-top goldenrod (*Solidago juncea*), and big bluestem (*Andropogon gerardii*) (Perles et al. 2006). Another Old Field subtype (Hawthorn) also occurs in the park on the slopes above the former lakebed and surrounding the visitor's center. This subtype occurs in areas that were probably farmed at one time but are no longer actively managed or mowed and is dominated by tall shrubs (*Crataegus* spp., *Malus* spp.). Grasslands also occur in the lakebed mosaic, interspersed with the Old Field Wet Meadow subtype (Perles et al. 2006).

Field studies at JOFL conducted by the Western Pennsylvania Conservancy documented one globally rare and Pennsylvania Endangered plant species, Appalachian blue violet (*Viola appalachiensis*) on park property (Western Pennsylvania Conservancy 2003). Another plant species of concern found within the former lakebed of the park is the veiny-lined aster (*Symphiotrichum praealtum/Aster praealtus*). Although not globally rare like the violet, its Pennsylvania state rank is S3 (vulnerable in the state either because rare or found only in a restricted range). Both species are classified in the state as 'Tentatively Undetermined' (species are believed to be in danger of population decline but taxonomic uncertainties, limited evidence or insufficient data prevent their classification elsewhere).

Biological Resources

A variety of wildlife can be found at JOFL. Species present or probably present in the park include 22 mammals, 112 birds, 6 fish, 16 amphibians and 8 reptiles (https://irma.nps.gov/App/Species/). Mammals were surveyed at JOFL from March to October in 2004 and 2005 by Yahner and Ross (2006). Moist riparian areas provide habitat for several small mammal species including the masked shrew (*Sorexcinereus*) and southern bog lemming (*Synaptomys cooperi*). Upland areas provide habitat from species ranging from Eastern cottontail (*Sylvilagus floridanus*) to the red fox (*Vulpes vulpes*). Eastern chipmunk (*Tamias striatus*) and white-footed mouse (*Peromyscus leucopus*) were the most abundant mammal species at the park. 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). The bat community at JOFL was surveyed using acoustic and mist-netting surveys in 2005 and 2006 and captured three species: big brown bat (*Eptesicus fuscus*), little brown myotis (*Myotis lucifugus*), and northern myotis, also called the northern long-eared bat (*Myotis septentrionalis*) (Gates and Johnson 2007). In 2013, the U. S. Fish and Wildlife Service proposed the northern long-eared bat for federal listing as Endangered under the Endangered Species Act.

JOFL provides a variety of bird habitat, especially early-successional habitats, and may serve as an important stopover for long-distance migrants (Yahner et al. 2001). Grassland-dependent birds have been documented in the park and include Henslow's Sparrow (*Ammodramus henslowii*), Vesper Sparrow (*Pooecetes gramineus*), Eastern Meadowlark (*Sturnella magna*), Bobolink (*Dolichonyx oryzivorus*), and Field Sparrow (*Spizella pusilla*). In addition, the silky willows (*Salix sericea*) and cattail marshes provide habitat for Yellow Warbler (*Dendroica petechial*), Willow Flycatcher (*Empidonax trailii*), Common Yellowthroat (*Geothlypis trichas*), Swamp Sparrow (*Melospiza* *georgiana*), and Red-winged Blackbird (*Agelaius phoeniceus*) (Yahner et al. 2001). The Golden-winged Warbler (*Vermivora chrysoptera*) is noted from historical records and is currently considered a migratory species that may be present in the park. Populations of this species have been declining due to loss of early-successional forest habitat and to competition and hybridizing with its close relative, the Blue-winged Warbler (*Vermivora cyanoptera*) (Bakermans et al. 2011). The Golden-winged Warbler was petitioned for listing under the Endangered Species Act in 2010 and is most likely a species of concern at JOFL. Final determination of its status from a park management perspective will depend on several factors, including (1) documentation of breeding populations in the park, (2) monitoring of hybridizing with the Blue-winged Warbler, which is known to breed in the park, and (3) the final determination of its conservation status (K. Penrod, pers. comm., 2013). Yahner and Keller (2000) detected 67 species during spring migration in 1997 at JOFL, of which the majority were long-distance migrants. Surveys during the breeding season of that year detected 43 species, with the most individuals as short-distance migrants. Total abundance was highest in the early successional habitats. When avian surveys were conducted again in the spring of 1999 and 2001, 94 species of birds were detected, with 10 species of special concern (Yahner and Keller 2001). The blackpoll warbler (*Dendroica striata*) is listed as endangered by the Pennsylvania Game Commission and has been found at JOFL (Yahner et al. 2001).

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 northern slimy (*Plethodon glutinosus*) and Wehrle’s salamanders (*Plethodon wehrlei*) were found in abundance; while mountain dusky (*Desmognathus ochrophaeus*) and northern two-lined salamanders (*Eurycea bislineata*) were the most abundant aquatic salamanders found within the park (Yahner and Ross 2006). JOFL also supports populations of the smooth green snake (*Liochlorophis vernalis*), which is listed as a species of special concern in Pennsylvania by the Pennsylvania Fish and Boat Commission.

Threats and Potential Stressors

<u>Air Pollution/Industry</u>

Bituminous coal mining and coke manufacturing for the iron and steel industry dominated much of western Pennsylvania’s economy during the late nineteenth and early twentieth centuries with hundreds of mines scattered across the region. Coal mining peaked in 1918, producing 177 million tons of coal annually, and then, faced with competition from other states, as well as cheaper sources of fuel (petroleum and natural gas), the coal industry entered a long-term decline (Sisson and Miner 2011). The steel industry, however, continued to prosper in Johnstown, led by the Bethlehem Steel Corporation (formerly the Cambria Steel Company), which closed its doors in 1992 (JAHA 2013b).

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.

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. AMD can be highly acidic, or, if the soils have enough acid-neutralizing capacity, can 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. The JOFL region's coal mining legacy dates back to the 1700s. There are no seeps or AMD arising within the park; only the South Fork Little Conemaugh River and certain tributaries are impaired. Results of a water quality assessment conducted in the park confirmed severe impairment of the mainstem and also moderate levels of impairment in two of the small tributaries (Sheeder and Tzilkowski 2006). Raw sewage, sediment, and industrial wastes have also impacted the river flowing through the park, but by far the most widespread and lasting impacts are from abandoned mine drainages scattered throughout the watershed that seep, flow and sometimes gush as artesian wells, lowering pH levels and contaminating the waterways with heavy metals (Figure 10). 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. Sites located farther upstream in the Little Conemaugh watershed include the Hughes Borehole (an artesian well draining 7,300 acres of abandoned and flooded Lower Kittanning deep mine area at Cresson), as well as drainage sites in the Sonman area and around Miller Shaft, both in Portage Township. Topper Run, a tributary to the South Fork Little Conemaugh River located just upstream of JOFL in the town of St. Michael, is said to be the single largest contributor of pollution in the Little Conemaugh River (Mellott 2012a, b).

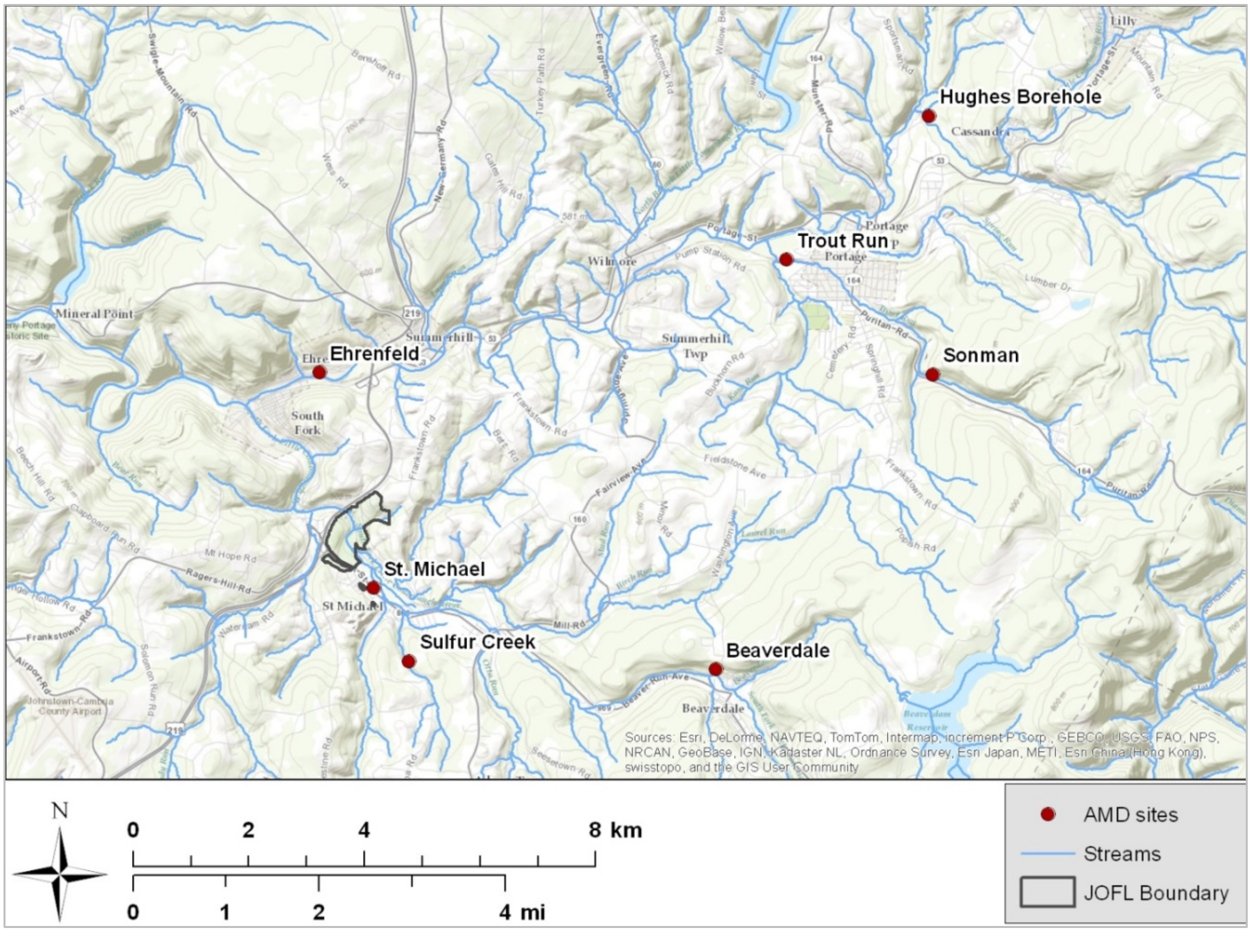


Figure 10. Locations of AMD sites in the Little Conemaugh watershed near JOFL. AMD sites upstream of JOFL in the South Fork Little Conemaugh River watershed include St. Michael, Sulfur Creek, and Beaverdale.

Addressing these impacts to water quality is beyond the park's ability to control. Mediation of these impacts, at least in the mainstem of the South Fork Little Conemaugh River, is not an option for park management. The recovery of the river is an ongoing project of federal, state, and private agencies. Currently there are several projects being implemented to address some of these issues. Perhaps the most important is the treatment of the Topper Run discharge, which accounts for close to one-third of the total iron, aluminum, manganese and other minerals polluting the Little Conemaugh River. According to the Cambria County Conservation District, the general consensus for treating the Topper Run discharge is to allow construction of a treatment plant coupled with additional mining (Mellott 2012a). This particular project is unique in that a good majority of the cost would be absorbed by a mining company, rather than state and federal funds. Rosebud Mining Co. is the third largest underground coal producer in Pennsylvania and operates deep and surface mines in western Pennsylvania and Ohio, including six deep mines in Cambria, Somerset, and Indiana counties (Sojak 2011). The company proposes to build a $15 million treatment plant, which would allow them to partially drain the borehole (located behind the St. Michael fire hall) in order to mine the rich seam of metallurgical coal underneath (Mellott 2012a). In December 2012, the Pennsylvania Department of Environmental Protection (PADEP) approved the project and issued the first mining permit in the state requiring Rosebud to document that its treatment of the Topper Run discharge site is improving water quality, as well as the first agreement to provide a method of calculating and reporting load reductions to the Little Conemaugh River (Mellott 2012c). A similar project is underway to treat AMD arising from the Hughes Borehole, an artesian well that also sends pollutants into the Little Conemaugh, upstream of its confluence with the South Fork Little Conemaugh River near Lilly (Mellott 2013d).

Invasive Species

Over time, several non-native, invasive species had colonized the woodlands and managed landscapes at JOFL. The dry bed of the former Lake Conemaugh is especially vulnerable to invasion, but to a lesser extent the fields at the Unger Farm cultural landscape and the forest at the Picnic and Maintenance areas were and are also invaded by non-native plant species. In 1999, a park survey for four species, identified many areas of invasion (Figure 11).

In 1999, multiflora rose and honeysuckle had invaded the Unger Farm cultural landscape fields surrounding the Visitor Center and Unger House, and portions of the dry bed of Lake Conemaugh. Knotweed species and/or hybrids were common in the dry lakebed, and a small amount of Japanese barberry was mapped. Through the early 2000's, the park controlled the knotweed and now it is a minor occurrence in the park. Exotic shrub honeysuckle was controlled at upland (non-wetland) areas of the dry lakebed and along the Picnic Area Road. In 2007, multiflora rose and honeysuckle were removed from the Unger Farm cultural landscape. Although not mapped in 1999, teasel is commonplace and garlic mustard poses a threat at JOFL. Recently, garlic mustard has increased rapidly along the Picnic Area and South Abutment Roads. The area south of Route 869 was not mapped in 1999. Invasive plant species, particularly exotic shrub honeysuckle, remain a problem there.

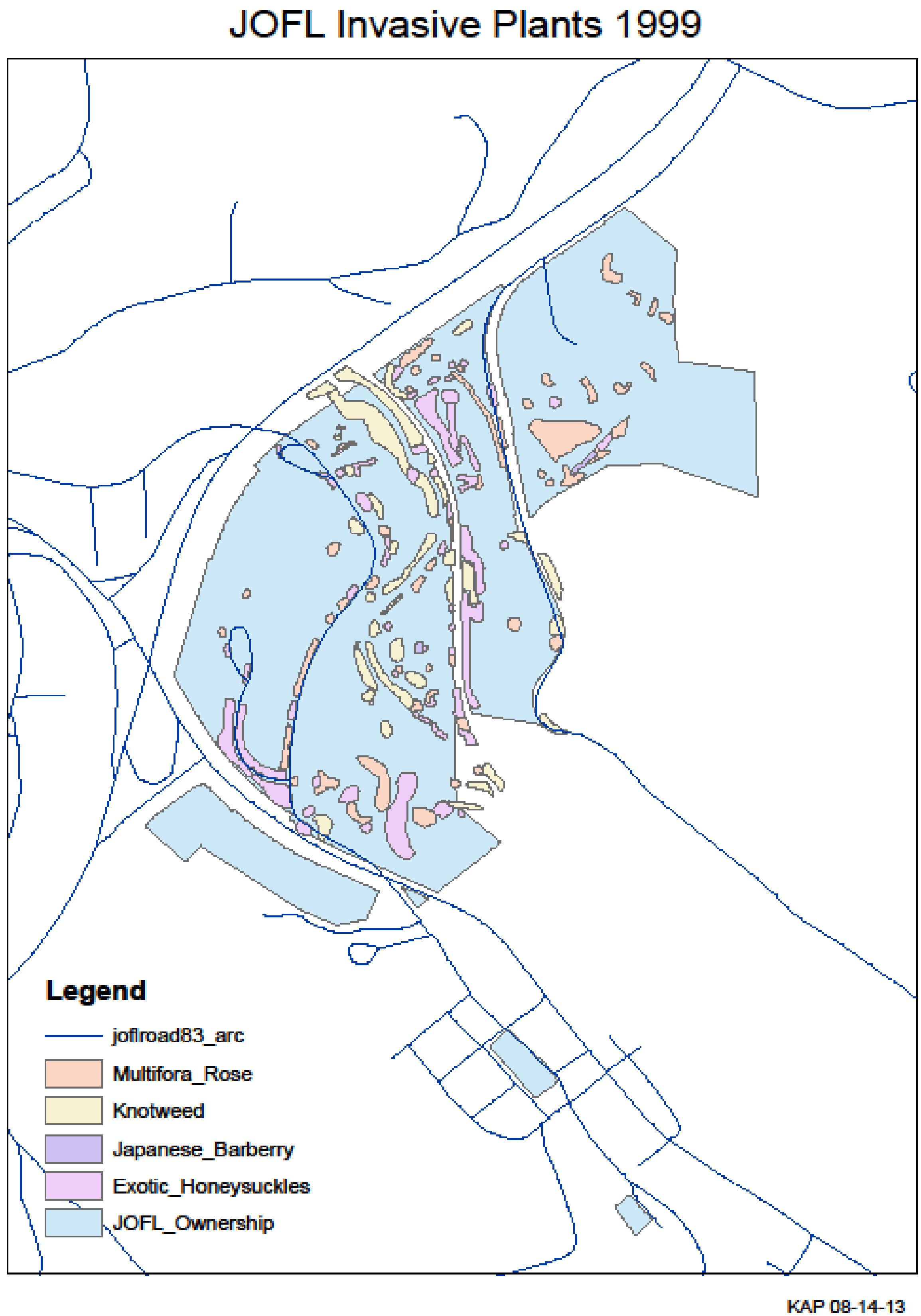


Figure 11. Locations of four non-native plant species at JOFL in 1999 as mapped through a park survey.

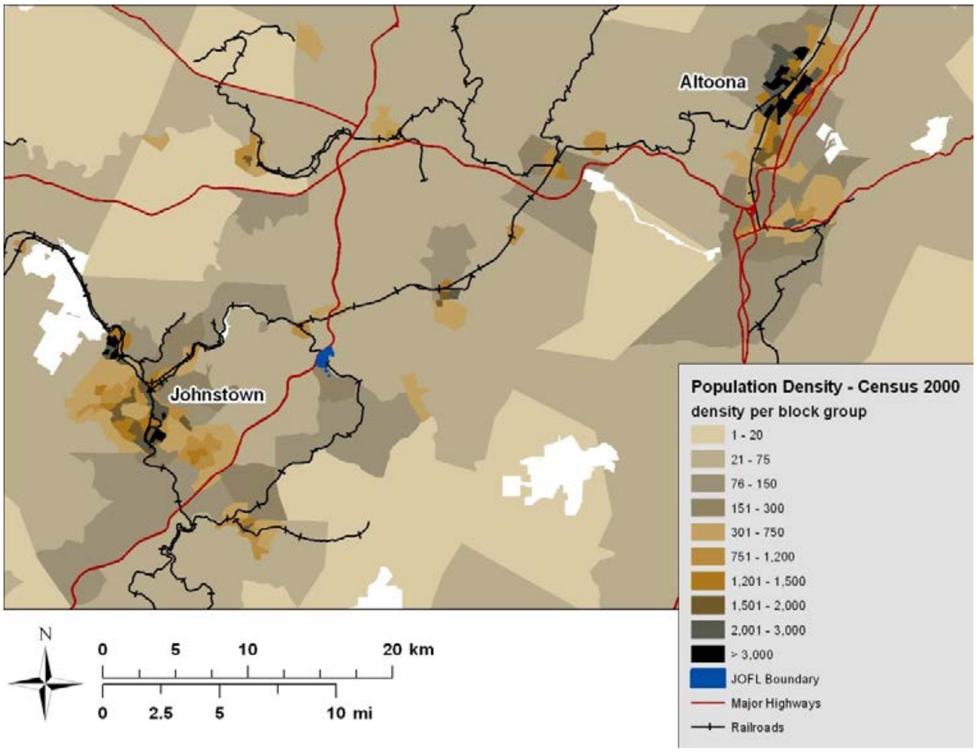
During the ERMN vegetation mapping and classification research, an invasive plant survey was undertaken at JOFL (Zimmerman 2007). A total of 54 non-native plant species were identified at plots throughout JOFL. The most widespread non-native plant species was Morrow's honeysuckle, an exotic shrub honeysuckle. Crown vetch and multiflora rose were also commonly found. At the time of the report, the invasive status of Morrow's honeysuckle and multiflora rose were listed as serious threats, but crown vetch was not considered a threat, as assessed by the Pennsylvania Department of Conservation and Natural Resources.

Non-native animal species currently posing a threat at JOFL include the viburnum leaf beetle, discovered during early detection monitoring by the ERMN Vegetation Mapping crew in 2010. This beetle is attacking the native arrowood shrubs, and the infestation is especially heavy at the parcel south of Route 869. Non-native invasive animal species that potentially threaten JOFL include the emerald ash borer and the Asian long-horned beetle. Emerald ash borer can kill most ash species which do occur at JOFL. Asian long-horned beetle threatens maple trees, which are also common in the forest at JOFL, and can also attack other hardwoods. While hemlock woolly adelgid has been found in Cambria County, the hemlock component of forests at JOFL is small, and occurs primarily at areas of the dam abutments where tree removal is planned for cultural resource protection.

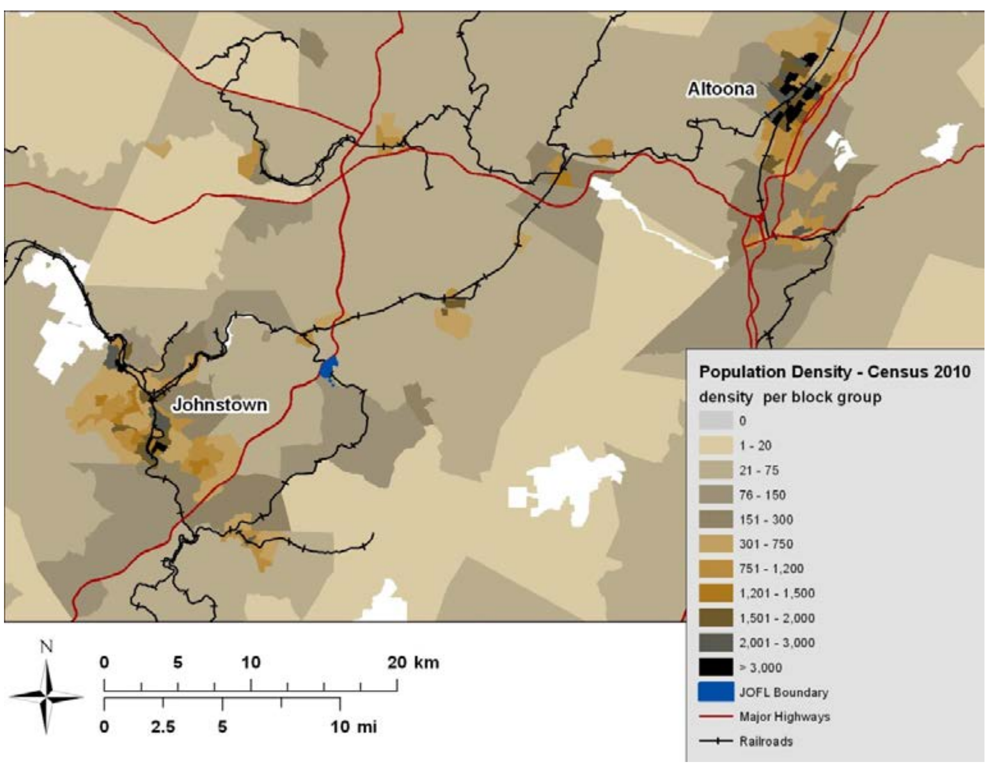
Population Density

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 JOFL has remained relatively unchanged since 2000, ranging between between 21 - 75 people/mi^2, although the area southwest of the park has experienced a population decline between 2000 and 2010, decreasing from 151 – 300 people/ mi^2 to 76 – 150 people/mi^2 (Figure 12). Denser populations occur near the city of Johnstown, which housed an urban population of 20,577 people in 2012 (www.city-data.com/city/Johnstown-Pennsylvania.html). Cambria County is considered to be in a small metro area with under 1 million residents. The 2010 Census reported populations of 143,679 people for Cambria County (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml). According to Greb et al. (2009), the percent population change has decreased between 2000 and 2006 (-7.6 to -2.0%) in Cambria county, and the projected population change for the county from 2006 to 2030 is negative (-21.2 to 0.0). Farmland has also decreased. From 1997 to 2002, Cambria County lost between 4.1 and 9.2% farmland.



a.)



b.)

Figure 12. Population density by census tract in the vicinity of JOFL 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. A spur of the Norfolk Southern (formerly the Pennsylvania Railroad) parallels the South Fork Little Conemaugh River and bisects the park. Rt. 219 is a busy highway that borders the northwest end of the park near the dam abutments. Rt. 869 runs along the southern border of the park (Figure 13). This can create multiple problems for the park's natural resources, including runoff from both roads and railroads, impoundments from railroad berms, and air and noise pollution from highway traffic.

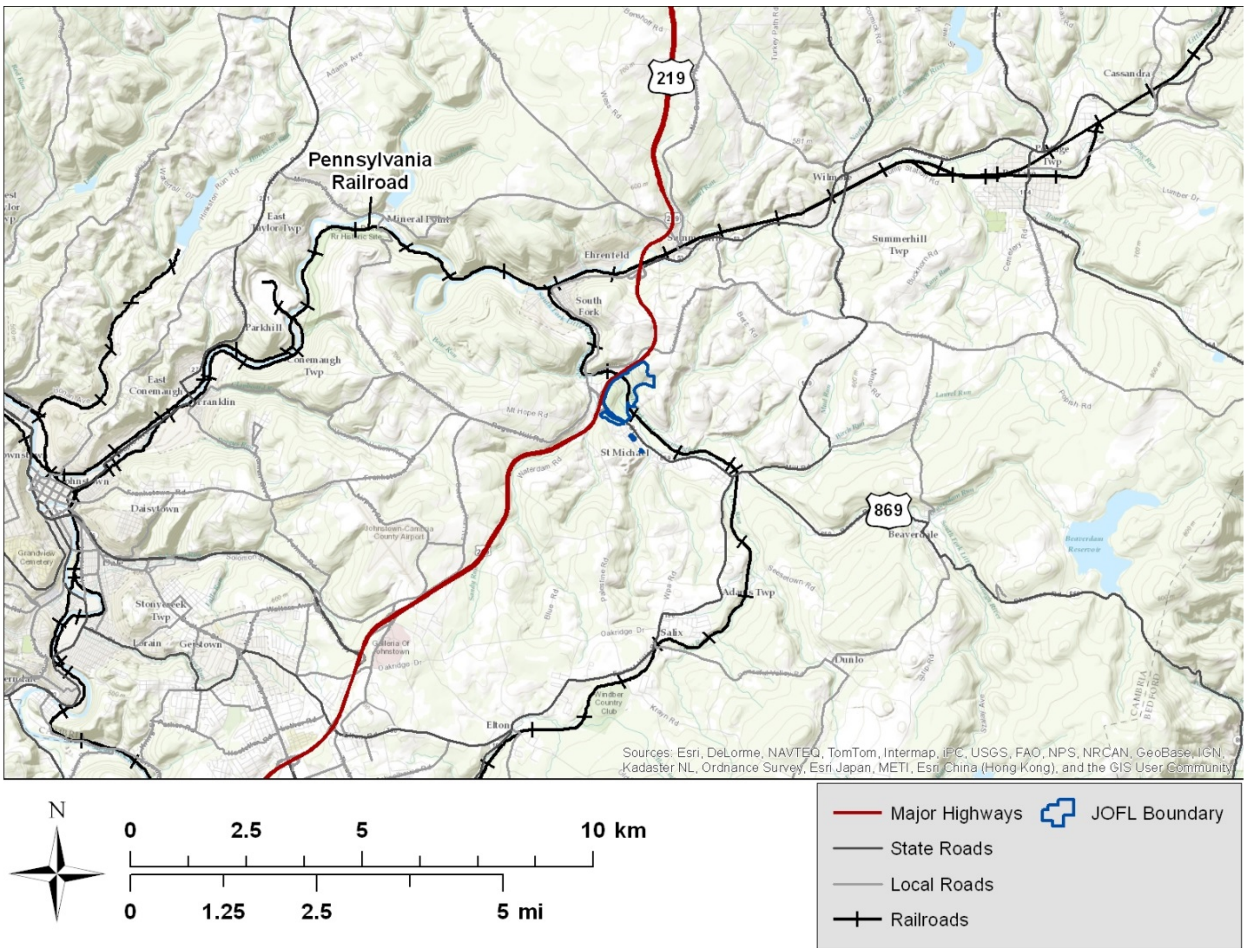


Figure 13. Major highways, roads, and railways surrounding JOFL.

Land Use Development

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. During the early part of the 20th 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 JOFL region maintains an active agricultural presence, mining was heavy in the immediate surrounding area, and active mining and re-mining are in process. Urban/suburban development also surrounds JOFL. The towns of St. Michael, Creslo, and Sidman sprang up literally in the former lakebed (Table 1, Figure 14).

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.

Table 1. Land use areas for JOFL and the immediate (1-km) surrounding area, National Land Cover Database (NLCD) 2006.

Land Cover Class	Percent
Water	0.05
Developed- Low Intensity	9.36
Developed- High Intensity	7.17
Bare Rock	0.94
Forest	49.34
Pasture	21.83
Row Crops	11.30

At a local level the forests within JOFL are experiencing these same fragmentation pressures. Urban and suburban expansion is occurring around the park, especially near the western and southern borders. Agriculture surrounds the northern and eastern borders of the park. 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 and loss of habitat. Wind energy also poses the threat of collision and other lethal impacts to birds and bats.

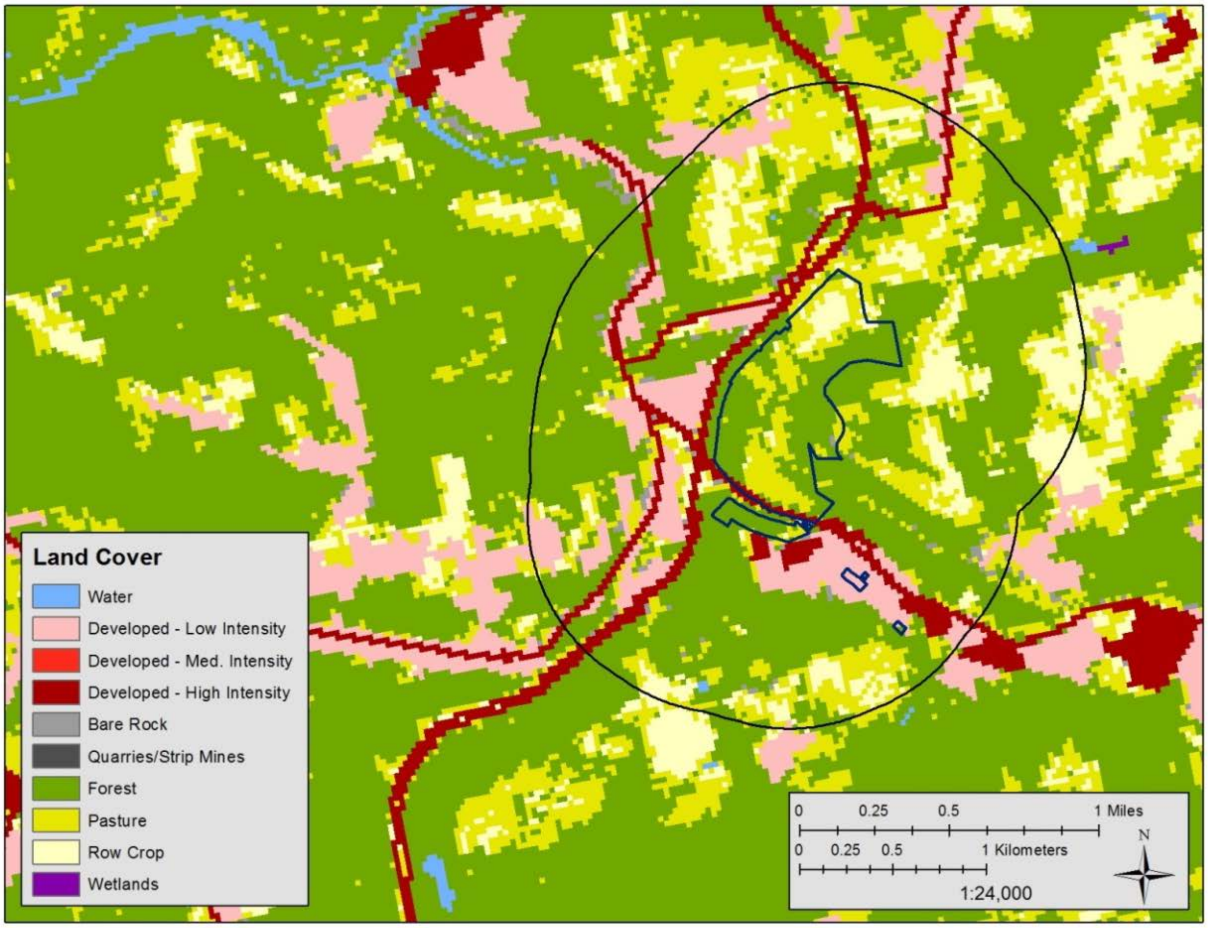


Figure 14. Land use based on the National Land Cover Database (NLCD) 2006. Displayed is an Anderson Level 1 land use interpretation (Anderson et al. 1976) for an area within a 1 km buffer zone around JOFL. Much of the area surrounding the park is developed land (both low and high intensity use) and agriculture with some forest patches interspersed.

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).

In the 30-km region around JOFL there were 35 well pads permitted by February 2012 and, based on 2010 aerial imagery 11 of those sites had begun pad construction (Figure 15). 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).

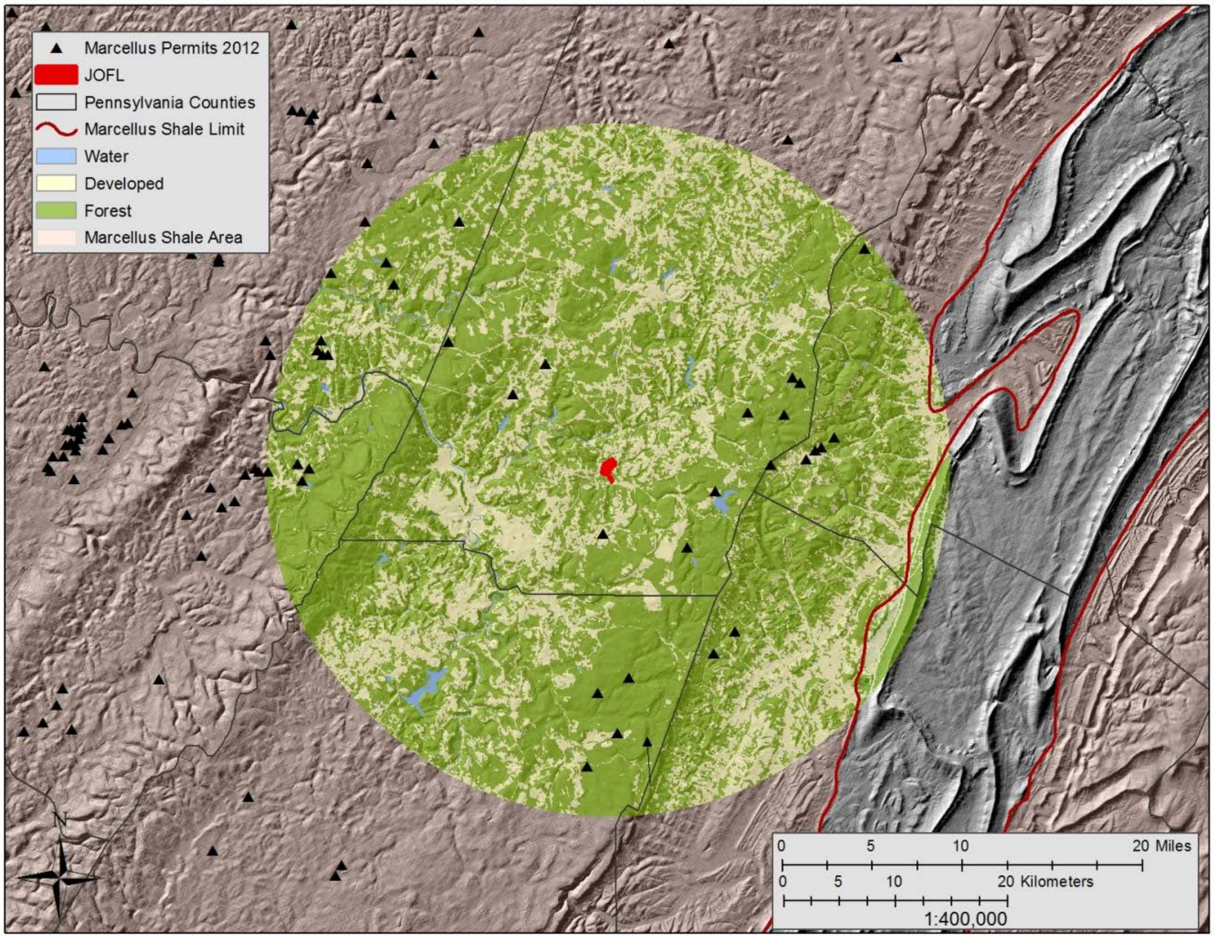


Figure 15. Locations of Marcellus Shale permitted pads (drilled or planned) within 30-km surrounding JOFL. There are 35 potential pad locations within this area based on permit information acquired from the Pennsylvania Department of Environmental Protection (PADEP), February 2012.

Wind Turbines

Wind energy development has been increasing along the Allegheny Front and many wind turbines are located or planned in southwestern Pennsylvania. Gamesa, a global leader in wind energy, produced blades for nearby wind turbines at its manufacturing plant outside of Ebensburg from 2006-2014 (Mellott 2014, Sojak 2011). The closest wind turbines near JOFL are located southeast of Sidman, approximately 7.25 km (4.5 mi) away from the park (Figure 16). Like Marcellus development, impacts from wind turbines is primarily in the form of land fragmentation, when 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). Bat mortality is also caused by air pressure disturbances around the moving blades (http://www.scientificamerican.com/article/wind-turbines-kill-bats/).

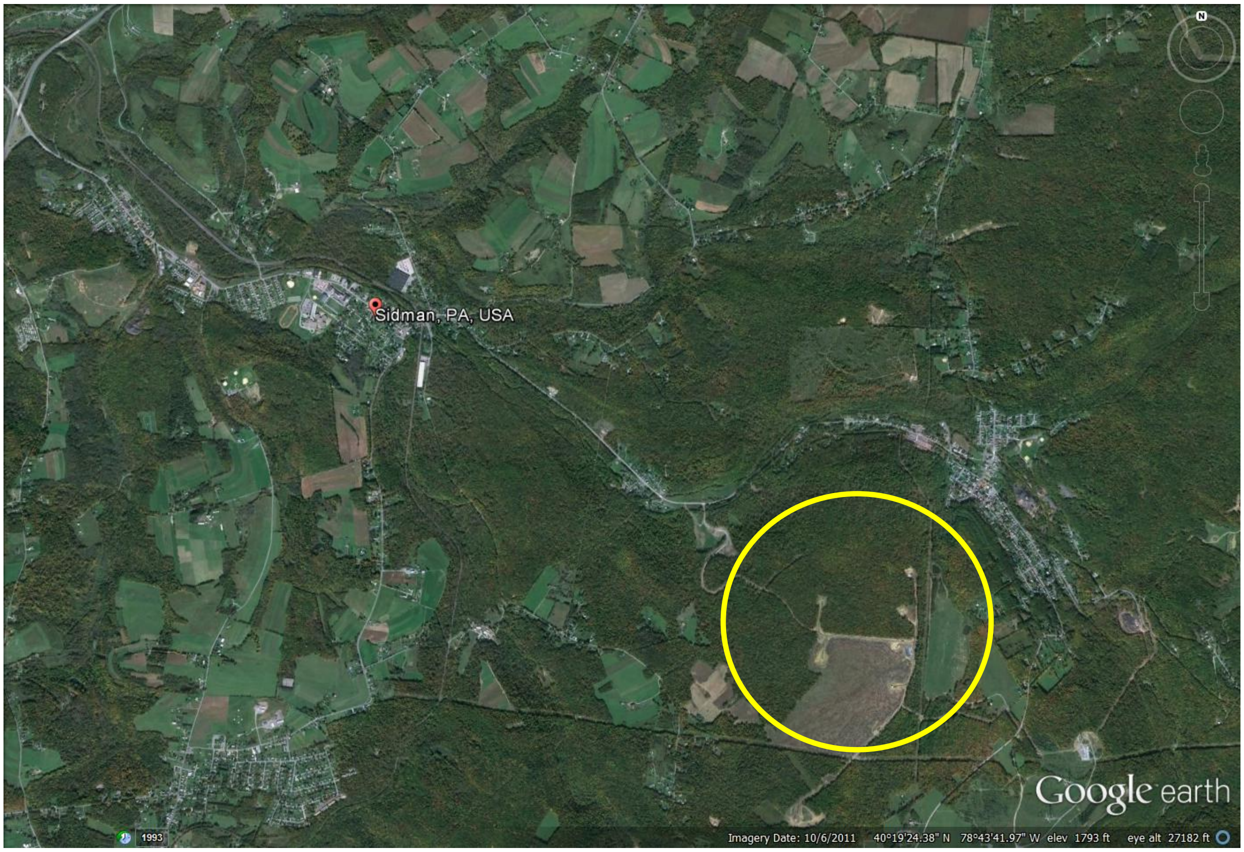


Figure 16. Wind turbine locations in the region surrounding JOFL. There are several wind farm developments along the Allegheny Front, but the closest to the park is shown on the map southeast of Sidman (yellow circle). The park is located northwest of Sidman in the upper left corner of the figure.

Resource Stewardship

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." Natural resource management issues at JOFL include air and water quality, invasive non-native plants, non-native insect pests,

Wind turbines located along a ridge northeast of JOFL. Photo by S. Yetter.

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 (NPS 1993, Figure 17):

- HISTORIC (CULTURAL) 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. The historic zone consists of the historic lake bed, dam abutments, spillway, culvert stones, as well as the Unger House."
- 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. The natural zone consists of a variety of open fields, brush and forest bordering the historical and developed areas. In the park, the natural zone offers a buffer to historic resources from intrusive adjacent land uses or activities."
- PARK DEVELOPMENT ZONE – "Lands that will be managed to provide and maintain facilities serving park visitors and management. The development zone includes the maintenance area, picnic area, the visitor center, the spring house, and associated access roads and parking areas."
- 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 or industry." (NPS 1993)

Managing natural resources can be difficult in an historic park managed for its cultural significance. Conflicts often arise between natural and cultural management objectives. At JOFL, management concerns focus primarily on the former lakebed. Natural resource management goals typically involve allowing a community or habitat to undergo natural succession, with active management objectives centered on preventing anthropogenic impacts (e.g., controlling for invasive species). However, allowing the former lakebed to revert to forest, directly interferes with the cultural mandates set forth in the park's General Management Plan, which are "to preserve and maintain the cultural resources and the setting of the South Fork Dam to approximate conditions in 1889." Prior to the 1980's, much of the lakebed was covered in trees, including conifer plantations of scotch pine, eastern white pine, and red pine. This obstructed the viewshed, making it difficult for visitors to visualize the extent of the former Lake Conemaugh. A lakebed management plan, was designed to promote the growth of herbaceous communities within the 1889 Lake Conemaugh shoreline (Bowersox 1986). Between 1988 and 1991, trees and shrubs were removed and the entire area was seeded to promote grassland development. This was only partially successful, as it was difficult to prevent shrub regrowth, and presently the lakebed is maintained as early successional habitat. Preventing tree regrowth is an ongoing issue that is compounded by the significant wetland acreage within the lakebed (Keller Engineers, Inc. 2009). Managers must be careful to avoid impacts to these wetlands, which are protected by Executive Order 11990.

Figure 17. Management zone map for JOFL. Aerial imagery from 2006 was used to aid interpretation.

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).

JOFL 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).

Status of the Supporting Science

We based this natural resource condition assessment on the ERMN's Vital Signs indicators (Table 2). 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.

Table 2. 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 -- Streamside Birds	Streamside Birds
Landscapes (Ecosystem Pattern and Processes)	Landscape Dynamics	Land Cover and Use	Landscape Dynamics
		Landscape Pattern	

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."

The optimal choice of vital signs 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 3).

Table 3. ERMN vital signs ranked by priority for JOFL, 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 Deposition	1	•	x	x
Weather and Climate	2	†	x	x
Soil Function and Dynamics	3	†		
Surface Water Dynamics	2	†		
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	1		x	
Birds--Riparian Communities	2	◊		
Land Cover and Use	1	†	x	x

• = monitored by another park, program, or federal/state agency
† = network has developed protocols and implementation of monitoring is underway
◊ = JOFL lacks sufficient stream lengths within the park to implement this protocol

Several inventory and monitoring reports currently exist for JOFL (Tables 4 and 5). Data from these reports was requested from NPS staff and used in the condition assessment.

Table 4. Compiled list of inventory reports available and used for the JOFL NRCA.

INVENTORY REPORTS
Geology
JOFL 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)
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 at JOFL (Perles et al., February 2006)
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 (Sneddon, December 2010)
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 5. Compiled list of monitoring reports available and used for the JOFL 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

Preliminary Scoping

Park Involvement

The process for developing the condition assessment for JOFL 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 metrics and scoring criteria must be made within the context of the park's management zones (cultural, natural, developed, and special use). For example, constraints placed on the ability of management to improve or maintain desired levels of natural resource condition in cultural resource zones should be accounted for when reporting condition.

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), 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 2014 between NRCS supervisors, ERMN staff, JOFL'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. Although initially these communications were focused on Allegheny Portage Railroad National Historic Site (ALPO), they provided the basis for understanding both the natural resource issues at JOFL and the template for the NRCA.

Study Design

Assessment Framework

Our approach utilizes the ERMN's 'vital signs' framework for reporting natural resource condition (Marshall and Piekielek 2007). This approach has both advantages and disadvantages for JOFL. First, it allows NPS to utilize these NRCA results in conjunction with ERMN's long-term monitoring, which provides several advantages, 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. These gaps can arise from multiple sources including 1) vital signs with no park data, and 2) park resources with data that are not vital signs. While identification of these gaps is important, they can serve as disadvantages for completing the NRCA.

This was often the case with JOFL. Several of the ERMN vital signs not included in this assessment were lacking data for JOFL or had very limited data where only heuristic or qualitative assessments were possible (Figure 18). This may be partly due to conflicts between monitoring and management zones. Much of the natural resource monitoring by the ERMN (e.g., vegetation communities) was conducted strictly within the natural zones, leaving a huge gap of monitoring information for the lakebed and Unger Farm, which are part of the cultural zone. Conversely, resources considered important to the park were not vital signs and, thus, had no ERMN monitoring data (Figure 18). For example, JOFL's most important and largest (~ 55 acres or about 1/3 of the park) natural resource is the former lakebed (JOFL Natural Resource Manager, pers. comm.). Consequently, the lakebed wetlands are an important resource for which the park has detailed information (e.g., wetland delineations and maps). However, JOFL wetlands are not monitored by the network. Other ERMN vital signs not monitored in the lakebed for condition or trends include soils, vegetation, and invasive species.

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 24 indicators are dispersed across these categories and are listed in Figure 18.

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 by stream and/or monitoring location. Forest/wood/shrubland condition and wetland condition are reported first by forest association and then scaled up to park-wide. Grassland condition is reported for each habitat patch and then for the entire park. Biological integrity results were reported 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. 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.

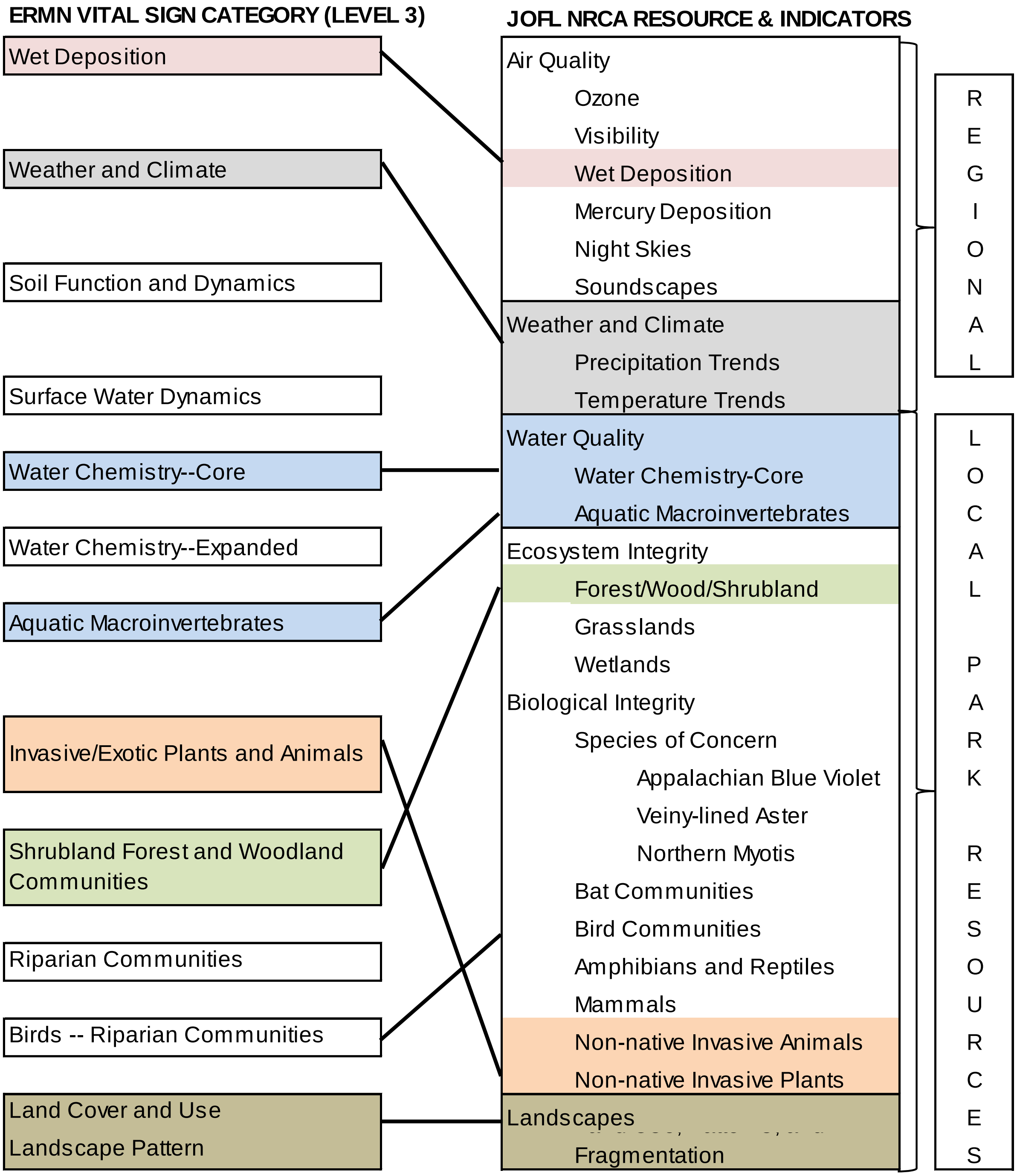


Figure 18. ERMN vital signs and their relation to JOFL's NRCA resources and indicators. Resources and indicators with vital sign monitoring data are emphasized by color. ERMN Vital Signs (left column) in white boxes had limited and/or inconsistent data and were not assessed. JOFL indicators in white boxes were assessed using other data sources.

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 6). Final sections include a brief explanation regarding data gaps and level of confidence and a list of sources of expertise utilized.

Table 6. Symbol key legend used to report resource condition, trend, and confidence levels in the JOFL NRCA.

CONDITION STATUS		TREND IN CONDITION		CONFIDENCE IN ASSESSMENT	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low
	Condition Status Unknown; Consequently, Trend is also Unknown and Confidence is Low				

Chapter 4. Natural Resource Conditions

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 (USEPA 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/index.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 impacts on human health and public welfare 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 (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). "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 2013b). This ARD guidance is applied in this document to help assess the condition of JOFL'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 JOFL include visibility, vegetation, surface waters, and fish and wildlife. Air-related vital signs monitored by the NPS ARD include ozone, visibility, wet deposition, mercury deposition, and particulate matter. All but particulate matter were selected for inclusion in the JOFL NRCA. 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 using the Haze Index. Table 7 provides a summary of the air quality monitoring networks (including state-level) involved and a list of nearby monitoring locations for JOFL's air quality -related values. Figure 19 shows the nearest monitoring stations providing the data for the different air quality condition assessments for JOFL.

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 products from an annual report on conditions (2005 – 2009) and trends (2000 – 2009) produced by ARD (NPS ARD 2013a). This report is available at http://www.nature.nps.gov/air/pubs/pdf/gpra/AQ_Trends_In_Parks_2013.pdf. The NPS ARD assessment guidance uses reports that 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 to each park:

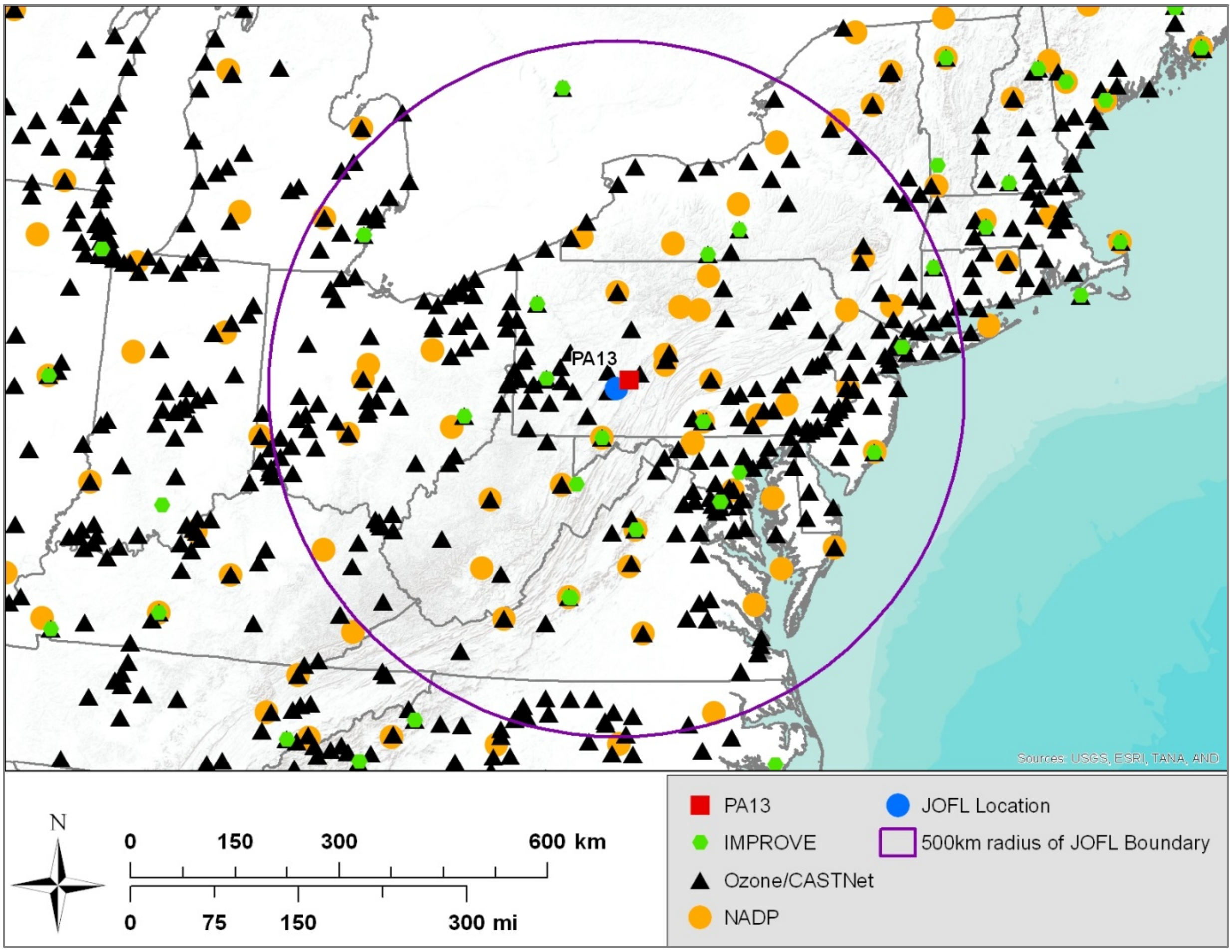
Air Quality Warrants Significant Concern (●)
Air Quality Warrants Moderate Condition (●)
Air Quality is in Good Condition (●).

Table 7. List of air quality networks and monitoring locations in or near JOFL.

PARAMETER	NETWORK	SITES	LOCATION
OZONE	CASTNet[1]	PSU106	State College, PA (75 km NE)
		LRL117	Laurel Hill State Park, PA (70 km SW)
	COPAMS[2]	42-013-0801-44201	Altoona, PA (20 km NE)
		42-021-0011-44201	Johnstown, PA (25 km SW)
VISIBILITY	IMPROVE[3]	AREN1 DOSO1	Arendtsville, PA (110 km SE) Davis, WV (165 km SW)
WET DEPOSITION (Nitrogen, Sulfur)	NADP/NTN[4]	PA13 [6]	ALPO[7] (PA13) (10 km W)
		PA42	Pine Grove Mills, PA (70 km NE)
		PA15	State College, PA (75 km NE)
	CASTNet[1]	PSU106	State College, PA (75 km NE)
		LRL117	Laurel Hill State Park, PA (70 km SW)
WET DEPOSITION (Mercury)	NADP/MDN[5]	PA13	ALPO (PA13) (10 km W)

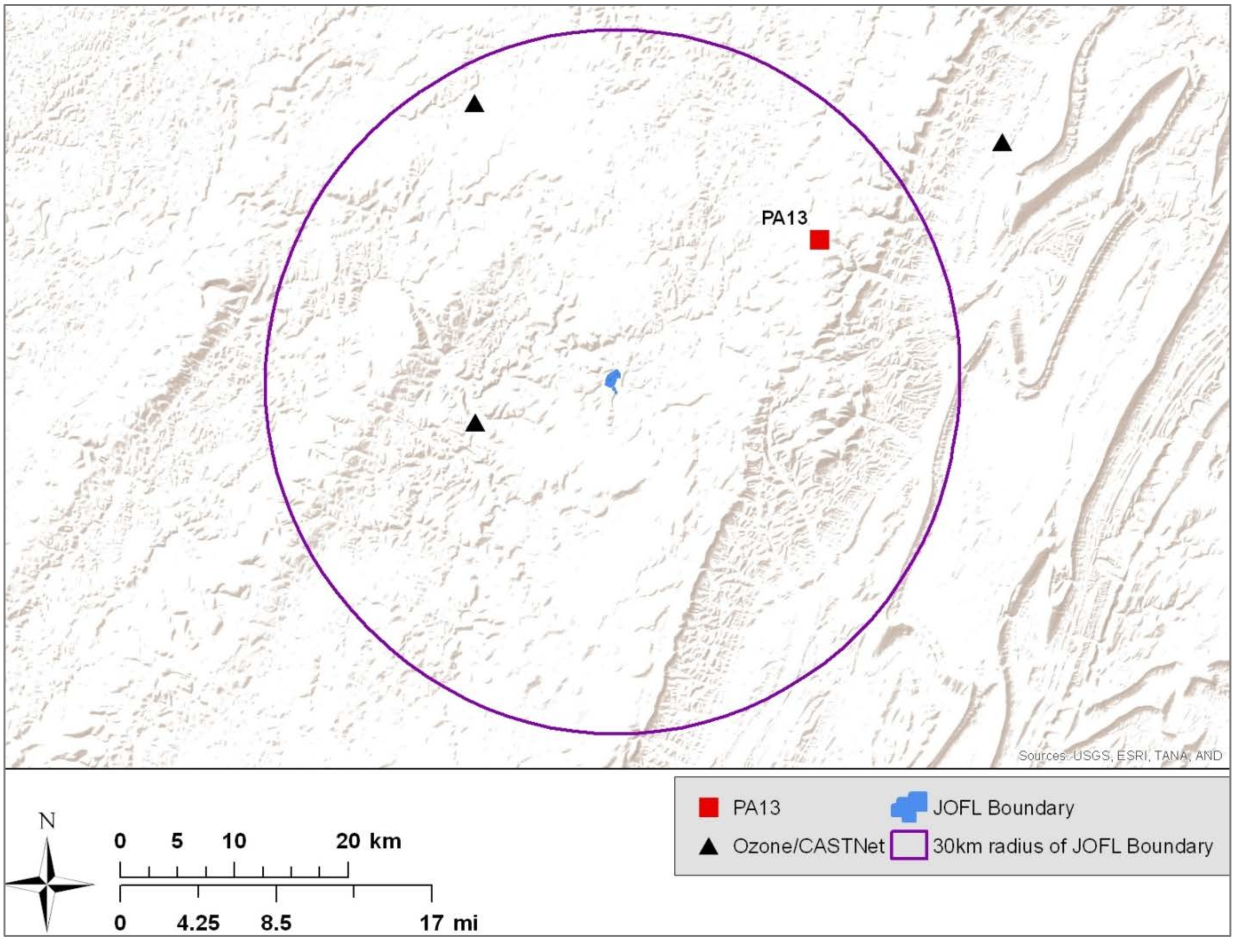
[1]CASTNet = Clean Air Status and Trends Network
[2]COPAMS = Commonwealth of Pennsylvania Air Monitoring system
[3]IMPROVE = Interagency Monitoring of Protected Visual Environments
[4]NADP/NTN = National Atmospheric Deposition Program/National Trends Network
[5]NADP/MDN = National Atmospheric Deposition 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)
[7]ALPO = Allegheny Portage Railroad NHS

For the JOFL 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 (D. Bingham, pers. comm.). We did include regional trends reported by NPS ARD for parks with on-site monitoring (NPS ARD 2013a). 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 19. Map showing air quality monitoring stations within a) 500-km radius and b) 30-km radius of JOFL. All stations within a 500-km radius (except PA-13) were used in the NPS-ARD interpolation estimates (inverse distance weighted).



b.)

Figure 19 (cont'd). Map showing air quality monitoring stations within a) 500-km radius and b) 30-km radius of JOFL. All stations within a 500-km radius (except PA-13) were used in the NPS-ARD interpolation estimates (inverse distance weighted).

Ozone

Relevance and Context

Ozone is an important phytotoxic air pollutant, especially in the eastern United States (Chappelka et al. 1999). Ground-level ozone (O_3) is the main component of smog and forms when sunlight reacts with methane (CH_4), carbon monoxide (CO), nitrogen oxides (NO_x), and volatile organic carbons (VOCs), most of which originate from man-made sources like burning of fossil fuels (USEPA 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, USEPA 2010b). Although studies of foliar injury have not been conducted at JOFL, 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 USEPA Clean Air Status and Trends Network (CASTNet). To assess park air quality, the NPS ARD assessment guidance estimates ozone condition based on interpolation of the 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. JOFL 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 JOFL 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 JOFL in the latest NPS ARD annual progress report (NPS ARD 2013a).

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-ERMN 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 JOFL (Table 8). Twelve are considered at risk by the NPS Ozone Injury Risk Assessment (NPS-ERMN 2004); the remaining 15 species (gray) are listed in the NPS 2003 workshop summary (NPS-ARD 2003).

Table 8. Plant species in JOFL 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 JOFL (NPS-ERMN 2004) but were listed in the Appendix from the invasive plant workshop (NPS-ARD 2003).

Scientific Name	Common Name	Lifeform	Category
Asclepias syriaca	Common milkweed	Forb/herb	Sensitive*
Aster acuminatus	Whorled aster	Forb/herb	Sensitive*
Fraxinus americana	White ash	Broad-leaved deciduous tree	Sensitive*
Liriodendron tuilipifera	Yellow-poplar	Broad-leaved deciduous tree	Sensitive*
Parthenocissus quinquefolia	Virginia creeper	Vine	Sensitive
Populus tremuloides	Quaking aspen	Broad-leaved deciduous tree	Sensitive*
Prunus serotina	Black cherry	Broad-leaved deciduous tree	Sensitive*
Robinia psuedoacacia	Black locust	Broad-leaved deciduous tree	Sensitive
Rubus allegheniensis	Allegheny blackberry	Broad-leaved deciduous shrub	Sensitive*
Rudbeckia laciniata	Cut-leaf coneflower	Forb/herb	Sensitive*
Sambucus canadensis	American elder	Broad-leaved deciduous tree	Sensitive*
Sassafras albidum	Sassafras	Broad-leaved deciduous tree	Sensitive*
Apocynum androsaemifolium	Spreading dogbane	Forb/herb	Sensitive*
Apocynum cannabinum	Indianhemp, Dogbane	Forb/herb	Sensitive
Asclepias incarnata	Swamp milkweed	Forb/herb	Sensitive
Eupatorium rugosum	White snakeroot	Forb/herb	Sensitive*
Fraxinus pennsylvanica	Green ash	Broad-leaved deciduous tree	Sensitive
Prunus virginiana	Choke cherry	Broad-leaved deciduous tree	Sensitive
Solidago altissima	Canada goldenrod	Forb/herb	Sensitive

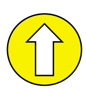
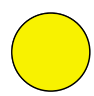
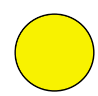
Reference Condition

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 the USEPA 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*. Only exposure levels are considered when defining reference condition, although ERMN's established criteria for assessing risk to plant resources are also included for reference purposes (NPS-ERMN 2004).

Current Condition and Trend

The 2006 – 2010 data estimates JOFL levels of ozone as 72.3 ppb, which is considered to be of *moderate concern* (Table 9). This represents an improvement in NPS Air Quality estimates (5-year averages) in the park since 1999 when the interpolated 4th -highest daily maximum 8-hour ozone concentration rated a significant concern at 85.4 ppb (Figure 20). 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 20; NPS-ARD 2013a). Trend results reported in the latest NPS-ARD air quality report (NPS ARD 2013a) also showed that JOFL exhibited a statistically significant improving trend, as well as reporting a similar decrease in ozone estimates for other park units in the eastern U. S. (Figure 21, NPS-ARD 2013a).

Table 9. Ozone condition assessment results for JOFL 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).

Condition Category	Human Health			Ecological Health					
	Ozone Concentration			Ozone Exposure (SUM 06)			Ozone Exposure (W126)		
	Reference Criteria	Current Condition	Condition Rating	Reference Criteria	Current Condition	Condition Rating	Reference Criteria	Current Condition	Condition Rating
Good	≤ 60 ppb			< 8 ppm-hrs			< 7 ppm-hrs		
Moderate Concern	61 - 75 ppb	72.3 ppb		8 - 15 ppm-hrs	13.3		7 - 13 ppm-hrs	10.1	
Significant Concern	≥ 76 ppb			> 15 ppm-hrs			> 13 ppm-hrs		

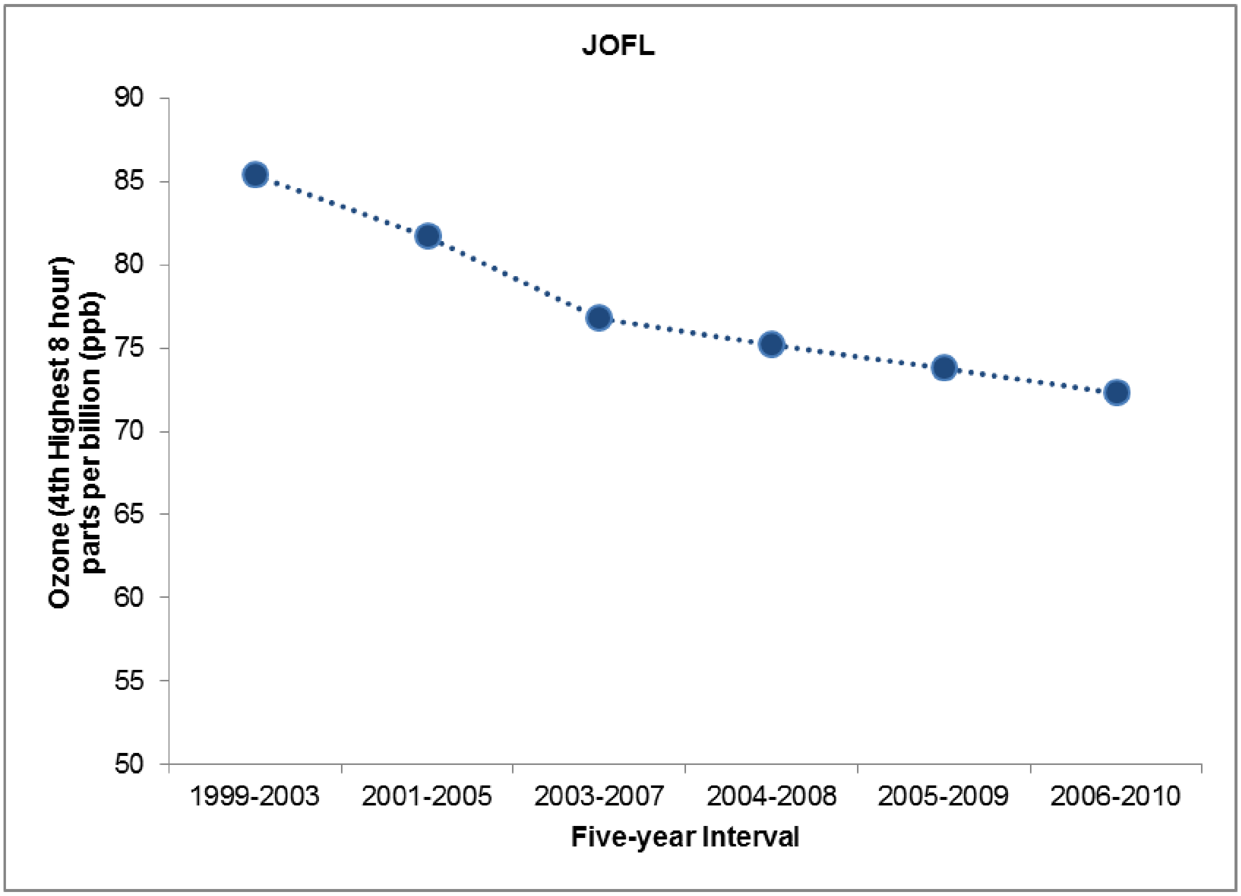


Figure 20. Five-year estimates of ozone concentration over an approximate 10-year period for JOFL derived from interpolations of 4th-highest daily maximum 8-hour ozone concentrations (NPS-ARD).

ERMN's risk assessment of ozone-induced foliar injury to sensitive plant species at JOFL 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). The Sum06 threshold for injury was consistently satisfied, and the W126 index criteria were generally fulfilled. Although exposure levels exceeded the thresholds for foliar injury in certain years, moisture conditions during these periods included three to four months of mild to severe drought. Ozone uptake during moderate to severe drought conditions is significantly diminished; thus, the risk of foliar injury is greatly reduced, despite high levels of exposure (Table 9; NPS-ERMN 2004).

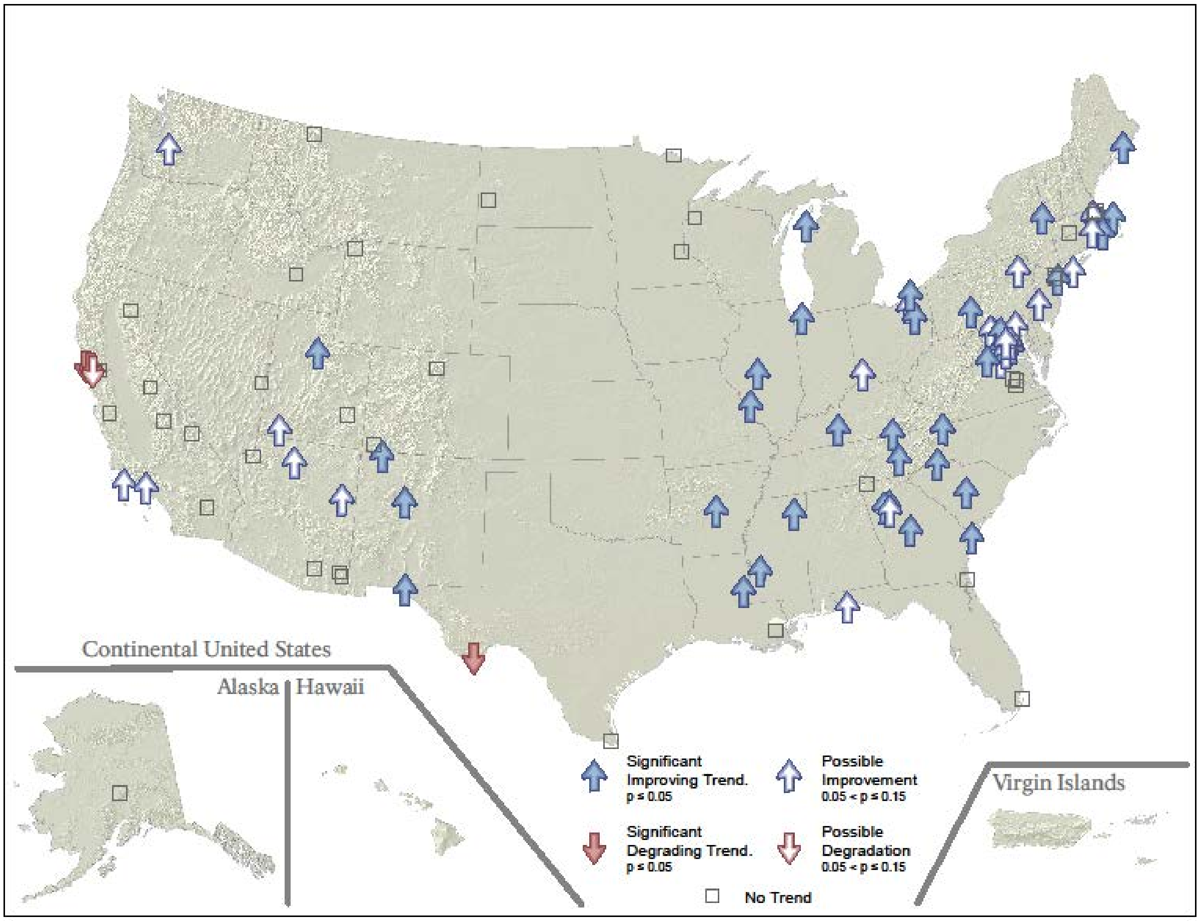


Figure 21. Trends in annual 4th-highest 8-hour ozone concentration, 2000-2009 (NPS ARD 2013a).

Data Gaps and Confidence in Assessment

Confidence in the current assessment was *medium* for JOFL, 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.

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 impairment of visibility is contributed to sulfate particulates (~60 – 90% visibility reduction) (Malm 1999). Emissions from the burning of coal in electric boilers accounts for a majority of the production of sulfate particulates (National Research Council 1993).

In response to the Clean Air Act (1977), NPS and USEPA started a visibility monitoring program in 1985 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 JOFL, are not required to meet this visibility mandate. However, JOFL can benefit from regional reductions goals of sulfates set by this visibility mandate. Given the small size of the park and its proximity to urban areas, managers are limited in their ability to control visibility levels in the park, but managers 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 110 km from JOFL in Arendtsville, PA (Table 7, Figure 19). These interpolated values (available at www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.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 10). 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 2013a).

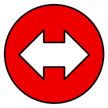
Reference Condition

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 JOFL warranting *significant concern* (Table 10). 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 22).

Table 10. JOFL condition assessment results for visibility based on NPS ARD 5-Year Interpolated Visibility Values for JOFL.

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		

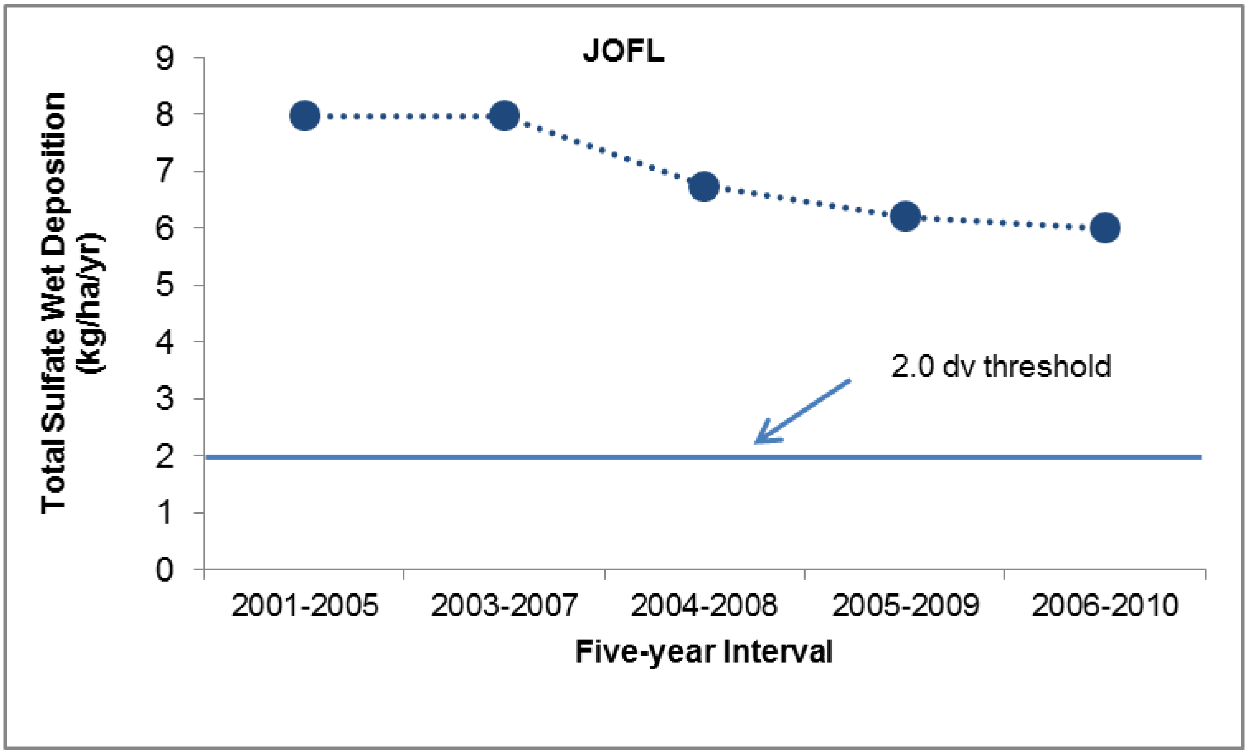


Figure 22. Five-year estimates in haze index (dv) for JOFL (NPS-ARD 2011).

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 23 and 24). Continued improvement is expected in the eastern US with further reduction in sulfur dioxide and nitrogen oxide emissions (NPS-ARD 2010).

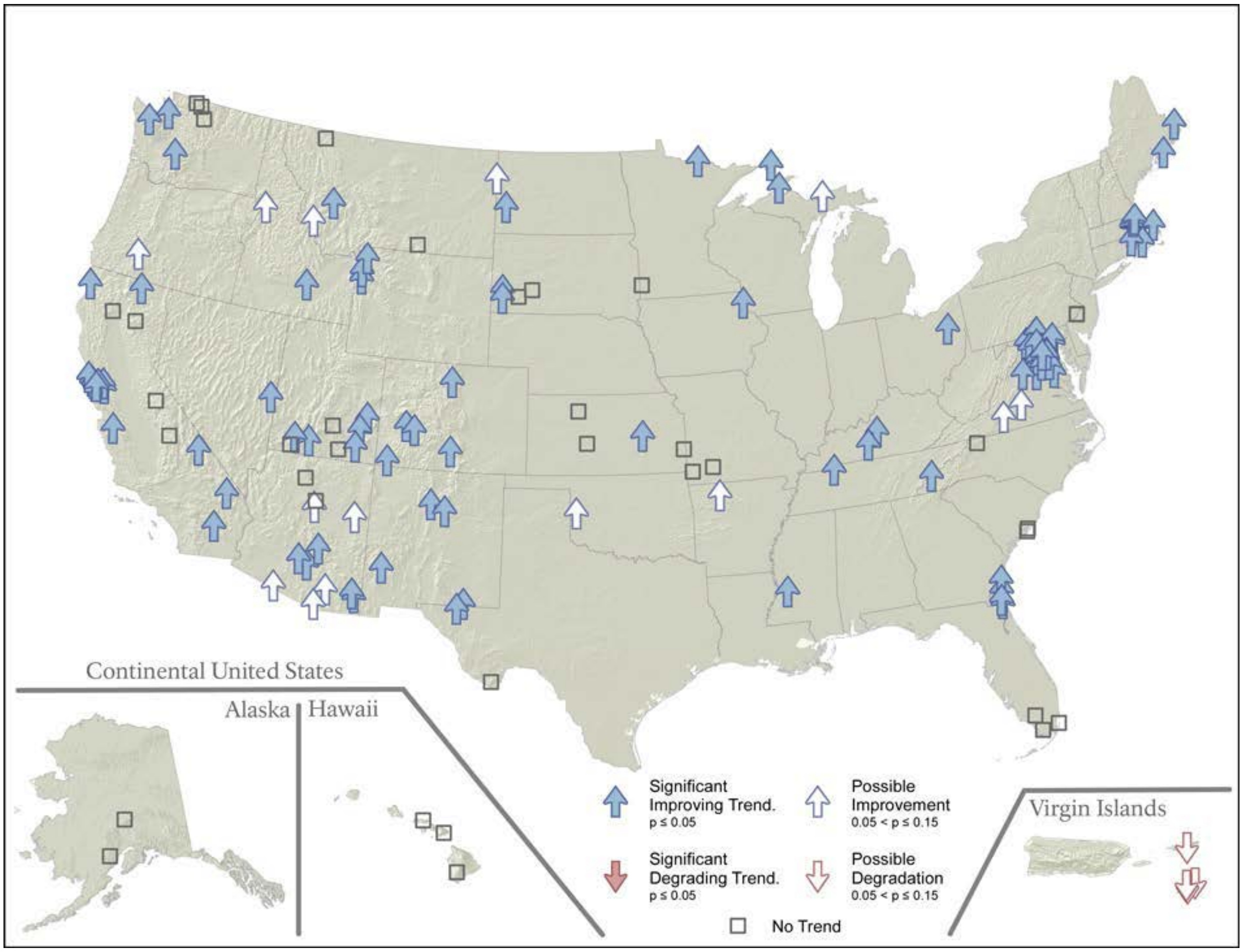


Figure 23. Trends in haze index (dv) on clearest days, 2000 – 2009 (NPS-ARD 2013a).

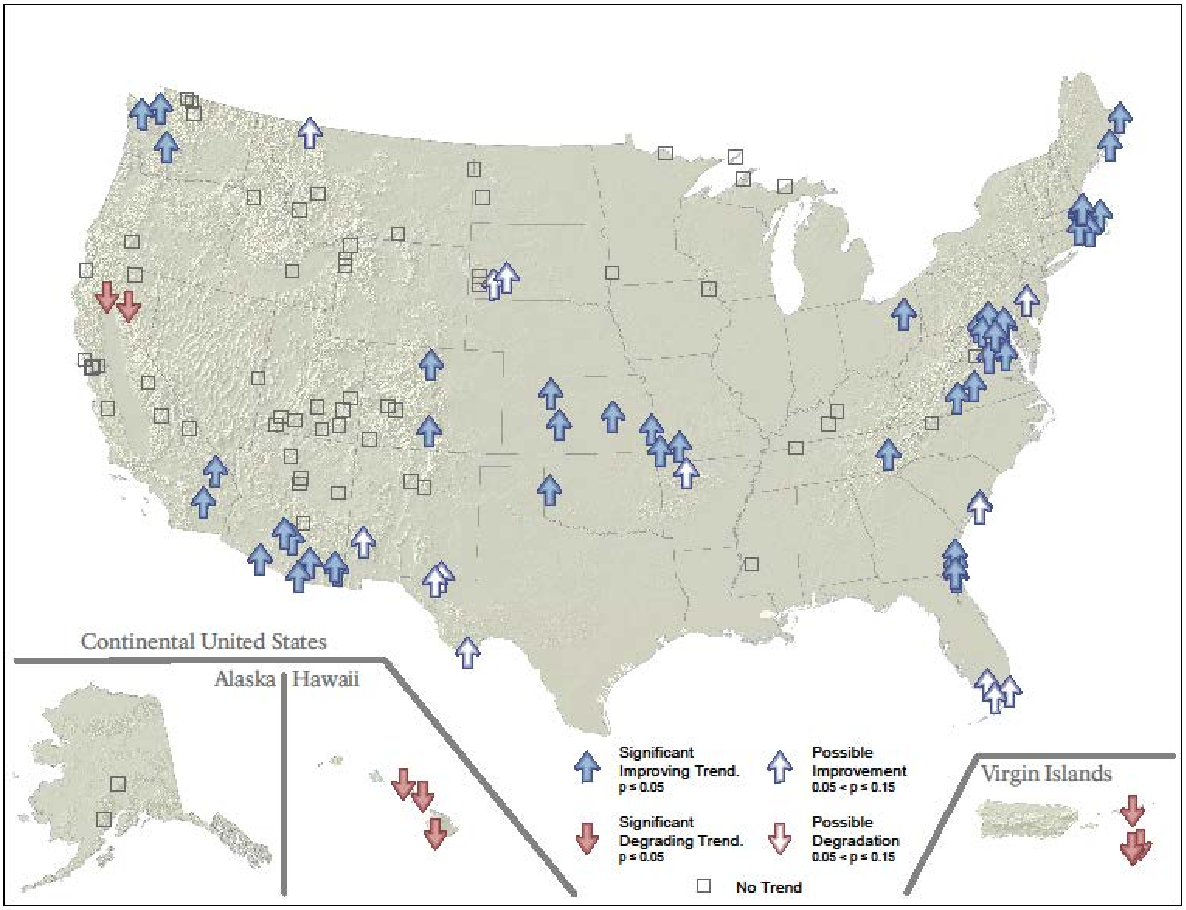


Figure 24. Trends in haze index (dv) on haziest days, 2000-2009 (NPS-ARD 2013a).

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. The current location of IMPROVE monitors is within at least 185 km of the park; thus, our confidence in the current assessment as *medium.*

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 2010a).

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 available nutrients 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 one of the most acid-sensitive species. 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 occurring 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 (i.e. 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 2010a). Factors influencing ecosystem 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 Northeastern United States 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). The history of mining and the legacy of acidic AMD in the JOFL region likely exacerbate negative effects of acidic wet deposition on water quality and aquatic biota. The SFLCR is severely impaired by AMD from upstream sources (Figure 8). It is likely that acidic wet deposition further lowers the ANC and pH of these waters, making water quality even less suitable for aquatic life; however, it is beyond the scope of this synthesis to determine effects of acidic wet deposition on waters already impaired by AMD. Nonetheless, we acknowledge that addressing this question may be critical for effective remediation of the contamination within the SFLCR and its tributaries.

Methods

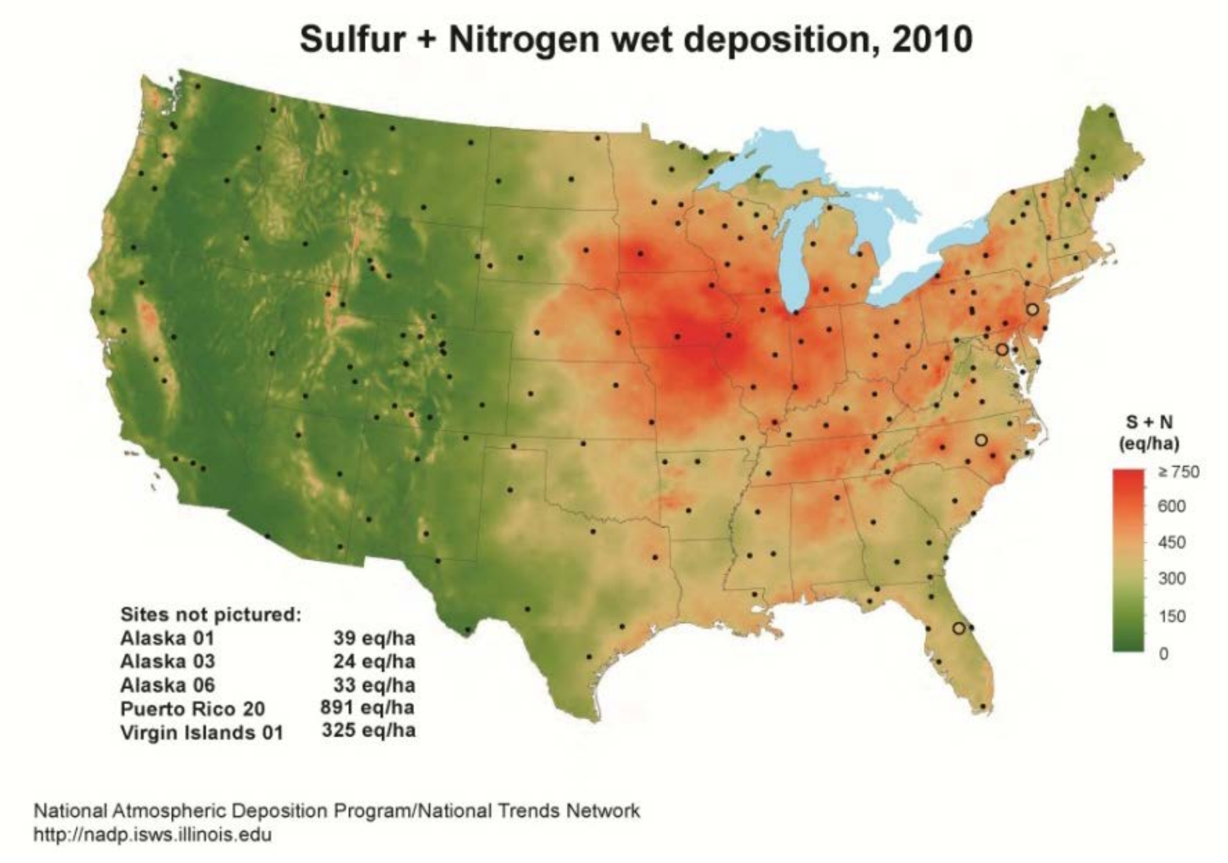
The NPS-ARD uses monitoring data collected from the National Atmospheric Deposition Program/ National Trends Network (NADP /NTN) to estimate wet deposition (N and S) for all parks within the network. The deposition measures are determined by estimating the contribution of nitrogen from both ammonium (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 19). There are several NADP/NTN monitoring sites near JOFL, including one monitoring station (PA-13) located nearby at Allegheny Portage Railroad National Historic Site (ALPO) (Figure 19). Since the PA-13 station was not part of the NADP/NTN until mid-2011, results from this station are not reflected in the NPS-ARD air estimate tables. Thus, we chose to report results for PA-13 separately. We obtained wet deposition data and results for 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, which PA-13 has been a part of since January 7, 1997. From this data, estimates for both S and N were calculated and compared with the surrounding site full records (i.e., air quality estimates) (D. Gay, pers. comm.). 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 station PA-13 separately and used the latter to report trends, since the station is located within 10 km of JOFL.

Conditions of atmospheric deposition are based on wet deposition only, because dry deposition is not available for most areas (http://www.nature.nps.gov/air/who/npsPerfMeasures.cfm). Although 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), 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).

In addition, we summarized the results from the NPS-ARD sensitivity reports, which evaluated the sensitivity of JOFL'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).

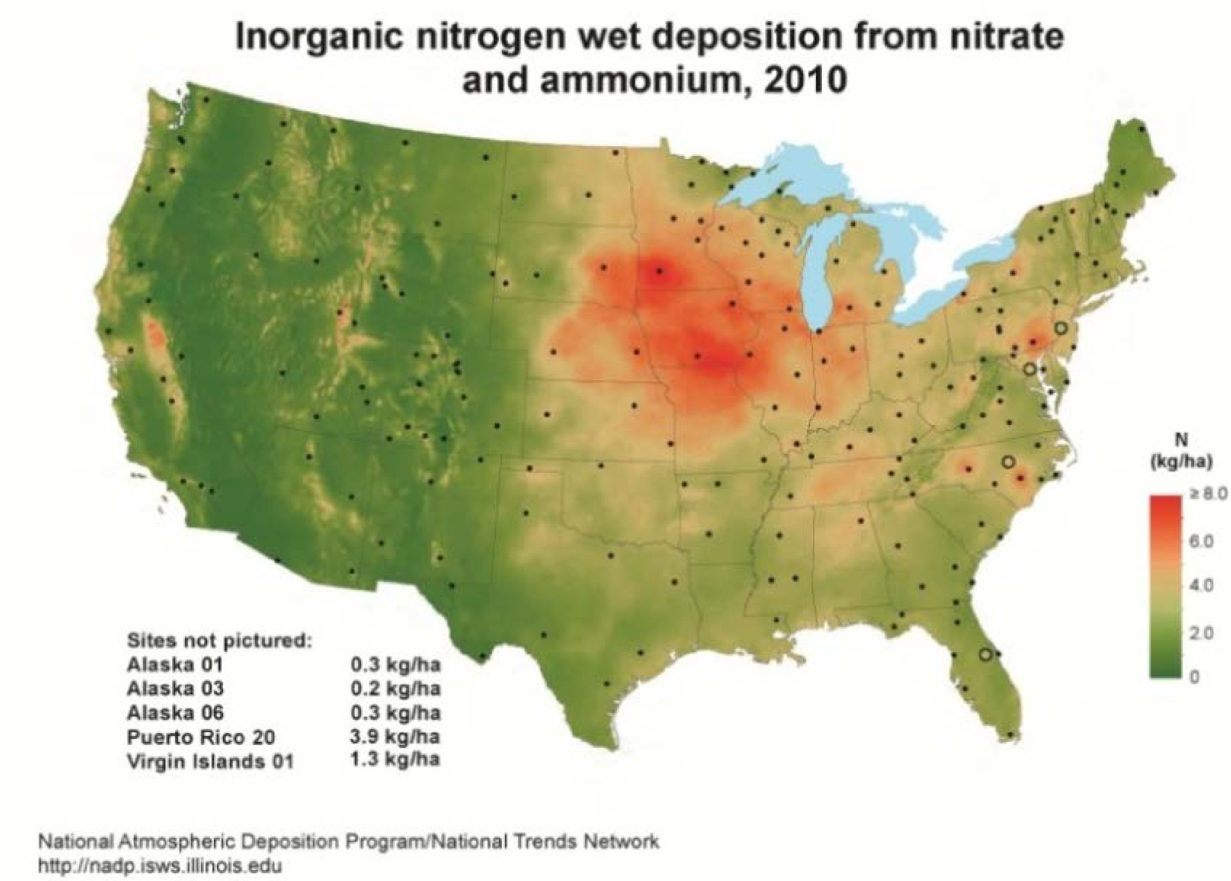
Reference Condition

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 25).



a.)

Figure 25. Sulfur and nitrogen wet deposition (a) and total inorganic nitrogen deposition (b) for the United States in 2010.



b)

Figure 25 (cont'd). 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 (located 10 km northeast of JOFL) were well above the threshold of 1.0 kg/ha/yr but appear to have decreased in recent years (Figure 26).

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 27). 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 28). The five year averages for both sulfur (red square) and nitrogen (blue square) determined from the PA-13 data displayed in Figure 26 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 surrounding PA-13 (including JOFL) receives greater wet deposition of nitrogen and sulfur than the estimated average for the region.

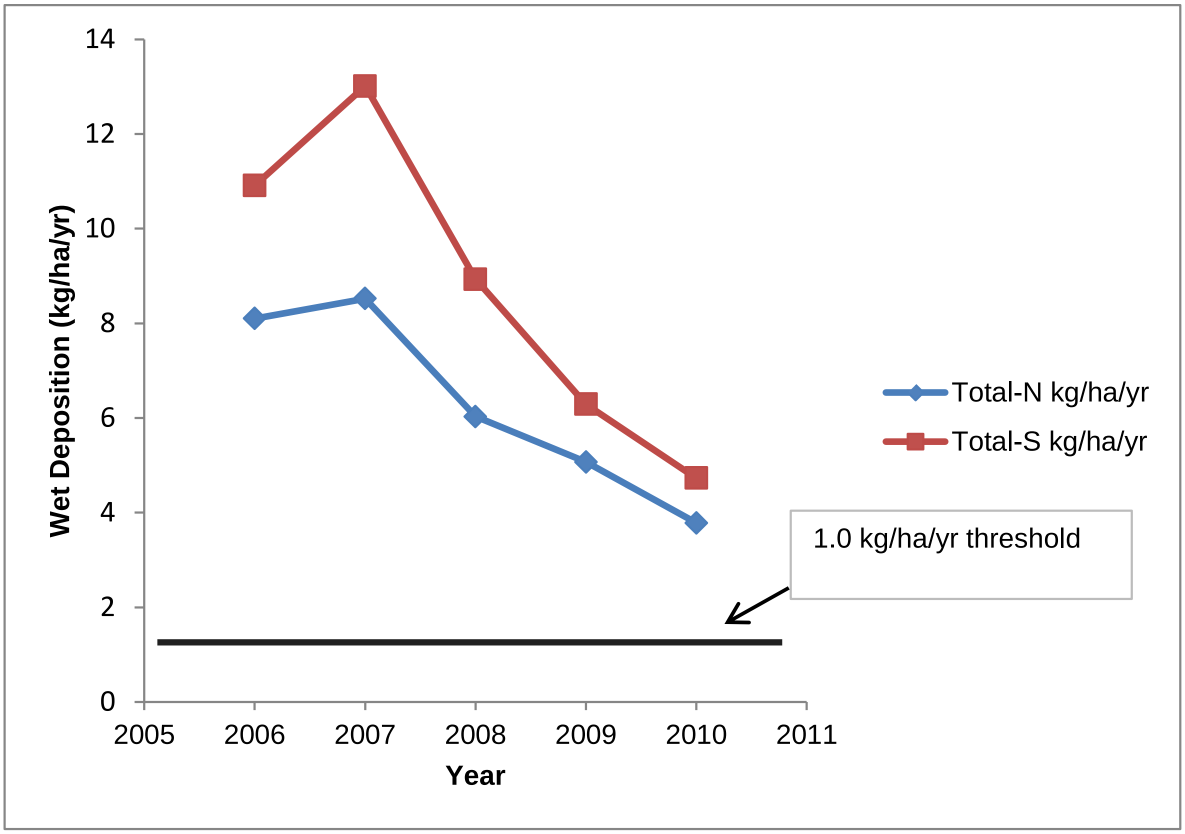
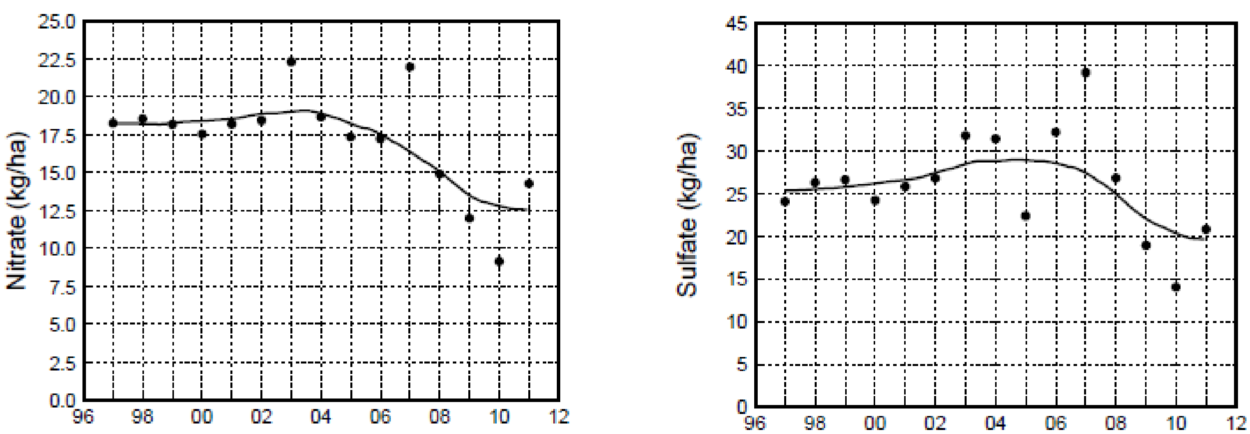


Figure 26. Total wet deposition of sulfur and nitrogen per year measured at the PA-13 station from 2006 through 2010. The black line represents the threshold above which may cause harm. Data was used to determine the five-year average for PA-13 in Figure 30.



a.) b.)

Figure 27. Smoothed line trends in annual wet atmospheric deposition for nitrate (a) and sulfate (b) from 1997 – 2011 at station PA-13 located near JOFL. Courtesy of Boyer Water Quality Lab at Penn State University and the Pennsylvania Department of Environmental Protection.

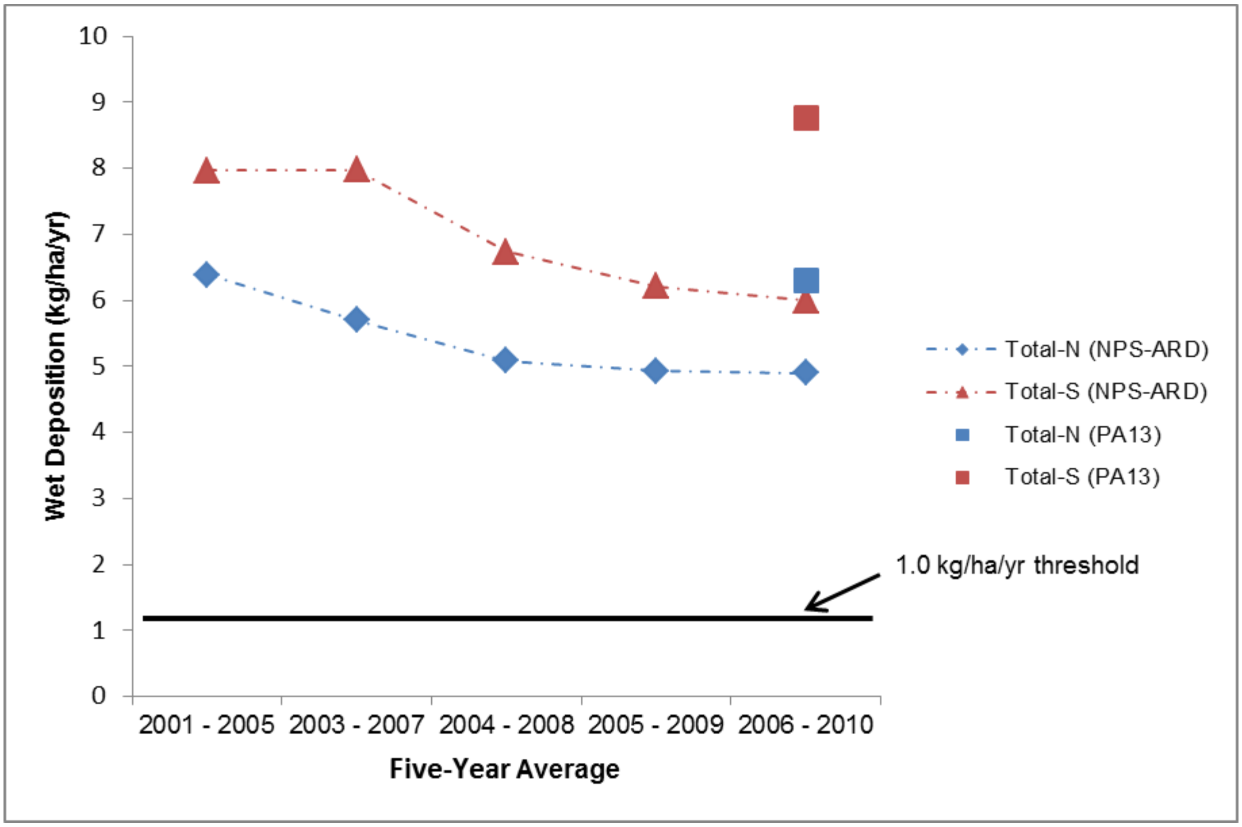
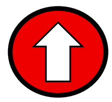
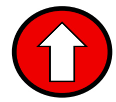


Figure 28. Five-year averages for total nitrogen and sulfur deposition in precipitation (wet deposition) from the surrounding site full records (NPS-ARD). The latest five-year average (2006 – 2010) from the yearly measured PA-13 data presented in Figure 25 is added for comparison. The latter is provided 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 11), which used the most recent five-year averages from both the NPS-ARD estimate and the PA-13 measured data (Figures 26 and 28). 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 11). 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 11. JOFL condition assessment results for nitrogen and sulfur wet deposition using NPS ARD 5-Year interpolated Sulfur and Nitrogen Wet Deposition Values and PA13 data. 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	4.9	6.3		1 - 3	6.0	8.77	
Significant Concern	> 3				> 3			

Results for the acidification risk assessment for JOFL were similar to those for the other parks in the ERMN. Both the park and network were perceived to be at very high risk for pollutant exposure and ecosystem sensitivity (Table 12). According to Sullivan et al. 2011(b), annual S and N emissions for Cambria County ranged from greater than 1 and up to 20 tons per square mile with a number of nearby western counties showing total S emissions greater than 50 and up to 939 tons per square mile and N emissions greater than 5 and 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 10 – 15 kg/ha/yr. Land cover types within the park were a mix of forest and pasture/hay surrounded by developed areas. Watershed slope for the park was in the 10° and 20° 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 JOFL 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.

The perceived risk for nutrient enrichment was higher for JOFL 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 moderate and very low, respectively, due to a lack of high elevation lakes and limited coverage of sensitive vegetation types.

Table 12. Results for the acidification risk assessment for the ERMN and JOFL. 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
JOFL	VERY HIGH	VERY HIGH	MODERATE	VERY HIGH	VERY HIGH	MODERATE	MODERATE	HIGH

Data Gaps and Confidence in Assessment

Confidence in the quality of the site assessment (PA-13) is *high*, and 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 *medium*, 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.

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 USEPA 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 JOFL 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 wetland area within the park. Thus, we believe that mercury deposition is an important indicator of air quality condition to monitor within the park. Sulfates in acidic wet deposition can increase mercury concentrations, methylation and biotic uptake. However, an analysis of these potential effects was determined during the planning phase to be beyond the scope of this synthesis with specific regard to how mercury deposition affects water quality and aquatic life within the SFLCR, the two moderately impaired unnamed tributaries, their associated wetland habitats, and the terrestrial flora and fauna associated with these ecosystems at JOFL.

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 10 km northeast of JOFL at ALPO.

Figure 29 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 JOFL 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).

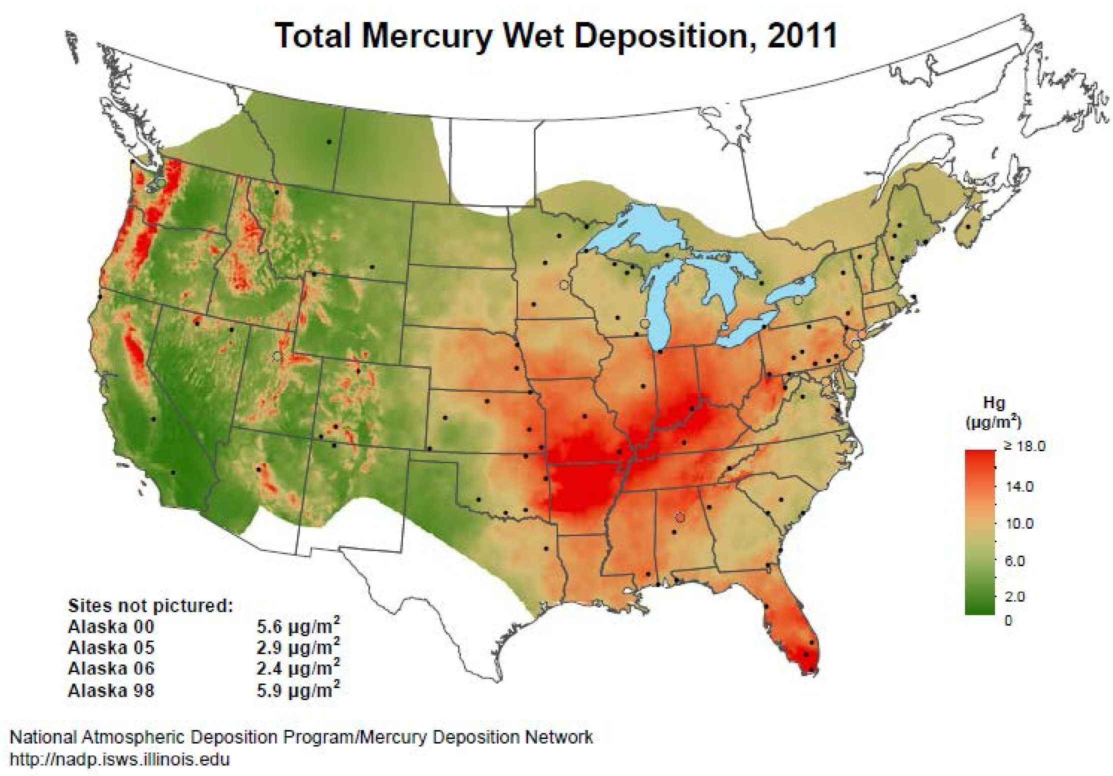


Figure 29. Total wet deposition of mercury in 2011. Source: NADP.

Method

The Pennsylvania Department of Environmental Protection in cooperation with NPS has been monitoring mercury wet deposition at station PA-13 since 1997. Due to the proximity of this station to JOFL, we present results from PA-13 to estimate condition of mercury deposition at JOFL. The

PA-13 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.

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 30).

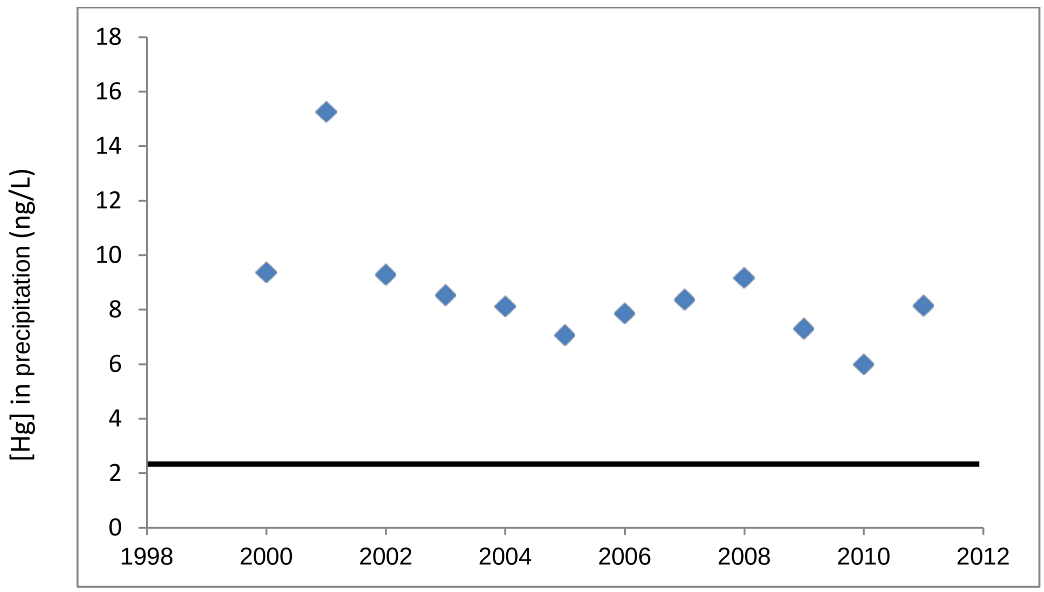
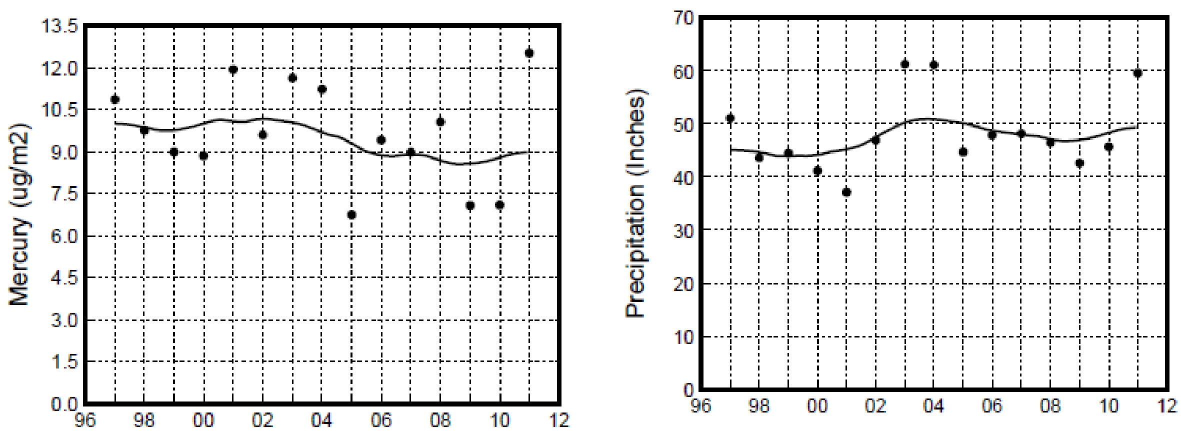


Figure 30. Annual volume-weighted total mercury concentrations (ng/L) in precipitation for PA-13 monitoring site (2000 – 2011). The line represents the indirect regulatory threshold of 2 ng/L modeled by Meili et al. (2003) for MeHg fish concentrations.

The total annual (a) wet mercury deposition and (b) precipitation measurements collected from PA-13 during the monitoring period (1997 – 2011) (Figure 31), as well as changes in mercury ion concentration and the long-term trends from 1997 – 2011 (Figure 32) 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 32) but no significant decrease in mercury wet deposition (Figure 33). 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 31a).



a) b)

Figure 31. Annual (a) wet mercury deposition and (b) precipitation for the PA-13 MDN site in Cambria County, Pennsylvania from 1997 – 2011 (Boyer et al. 2010).

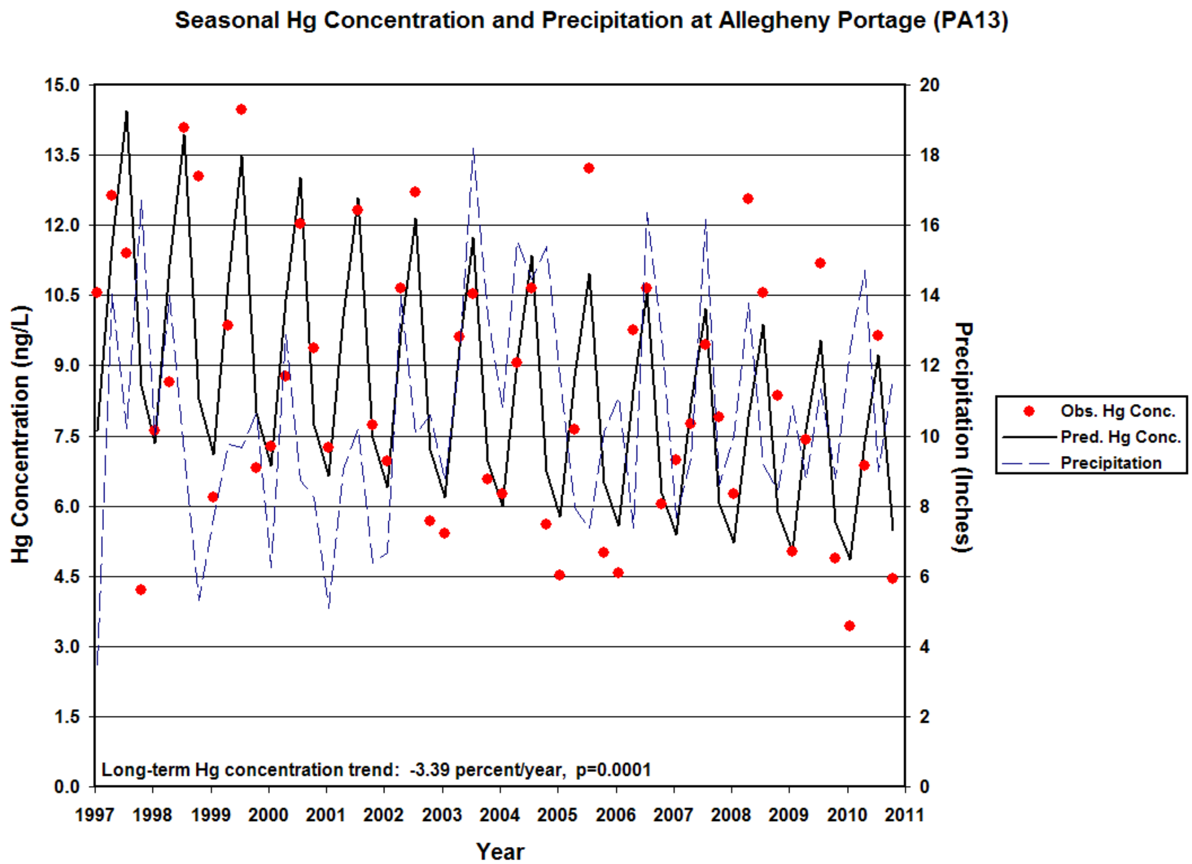


Figure 32. Seasonal trends in total mercury concentrations at the PA-13 MDN site in Cambria County, Pennsylvania from 1997 through 2010. A standard linear trend model reveals significant decrease in total mercury concentration (Boyer et al. 2010).

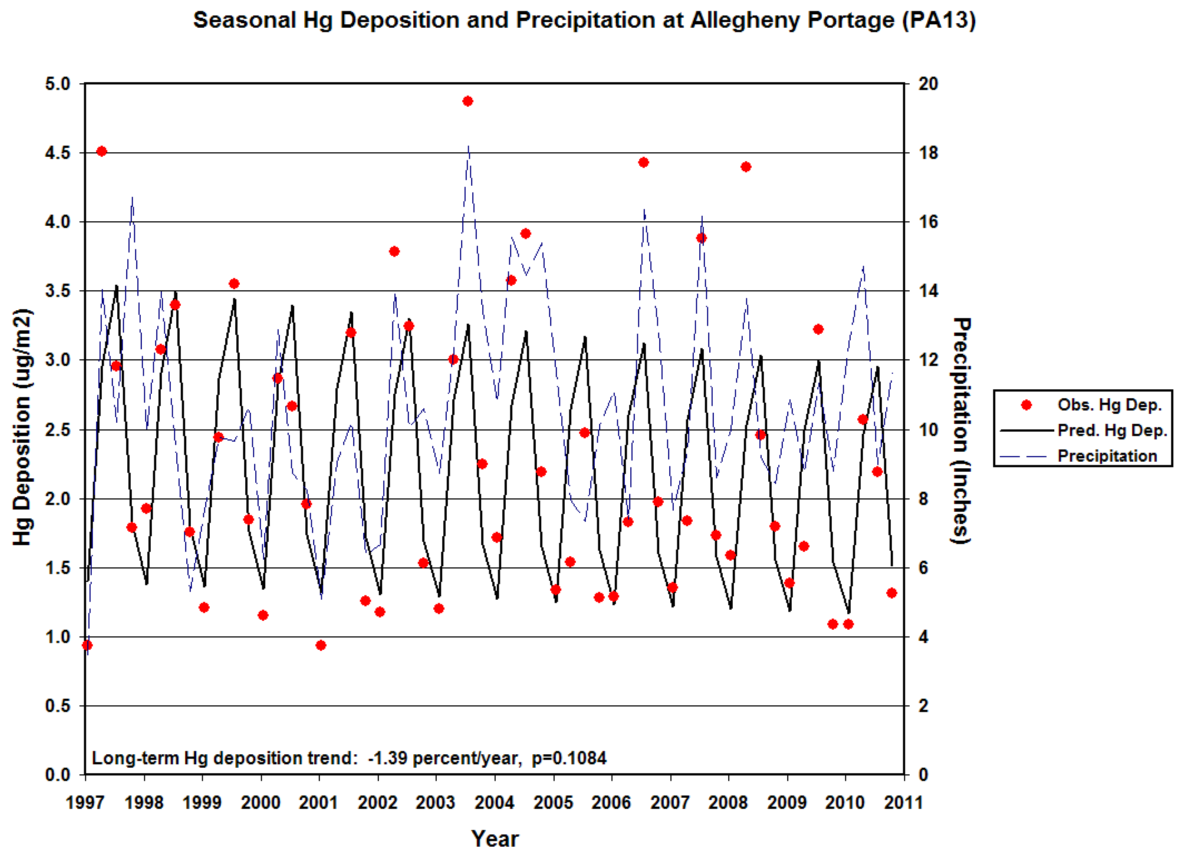
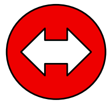


Figure 33. Seasonal trends in total mercury wet deposition and precipitation at the PA-13 MDN site in Cambria County, Pennsylvania from 1997 through 2010. A standard linear trend model reveals no significant change in mercury wet deposition (Boyer et al. 2010).

The current condition (2011 estimate) for wet mercury deposition at PA-13 is 8.55 ng/L, well above the indirect regulatory mean annual threshold of 2 ng/L in rain water (Table 13). This resulted in 0% attainment of reference condition and warrants *significant concern* for JOFL. Although the total mercury concentration declined from 1997 through 2010 (Figure 32), mercury wet deposition did not show a declining trend (Figure 33). Thus, we reported the trend as unchanging (Table 13).

Table 13. JOFL condition assessment for mercury wet deposition from measured data at the PA-13 monitoring site located 10 km northeast of JOFL.

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

These results differ somewhat from the NPS-ARD's 2009 Annual Progress Report (NPS-ARD 2013a), which reported a significant improving trend for wet mercury deposition at PA-13 for 2000-2009 (slope = -0.23, p = 0.04).

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 mercury deposition) from 2007 – 2009 was 62% (Risch et al. 2012).

<u>Data Gaps and Confidence in Assessment</u>
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). As previously described, sulfates from acidic wet deposition can increase mercury concentrations, methylation, and biotic uptake. Although there were declining concentrations in the acidic deposition of nitrogen and sulfur (Table 11) there was no discernable trend in the mercury deposition (Table 13) and both indicators were of significant concern at JOFL. But it is beyond the scope of this synthesis to extrapolate indirect or direct impacts of mercury deposition as they relate to the environment, biota, forested landscapes, streams, or wetlands at JOFL.

Night Skies

<u>Relevance and Context</u>
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 34). Consequently, managing for dark skies can be difficult for a small park located near urban areas (Figure 34).

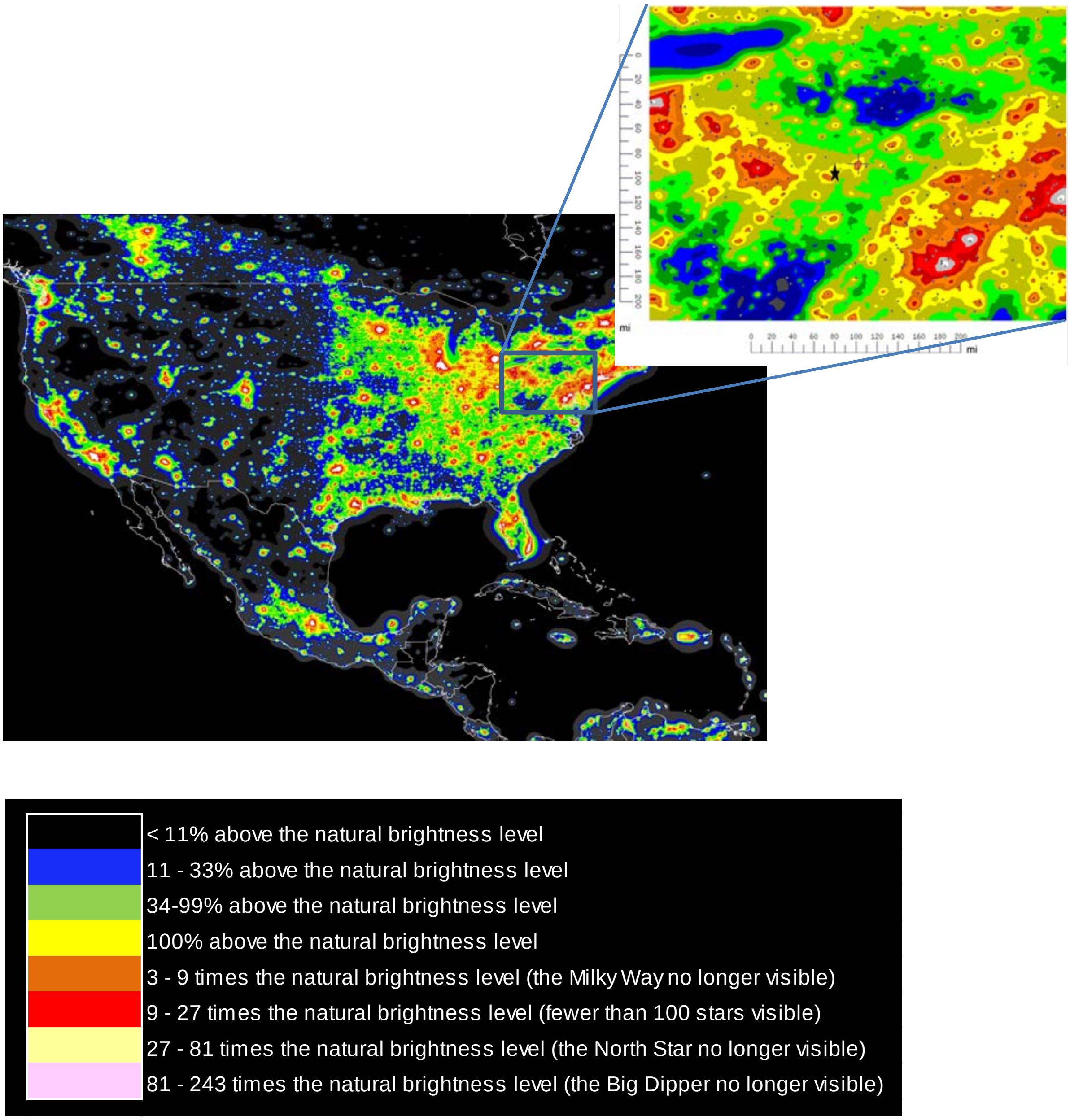


Figure 34. Artificial night sky brightness at sea level showing levels of pollution in the atmosphere for North America. The map is based on upward light measured by the Defense Meteorological Satellite Program after accounting for propagation and scattering of that light in the atmosphere. Inset is 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 location of JOFL is represented by the black star. 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).

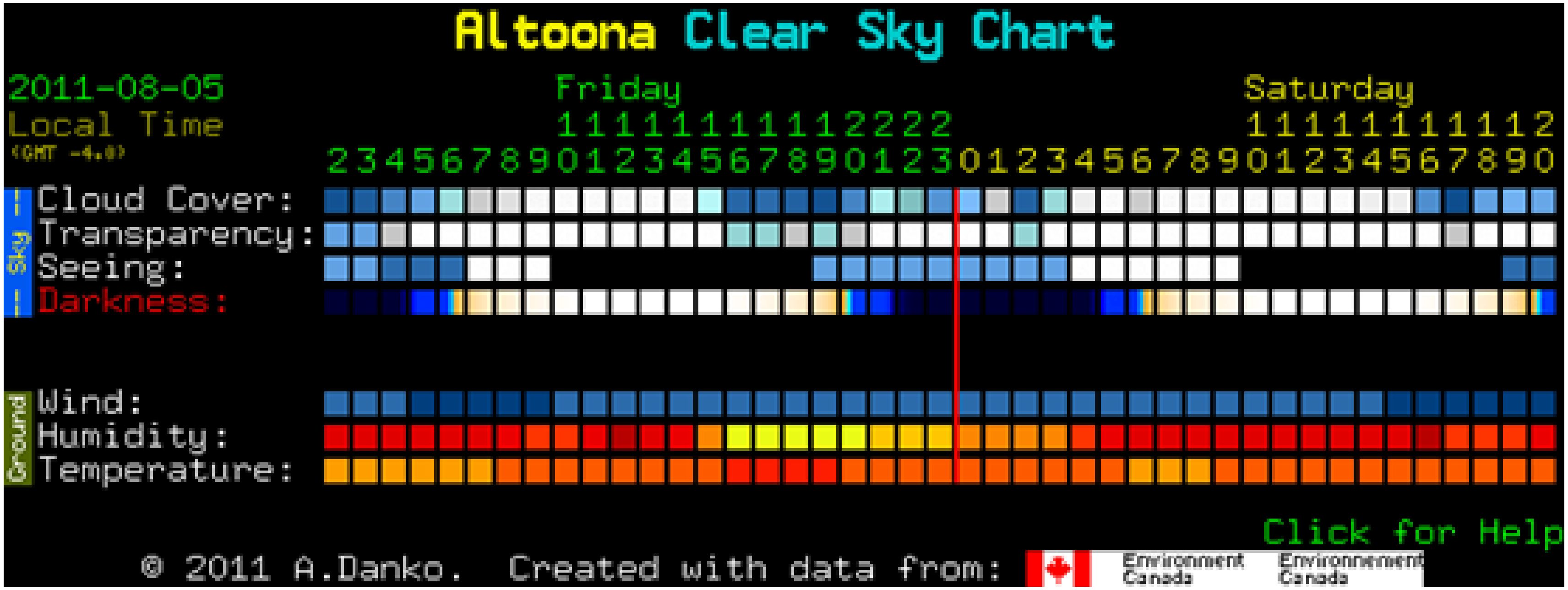
The NPS monitors light pollution at many of its parks, most of which are located in the western half of North America. Using a research grade digital camera attached to a robotic mount and laptop computer, background brightness levels are recorded individually and joined together to form a panorama of 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 JOFL 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 14). 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 35).

Table 14. 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.



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 35. 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.

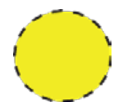
Reference Condition

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 34), JOFL lies within the yellow area, which approximates areas where light pollution is visible in various directions over the horizon and the Milky Way is still visible but lacks detail. This would correspond to a 4 on the Bortle scale (Table 14). Thus, we rated the condition of dark skies for JOFL as warranting *moderate concern* (Table 15).

Table 15. JOFL 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 4	
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.

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. Understanding and preserving the park's acoustical environment and soundscapes is relevant to park management objectives by "providing visitors a range of recreational opportunities….without impairing natural or cultural resource values or the atmosphere of quiet contemplation" (NPS 1993). The natural soundscape is composed of both physical (e.g., wind, flowing water) and biological (e.g., bird calls) sounds: the rushing waters of the South Fork Little Conemaugh River; the sounds of birds singing in the shrublands; 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. Minimal noise is also important to achieving the contemplative experience the Memorial wishes to convey to its visitors. 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 JOFL. 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 busy highways and roads (Interstate Route 219 is to the north of JOFL while State Route 869 is to the south), 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 JOFL, 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 JOFL. McCusker and Cahill (2009-2010) provide some examples of desired condition, possible indicators and target values for soundscapes, which we’ve adapted for JOFL (Table 16).

Table 16. Possible condition metrics to use for soundscape monitoring at JOFL.

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 but non-natural sounds should be minimized to promote the quiet, contemplative atmosphere the Memorial wishes to convey to visitors	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/

Natural Sounds and Night Skies Division, National Park Service http://www.nature.nps.gov/sound_night/index.cfm

Natural Sounds and Night Skies Division, National Park Service; http://www.nature.nps.gov/sound_night/index.cfm

Weather and Climate

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 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). There were declining concentrations in the acidic deposition of nitrogen and sulfur (Table 11) but there was no discernable trend in the mercury deposition (Table 13). Both indicators were of significant concern at JOFL. So, it is beyond the scope of this synthesis to determine whether such offsets are occurring at JOFL, especially in the severely impaired waters of the SFLCR and the two moderately impaired unnamed tributaries flowing through JOFL.

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 17) (Marshall et al. 2012).

Table 17. 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 36). This station is part of the National Weather Service Cooperative Observer Program (COOP) and was selected as the nearest location with both a high quality data set and a long-term data record (February 1964 to present) that was most representative of park conditions. 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). Other nearby locations with weather data, including the Johnstown Airport and Dunlo, provided either incomplete or smaller data sets and were not used for weather and climate analysis at JOFL. Figure 36 shows the location of the EB STP station in relation to the park.

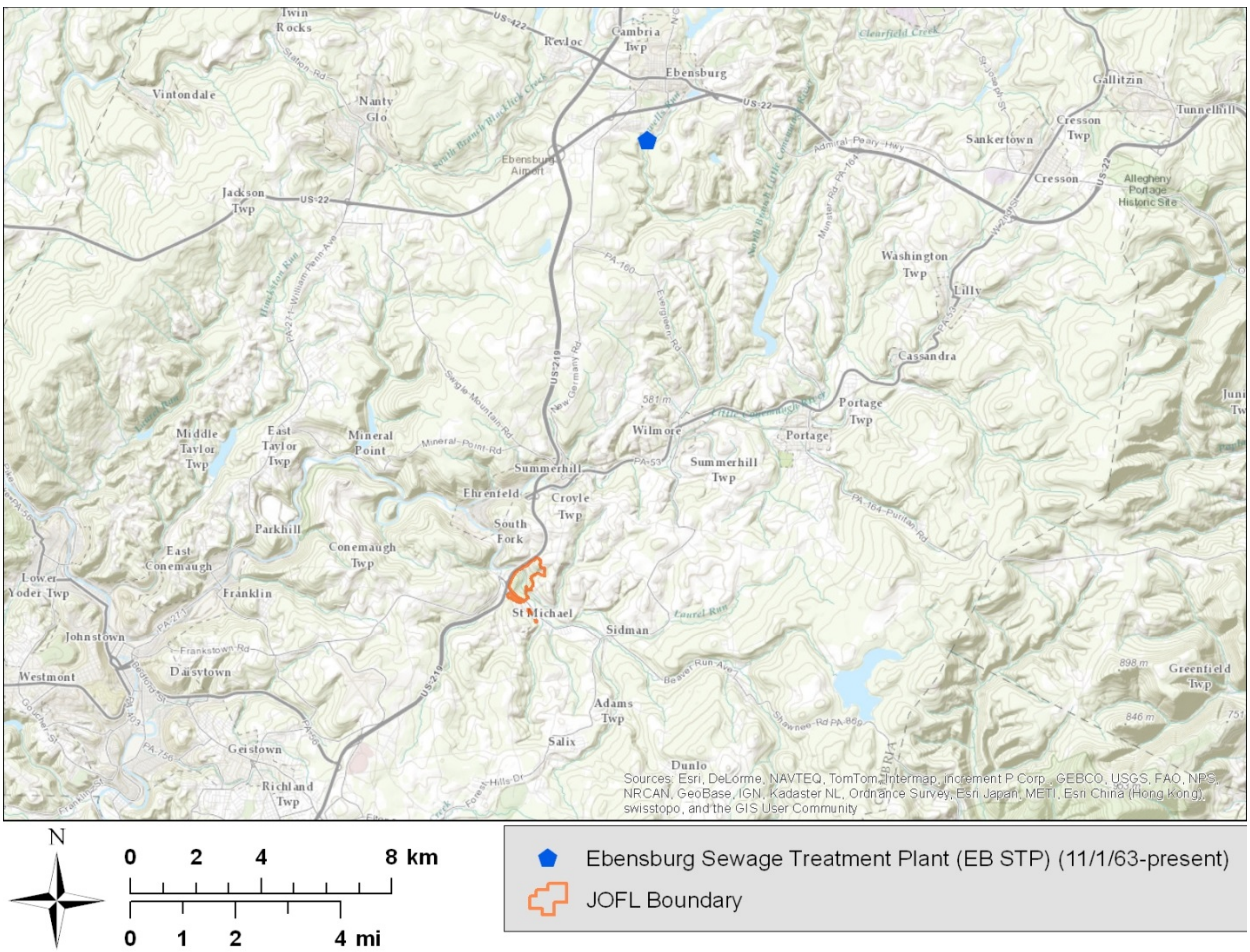


Figure 36. Location of the Ebensburg Sewage Treatment Plant (EB STP) in relation to JOFL. Long-term precipitation and temperature data are available from this station from November, 1963 to present.

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 17). 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 (1965 – 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 (Arguez 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 1965 instead of 1961 as the first year of the earliest climatological normal because it was the first year with a complete data set at EB STP. 2010 was selected to represent current weather conditions 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.

Trends

Table 18 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 37.

Table 18. 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).

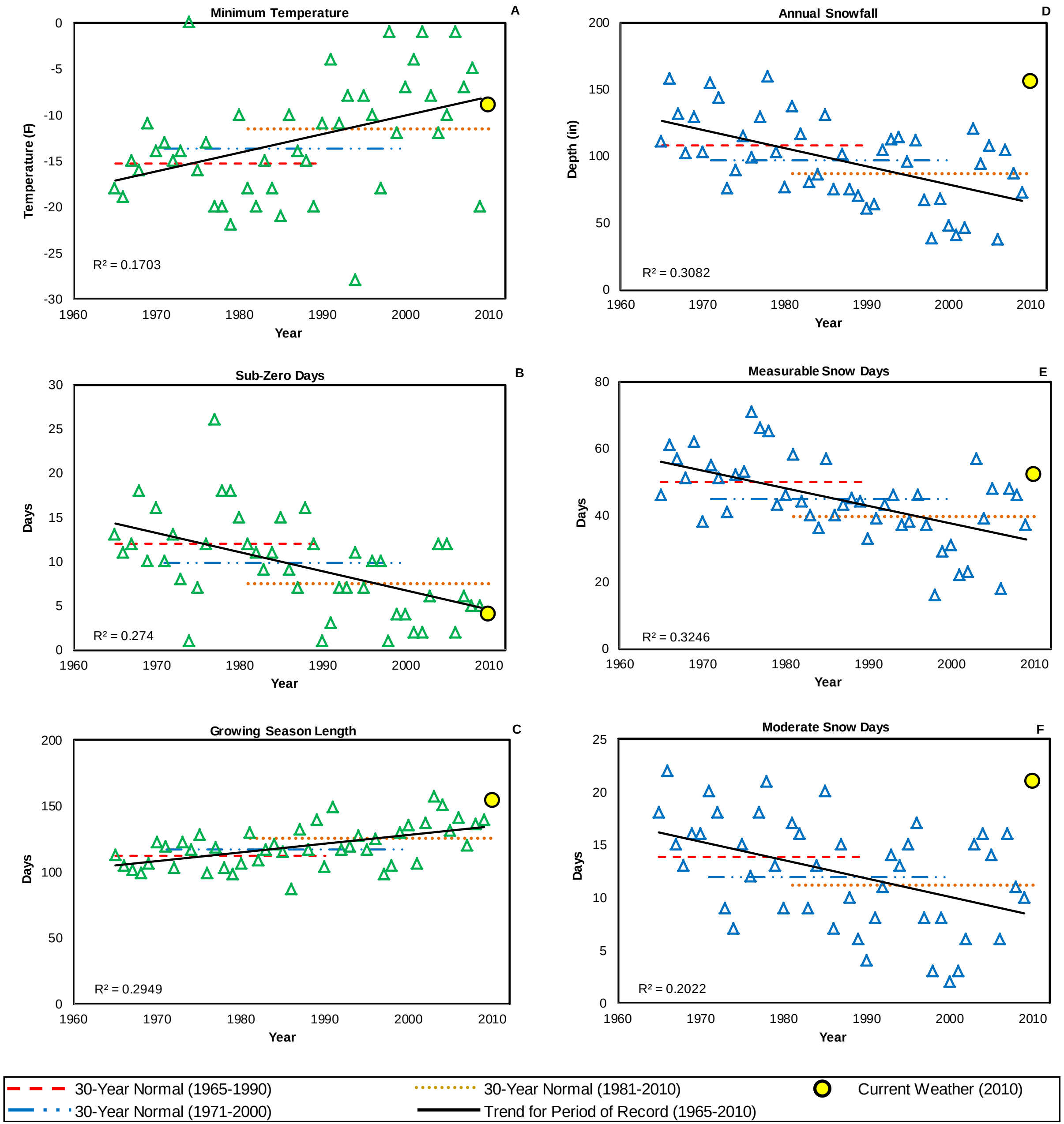


Figure 37. Graphs depicting changes in Minimum Temperature, Sub-Zero Days, Growing Season Length, Annual Snow Fall, Measurable Snow Days and Moderate Snow Days between the current year (2010), each 30-year normal period, and the entire period of record (1965-2010).

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 18, 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 the last 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.

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 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).

Downstream view of South Fork Little Conemaugh River near the dam breast at JOFL. Photo by S. Yetter.

Watershed Characteristics

The main water resource at JOFL is the South Fork Little Conemaugh River (SFLCR) which bisects the park. Several small tributaries join the river from the east and flow through park property (Figure 38). The SFLCR flows into the Little Conemaugh River near the town of South Fork, and then joins with Stonycreek River to form the Conemaugh River at Johnstown, then to the Kiskiminetas, Allegheny and Ohio Rivers. JOFL is located two miles upstream of the SFLCR confluence with the Little Conemaugh River. The drainage area of the streams running through the park is quite large (~ 165.8 sq km [64 sq miles]) and there are 195 km [121 miles] of streams (Figure 38). Most of this area is woodland, but abandoned mine lands occur throughout the watershed, mostly to the south and east of the park, as well as scattered agricultural and urban lands. The SFLCR is believed to be severely impaired by AMD originating from upstream sources (Figure 10) (Sheeder and Tzilkowski 2006). Within the park, three small unnamed tributaries join the SFLCR mainstem. Two of the three unnamed tributaries sampled by Sheeder and Tzilkowski (2006) were moderately impaired but the source of pollution remains unconfirmed.

Water Quality Threats and Designated Uses

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.

Although several of the upstream portions of the SFLCR watershed have been designated High Quality Cold Water Fishes (HQCWF) or Exceptional Value (EV) due to excellent water quality, water supply, and/or Class A native brook trout fishery, the designations of many lower reaches, including at JOFL were lowered to Cold Water Fishes (CWF) due to impairment from coal refuse piles and discharges of AMD with high concentrations of iron and aluminum (files.dep.state.pa.us/Water/Watershed_Management/lib/watershedmgmt/nonpoint_source/wras/wras-18e.pdf, PADEP 2012) (Figure 38). For specific locations of mine drainage sources directly impacting the SFLCR upstream of JOFL, refer to Figure 10.

Once contaminated by AMD, polluted waters tend to remain contaminated for decades, unless treatments or re-mining of the source area are instituted. Addressing these impacts to water quality is beyond the park's ability to control. Mediation of these impacts, at least in the mainstem of the SFLCR, is not an option for park management. The recovery of the river is an ongoing project of federal, state, and private agencies. Fortunately, in December 2012, PADEP approved a remediation project to treat the Topper Run discharge at St. Michael (Figure 10) and requires the documentation of water quality improvements resulting from the treatment (Mellott 2012c). This project is still in the initial stages.

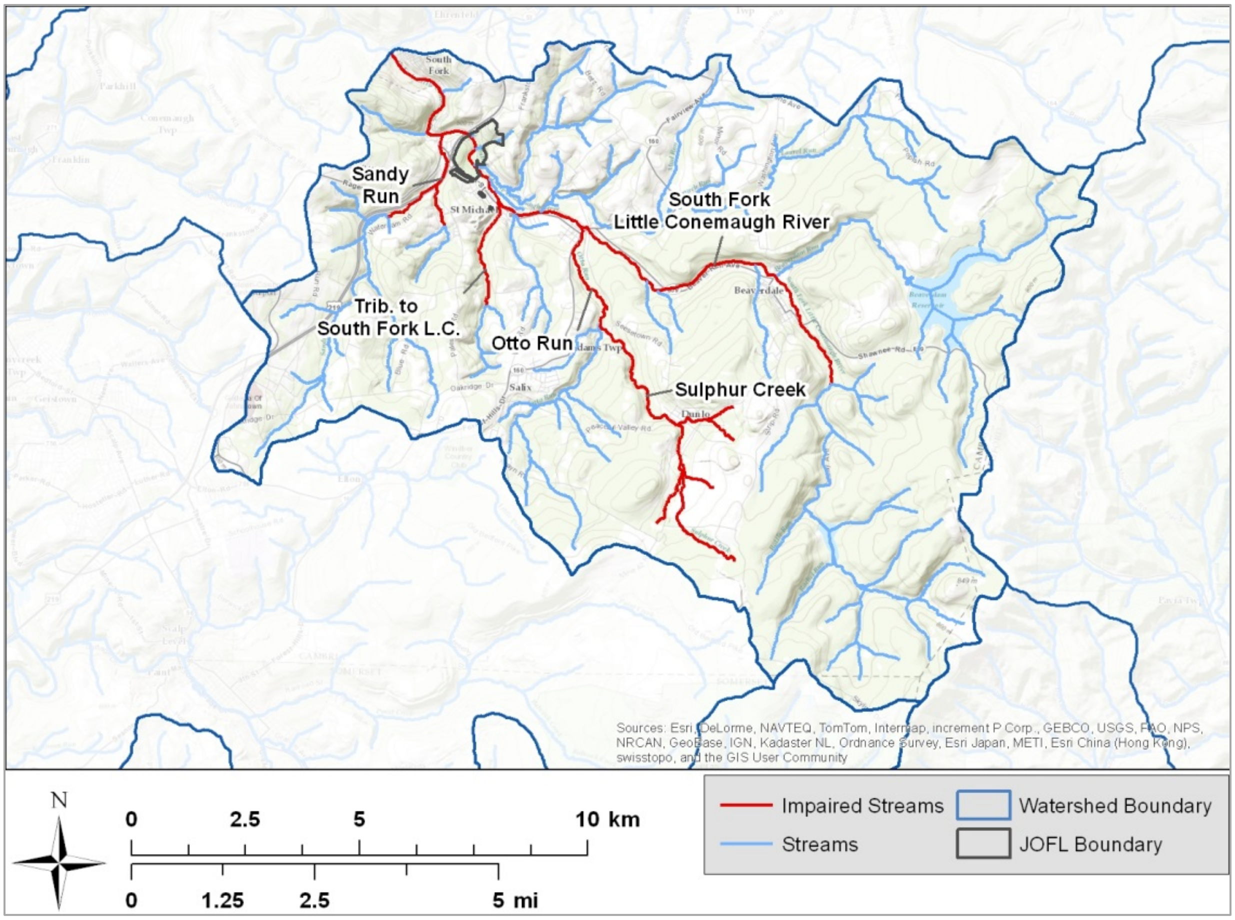


Figure 38. South Fork Little Conemaugh River (SFLCR) watershed showing JOFL boundary and location of impaired stream segments within the watershed (obtained from PASDA's Stream's Integrated List of Nonattaining Stream Segments published by PADEP Office of Water Management, July 2013).

Water Quality Studies at JOFL

Concern for possible adverse impacts from abandoned mine discharges and other stressors prompted several water quality studies at JOFL. The Water Resources Division of NPS prepared a detailed analysis of water quality based on existing data within and around JOFL (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. Much of this data is not considered relevant to water quality issues for JOFL, however, because 1) most, if not all, of the stations reported are located on streams that do not flow through the park or contribute flow to the park area, and 2) some of the monitoring data was quite old (e.g., 1926) and may refer to problems no longer in existence (Sheeder et al. 2004).

Two other water quality datasets were available for JOFL, but neither of these was used in the condition assessment due to uncertainties regarding sources, methods, and sampling locations (Table 19). The first consisted of data collected by the University of Pittsburgh at Johnstown (UPJ) during 1986 and 1987. Six monitoring stations were established but only one was within the park, most likely below the dam breast. Water quality results at the park location supported the 303d impairment listing. Mean pH levels (3.97) and mean conductivities (1002.75 µS/cm) both indicated impairment from mine discharge (Aluminum cations predominate at pH <4; elevated conductivity levels are often associated with high dissolved metal concentrations). The second dataset (collected at varying intervals from 1997 – 2001) represented a joint endeavor between park staff, the Stonycreek Conemaugh River Improvement Project (SCRIP), and the Alliance for Aquatic Resource Monitoring from Dickinson College (ALLARM). This data was also most likely collected at the dam breast near the trail intersection and indicated impairment by AMD (mean pH = 4.80, mean conductivity = 517 µS/cm).

To address the lack of water quality information within JOFL, a comprehensive survey of water chemistry (core and expanded parameters), benthic macroinvertebrates, and fishes was conducted by Pennsylvania State University in 2004 - 2005 (Sheeder and Tzilkowski 2006) and is referred to as the Level 1 Water Quality (WQ) Inventory. Five stations were selected for the assessment: two along the mainstem of the SFLCR and three located on unnamed tributaries within the park (Figure 39, Table 19). Biological sampling was not conducted on the mainstem of the SFLCR, because the water chemistry analysis confirmed severe impairment, most likely due to the upstream sources of AMD (Figure 10) flowing through JOFL. Elevated nutrient levels and high sodium concentrations were found in two of the tributaries, indicating impairment, possibly from upstream agricultural operations, highway proximity, and other land use disturbances, but the source of these pollutants is unconfirmed. All three tributaries had impaired biology, most likely due to habitat degradation and the severe impairment of the mainstem SFLCR, which would likely impede the recruitment and recolonization of the nearby tributaries. It is beyond the scope of this document to determine how acidic AMD impairment of the SFLCR, or unconfirmed source impairment of two of the three tributaries flowing through JOFL, affected available JOFL data for water quality, expanded water chemistry parameters, benthic macroinvertebrates or fishes. If the reader wishes to investigate these impairment interactions further he/she is referred to the Sheeder and Tzilkowski (2006) report for specific data.

Currently, the ERMN monitors water quality within the park annually (fall sampling) at one location along one of the unnamed tributaries to the South Fork Little Conemaugh River (Tzilkowski et al. 2010, 2011a, 2011b). One station along the SFLCR was also sampled in 2012 (C. Tzilkowski pers. comm.). Annual monitoring consists of benthic macroinvertebrate assessments supplemented with discrete samples of core water chemistry parameters (Figure 39, Table 19).

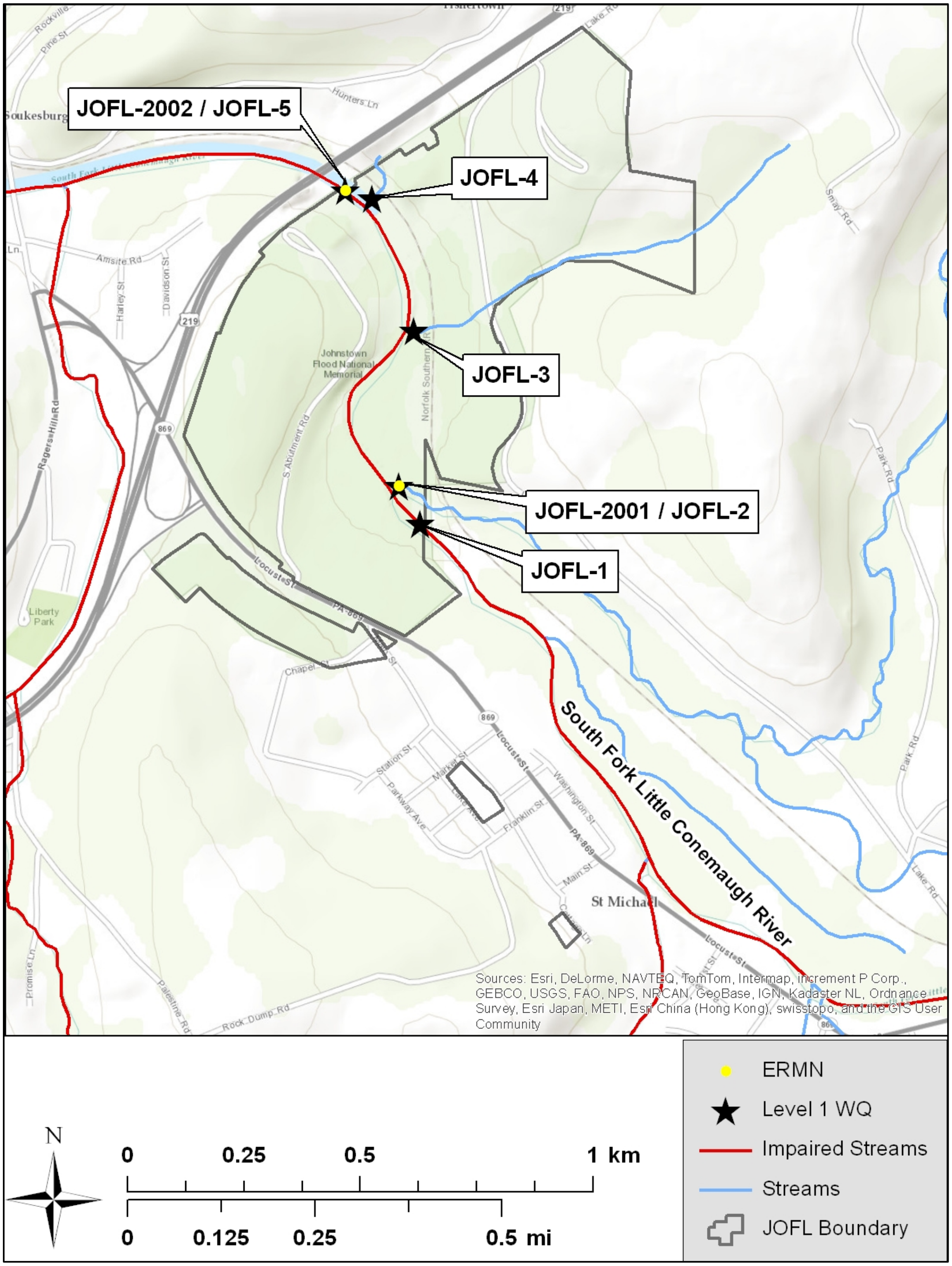


Figure 39. Water quality monitoring locations in the South Fork Little Conemaugh River (SFLCR) used for the JOFL condition assessment. ERMN water quality monitoring was conducted at JOFL.2001 (2008-2011) and at JOFL.2002 (2012) and consisted of benthic macroinvertebrates (BMI) and water chemistry. The Level 1 WQ study was conducted in 2004 (water chemistry) at five locations and 2005 (BMI) at the UNT locations.

Table 19. Water quality studies conducted at JOFL, including time period of data collection, monitoring locations, and type of data collected. The study is identified by the general description assigned for this condition assessment (e.g., ERMN Monitoring) and is followed by the associated report(s) in parentheses. Data collected but not included in the JOFL NRCA are also listed.

STUDY	TIME PERIOD	MONITORING SITE(S)	TYPE OF DATA COLLECTED[1]	
			Used in JOFL NRCA	Not Used in JOFL NRCA
ERMN Monitoring (Tzilkowski et al. 2011a, 2011b)	11/4/2008 10/21/2009 10/11/2010	JOFL.2001	BMI, pH, SC, DO, Temp	
ERMN Monitoring (Tzilkowski unpublished data)	10/25/2011	JOFL.2001	BMI, pH, SC, DO, Temp	
ERMN Monitoring (Tzilkowski unpublished data)	10/16/2012	JOFL. 2002	BMI, pH, SC, DO, Temp	
Level 1 WQ (Sheeder and Tzilkowski 2006)[2]	11/12/2005	JOFL 2, JOFL 3, JOFL 4 (3 total sites)	BMI	
Level 1 WQ (Sheeder and Tzilkowski 2006)	4/13/2004 - 11/08/2004	JOFL 1, JOFL 2, JOFL 3, JOFL 4, JOFL 5 (5 total sites)	pH, SC, DO, Temp	Fish; Acidity, Alkalinity, Turbidity, NO_3-N, TP, SO_4, Al, Sb, As, Be, Cd, Pb, Ti, Se, Ba, Ca, Cr, Cu, Fe, Mn, Mg, Ni, K, Na, Sr, Zn, CN, Hg, F. Coliform
SCRIP/ALLARM Data[3]	11/05/1997 - 2/09/2001	SFLCR (unspecified)		pH, Conductivity, TDS, Alkalinity
UPJ Data[4]	5/07/1986 - 7/07/1987	SFLCR (unspecified)		pH, Conductivity, Temperature, DO, Fe, SO_4, Turbidity, PO_4, Acidity, Alkalinity, NO_3-N, NO_2-N, NH_4, Al, Zn, Mn, Ca, Mg

[1]BMI = benthic macroinvertebrates; SC = specific conductivity; DO = dissolved oxygen; Temp = temperature
[2]WQ = water quality
[3]SCRIP/ALLARM = Stony Creek River Improvement Project/Alliance for Aquatic Resource Monitoring
[4]UPJ = University of Pittsburgh at Johnstown

The severity of impairment to the SFLCR on a regional scale combined with the focus of the NRCA on park-specific natural resource conditions prompts a discussion of whether or not to include the SFLCR water quality results in the JOFL NRCA. Although the SFLCR is an integral part of JOFL's history and landscape, the extensive legacy of mining and other activities in the watershed have produced a large proportion of impaired stream lengths upstream of JOFL (Figure 37). Thus, although the miles within the park are also impaired, the enormity of this stressor goes far beyond that of park management and renders the aquatic condition of the mainstem of the SFLCR less relevant to the JOFL NRCA. A similar conclusion was reached in the park water quality inventory and monitoring reports. Sheeder and Tzilkowski (2006) recommended continued monitoring of the tributaries but not the SFLCR, stating the severe impairment of the latter would require a major watershed reclamation project far beyond park resources. Annual wadeable stream monitoring by the ERMN followed this same argument by focusing on the upstream UNT (JOFL.2001/JOFL 2), which represented the only water resource in the park with sufficient flow and proportion of stream length within park boundaries (C. Tzilkowski, pers. comm.). The ERMN did, however, conduct biological monitoring in the SFLCR (JOFL.2002) in 2012. In light of the reclamation activities being initiated by Rosebud Mining Co. on nearby Topper Run (St. Michael), future monitoring of the SFLCR within the park may be warranted to track any changes in water quality resulting from these activities. In addition, it is still important for park managers and others to be aware of the problem and resulting impairments to the SFLCR. Therefore, our approach for JOFL's water quality condition assessment is to report the Level 1 (Sheeder and Tzilkowski 2006) and ERMN monitoring results (Tzilkowski et. al. 2011a, 2011b, and Tzilkowski pers. comm.) for all stations assessed, including the SFLCR. Overall water quality condition for the park will be reported as 1) park-level water quality (i.e. the UNT monitored annually by the ERMN) and 2) regional-level water quality (i.e. the SFLCR).

We provide condition assessments for two vital sign indicators: core water chemistry (pH, dissolved oxygen, specific conductivity, and temperature) and macroinvertebrates. The datasets for JOFL core water chemistry 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 2009b). 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, with specific conductivity serving as a more informative indicator than water pH, dissolved oxygen and temperature due to the greater stability of specific conductance under normal 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. Because the condition of biological communities reflects the condition of the surrounding environment, and thus integrates habitat condition, as well, the overall water quality condition (discussed in Chapter 5), is based on the macroinvertebrate results with water chemistry serving as supplemental information.

We did not conduct condition assessments for expanded water chemistry parameters or fish, primarily due to the absence of these parameters in the ERMN monitoring protocol and the lack of long-term monitoring data. Sheeder and Tzilkowski (2006) sampled expanded water chemistry at all JOFL sampling sites including the SFLCR and fish at three unnamed tributaries of the SFLCR. Expanded water chemistry parameters were provided as Appendix B in Sheeder and Tzilkowski (2006). Fish data constituted a one-time inventory for JOFL. Follow-up water quality and benthic macroinvertebrate monitoring by ERMN Vital Signs program is conducted at only one of the three tributaries where six fish species were found, five of which were classified as pollution tolerant

(Sheeder and Tzilkowski 2006). Expanded water chemistry parameters and fish sampling were not included in the ERMN long-term Vital Signs monitoring program, so were excluded from analysis in this condition assessment. Refer to Section 3.2 of this document for Study Design.

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, 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 determines the distribution of aquatic species, controls spawning and hatching, regulates biological activity, and stimulates or suppresses growth and development. Cold blooded animals 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 and increases with increasing amount and mobility of ions (Hem 1982). Increased temperatures result in increased ion movement; therefore, conductivity measures must be corrected for temperature (hence the term 'specific' conductance). 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 also increase while those with lower tolerances decrease (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.

It is likely that water pH and specific conductivity at JOFL are affected by AMD or other sources of pollution. The SFLCR is severely impaired most likely by upstream sources of AMD, and the sources of moderate impairment at two of the three tributaries flowing through JOFL remains unconfirmed. It is beyond the scope of this document to determine how AMD or other impairments affected data used for this condition assessment. Thus, results presented and conclusions reached in this condition assessment reflect the available data, and the reader is referred to the appropriate literature cited to further investigate interactions between AMD or other pollution and the results presented herein for JOFL.

<u>Methods</u>
To aid interpretation of results and compare parameters between sites and data sets, statistical summaries are provided for each indicator at each water quality monitoring locations. For the condition assessment, we compiled the water quality monitoring data for each site (five sites total: one on each of three UNTs and two on SFLCR). We then reported condition based on either the percentage of measurements in each condition category (e.g., 46% good, 53% moderate, and 1% significant concern equates to an overall condition rating of *moderate concern*) or the percent attainment of water quality standards. Water quality data used in the condition assessment were collected from 2004 to present; however, given the previous comments regarding the limitations of field chemistry measurements, we did not attempt to ascertain trends in any of the parameters.

<u>Reference Condition</u>
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). Regulatory criteria or thresholds for pH, dissolved oxygen, and specific conductivity vary depending on the type of water body, its protected use, and in some cases the time of year (Tables 20 and 21).

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 (USEPA 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 2009a). 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 (USEPA 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 *significant concern*.

Currently, there are no water quality standards or criteria set for specific conductance in fresh water. However, results from extensive field studies in the Central Appalachians suggest a benchmark of 300 µS/cm is necessary to protect 95% of native species from extirpation, while values below 100 µS/cm would be needed to protect more sensitive genera (USEPA 2011). This benchmark is applicable to Pennsylvania Ecoregions 68, 69, and 70 (Omernick 1987), which includes the area surrounding JOFL (69b). Thus we assigned values < 100 µS/cm to the *good* condition category and values between 100 and 300 µS/cm to the *moderate concern* category. Values above 300 µS/cm were considered to be of *significant 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; Table 21). 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 2009a). Temperature measurements below the maximum threshold criteria were defined as attaining water quality standards, whereas those above the maximum threshold criteria 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 20. 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	Designation	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)	< 100	Good	Inland freshwaters	4
	100 - 300	Moderate Concern		
	> 300	Significant Concern		
Temperature (°C)	Below maximum (Table 21)	Good	See Table 21	1
	Above maximum	Moderate Concern		

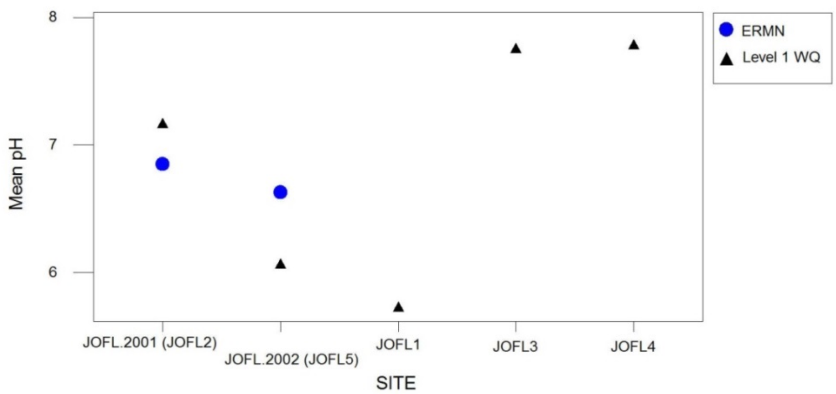
Table 21. Pennsylvania temperature criteria for the protection of aquatic life (PADEP 2009a). Time period and maximum temperature criteria for Cold Water Fishery (CWF), Trout Stocking Fishery (TSF), and Warm Water Fishery (WWF) designated life uses are presented.

	Temperature		
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

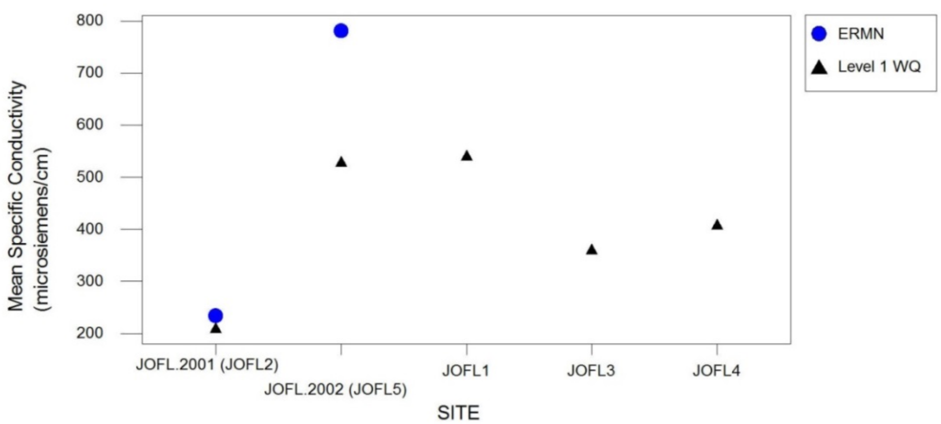
Current Condition and Trends

Given the significant concerns of nitrogen, sulfur and mercury in atmospheric wet deposition, the severe impairment of the SFLCR likely emanating from upstream sources of acidic AMD, and the moderate impairment of two of three tributaries flowing through JOFL from unconfirmed pollution sources, the reader should exercise caution in interpretation of indicator conditions at JOFL. Results presented and conclusions reached in this document reflect only the available data. The reader is referred to the appropriate literature cited to further investigate interactions between JOFL data used in this document and AMD or other types of pollution.

Water pH levels were lower in SFLCR than in the tributaries (Figure 40a). Mean water pH for both stations, however, was very close to 6.0 (JOFL 5 = 6.1; JOFL 1 = 5.7). All stations had relatively high specific conductivity levels. Specific conductivity levels were lowest at the ERMN UNT monitoring site (JOFL 2001/JOFL 2) and highest in the SFLCR (Figure 40b).



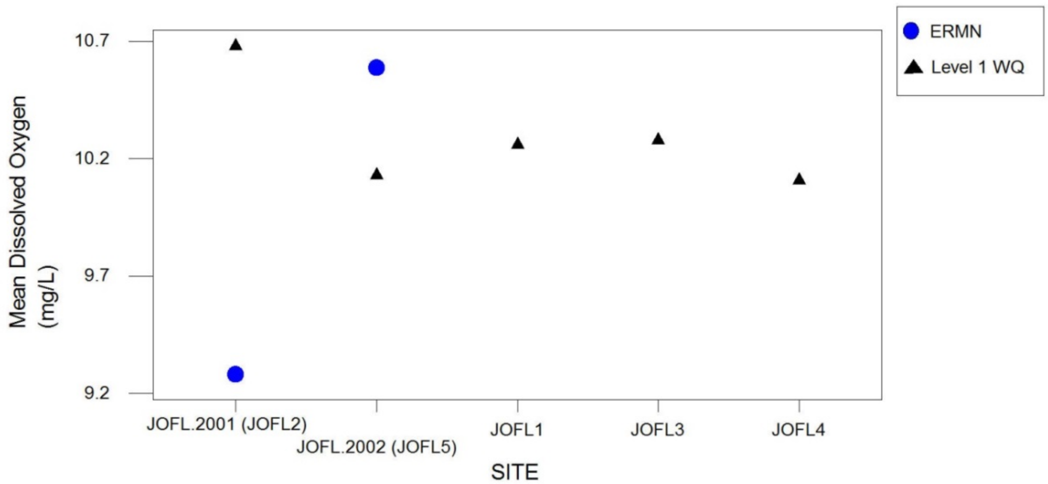
a.)



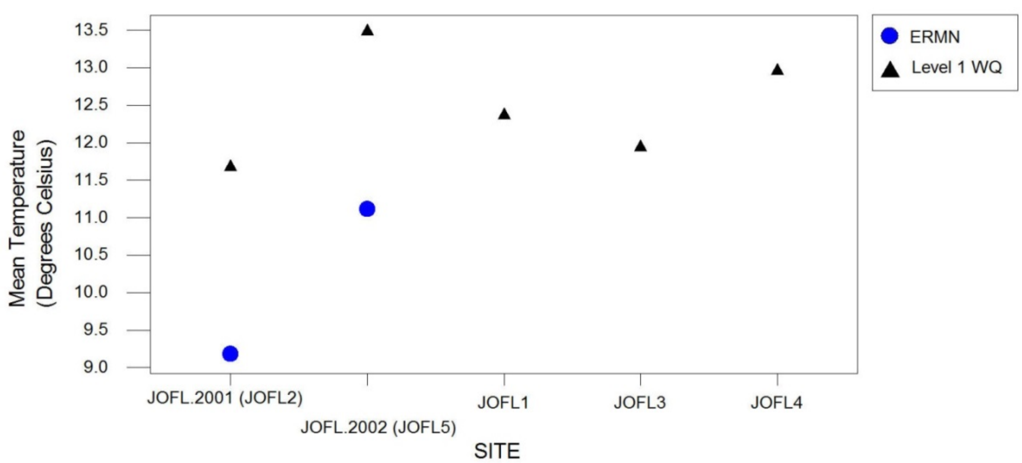
b.)

Figure 40. Mean water pH (a) and specific conductivity (b) measured at monitoring locations in JOFL: Upper UNT [JOFL.2001(JOFL2), SFLCR Downstream [JOFL.2002(JOFL 5)], SFLCR Upstream [JOFL1], Middle UNT [JOFL3], and Lower UNT [JOFL4]. Means are reported separately for each study (blue circle = ERMN monitoring; black triangle = Level 1 WQ study).

Mean DO measurements at all monitoring locations were well above the water quality standard for salmonid production in CWF of 8 mg/L. When separated by study, the mean DO was lower at the upper tributary (JOFL.2001) for the ERMN monitoring period but still well above water quality standards (Figure 41a). Mean temperatures reported in the Level 1 WQ study (Sheeder and Tzilkowski 2006) were higher than those taken in later years during the ERMN monitoring (Figure 41b).



a.)



b.)

Figure 41. Mean dissolved oxygen (a) and mean temperature (b) measured at water quality monitoring locations in JOFL: Upper UNT [JOFL.2001(JOFL2), SFLCR Downstream [JOFL.2002(JOFL 5)], SFLCR Upstream [JOFL1], Middle UNT [JOFL3], and Lower UNT [JOFL4]. Means are reported separately for each study (blue circle = ERMN monitoring; black triangle = Level 1 WQ study).

The above water chemistry results were reflected in the condition ratings. In SFLCR, three of the seven pH measurements taken at the downstream location (JOFL 5) and five of the six pH measurements taken at the upstream location (JOFL 1) were below the PADEP water quality standard of 6.0, resulting in *good* and *moderate concern*, respectively (Table 22).

For specific conductance, JOFL 2001/JOFL2 warranted *moderate concern*, while both the upstream (JOFL 1) and downstream (JOFL 5) stations of the SFLCR warranted *significant concern* (mean specific conductivity levels of 539.7 µS/cm and 563.2 µS/cm, respectively (Table 22). The other unnamed tributaries (JOFL 3, JOFL 4) also warranted *significant concern.* Specific conductivity measurements are rarely this high in naturally occurring coldwater streams and typically indicate anthropogenic influences (e.g., road proximity, AMD, etc.). Dissolved oxygen concentrations were consistently above the PADEP's water quality standard of 5.0 mg/L for CWF-designated streams, and above the 8 mg/L standard for salmonid production, corresponding to *good* condition. Results for temperature indicated *good* condition at all sites with the exception of the downstream location of the SFLCR (JOFL.2002/JOFL 5), which had five of eight total temperature measurements exceed the allowable threshold for that time period (Table 22). Exceedance of PADEP CWF temperature criteria was recorded at least once at every monitoring site, usually in October and/or November. Mean exceedance for all monitoring locations ranged from 1.8 to 4.3 °C (Table 22). For all core parameters, it must be noted that differences in data values between the Level 1 WQ study and ERMN monitoring could be attributed to differences in sampling season or time of day. For pH and specific conductance, different environmental influences could affect data values on any given day. Dissolved oxygen is a function of temperature, and temperature itself varies diurnally and seasonally.

Table 22. JOFL water quality condition assessment for pH, specific conductivity, dissolved oxygen, and temperature showing mean, (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. Condition rating for temperature is based on the percentage of samples meeting attainment with >67% = *good* (🟢); 33-67% = *moderate concern* (🟡); or <33% = *significant concern* (🔴)] Trends were not assessed due to lack of long-term monitoring data with consistent, standardized collection procedures.

CORE PARAMETER	STREAM	SITE NAME	AQUATIC LIFE USE	N	Mean	% GOOD CONDITION	% MODERATE CONCERN	% SIGNIFICANT CONCERN	CONDITION RATING
pH	UNT SFLCR (upper trib)	JOFL.2001/ JOFL 2	CWF	10	7.04	(10) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	UNT SFLCR (middle trib)	JOFL 3	CWF	6	7.7	(6) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	UNT SFLCR (lower trib)	JOFL 4	CWF	6	7.8	(6) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	SFLCR (upstream)	JOFL 1	CWF	6	5.7	(1)16.7%	(5) 83.3%	(0) 0.0%	🟡
	SFLCR (downstream)	JOFL.2002/ JOFL 5	CWF	7	6.1	(4) 57.1%	(3) 42.9%	(0) 0.0%	🟢
Specific Conductivity (µS/cm)	UNT SFLCR (upper trib)	JOFL.2001/ JOFL 2	CWF	10	218.2	(0) 0.0%	(10) 100.0%	(0) 0.0%	🟡
	UNT SFLCR (middle trib)	JOFL 3	CWF	6	358.7	(0) 0.0%	(0) 0.0%	(6) 100.0%	🔴
	UNT SFLCR (lower trib)	JOFL 4	CWF	6	407.1	(0) 0.0%	(0) 0.0%	(6) 100.0%	🔴
	SFLCR (upstream)	JOFL 1	CWF	6	539.7	(0) 0.0%	(0) 0.0%	(6) 100.0%	🔴
	SFLCR (downstream)	JOFL.2002/ JOFL 5	CWF	7	563.2	(0) 0.0%	(0) 0.0%	(7) 100.0%	🔴
Dissolved Oxygen (mg/L)	UNT SFLCR (upper trib)	JOFL.2001/ JOFL 2	CWF	10	10.3	(10) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	UNT SFLCR (middle trib)	JOFL 3	CWF	7	10.3	(7) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	UNT SFLCR (lower trib)	JOFL 4	CWF	7	10.1	(7) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	SFLCR (upstream)	JOFL 1	CWF	7	10.3	(7) 100.0%	(0) 0.0%	(0) 0.0%	🟢
	SFLCR (downstream)	JOFL.2002 /JOFL 5	CWF	8	10.2	(8) 100.0%	(0) 0.0%	(0) 0.0%	🟢
					Mean Exceedance (°C)		% ATTAINMENT	% EXCEEDANCE	
Temperature (°C)	UNT SFLCR (upper trib)	JOFL.2001/ JOFL 2	CWF	11	1.9		(8) 72.7%	(3) 27.3%	🟢
	UNT SFLCR (middle trib)	JOFL 3	CWF	7	4.3		(6) 85.7%	(1) 14.3%	🟢
	UNT SFLCR (lower trib)	JOFL 4	CWF	7	2.1		(5) 71.4%	(2) 28.6%	🟢
	SFLCR (upstream)	JOFL 1	CWF	7	2.6		(5) 71.4%	(2) 28.6%	🟢
	SFLCR (downstream)	JOFL.2002/ JOFL 5	CWF	8	1.8		(3) 37.5%	(5) 62.5%	🟡

Data Gaps and Level of Confidence

Confidence level depended on the specific parameter with specific conductivity assigned a higher confidence level (medium) than pH, temperature and dissolved oxygen (low). The latter three parameters are more susceptible to temporal variation. Overall confidence in the core water chemistry assessment is medium, due primarily to sparse datasets and the limitations of discrete grab samples in accounting for temporal 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 condition at JOFL. This is especially prudent because the water quality data available for JOFL and presented above do not account for interactions of AMD or other atmospheric or anthropogenic pollutants.

Sources of Expertise

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

Aquatic Macroinvertebrates

Relevance and Context

Unlike chemical measurements, which 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 a community often reflects the suite of environmental conditions present throughout the year.

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

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.

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 measures (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 23). Refer to Klemm et al. (2003) for more information regarding calculating metrics and MBII calculation.

Table 23. 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	$\Sigma_i p_i t_i$ where p_i is the proportion of individuals in taxon *I* and t_i is the pollution tolerance value (PTV) for general pollution	Increase
Percent five dominant taxa	Percentage of individuals in the five numerically dominant taxa	Increase

The ERMN lists benthic macroinvertebrates (BMI) as an important vital sign and began collecting macroinvertebrate data within JOFL using the Wadeable Streams Monitoring Protocol in 2008 (Tzilkowski et al. 2009, 2010, 2011a, b). Four studies at the park contained BMI data: Level 1 WQ (Sheeder and Tzilkowski 2006), and the ERMN monitoring data (Tzilkowski et al. 2010, 2011a, 2011b).

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

Methods

We used the MBII to report condition of BMI communities at JOFL using available data. It is noted that atmospheric and anthropogenic pollution are well documented at JOFL, including severe impairment of the SFLCR by acidic AMD. A robust and ecologically meaningful macroinvertebrate community is not expected in waters affected by acidic AMD. In addition to the available data from the Level 1 WQ and ERMN monitoring reports, we also obtained recent metrics and MBII scores from ERMN monitoring in 2011 and 2012 (C. Tzilkowski pers. comm.). 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. These studies differed slightly in collection methods: Sheeder and Tzilkowski (2006) collected nine kicks per site using a D-frame kick net (250 µm mesh) in January, while ERMN monitoring methods consist of 5 composited samples per site using a slack sampler (500 µm mesh) during October or November. Differences in sampling apparatuses (e.g., kicknet and slack samplers) do not appear to affect metric results if data are standardized to a fixed count (Cao et al. 2005, Peterson and Zumberge 2006). We could not find any specific references regarding the susceptibility of the MBII to seasonal variation. 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). 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 MBII does not contain any functional feeding group or habitat metrics. 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.

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 JOFL 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 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 JOFL NRCA (Table 24).

Table 24. MBII scoring criteria and condition categories used for the JOFL benthic macroinvertebrate condition assessment.

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

<u>Current Condition</u>

MBII scores computed from the Level 1 WQ study were much higher than those computed from the more recent ERMN monitoring, including the upper UNT (JOFL.2001/JOFL 2) (Figure 42). MBII scores at this location were 47.95 in the 2004 study and ranged from 21.73 to 23.82 during the ERMN monitoring. It is possible that water quality conditions may have decreased at this location since 2004, but given the land use history of the area, including mining activities and the close proximity of the railroad, this is unlikely. Differences in sampling gear, season, and habitat may also confound these results. The SFLCR (JOFL.2002) scored lowest (MBII = 7.10). Of the EPT taxa, mayflies are the most sensitive to acidic conditions. No mayflies were collected in the SFLCR, and only one stonefly and two caddisfly genera were collected. MBII scores from all studies and monitoring locations were low and rated as significant concern (Table 25). These results support the impairment listing of this section of the SFLCR.

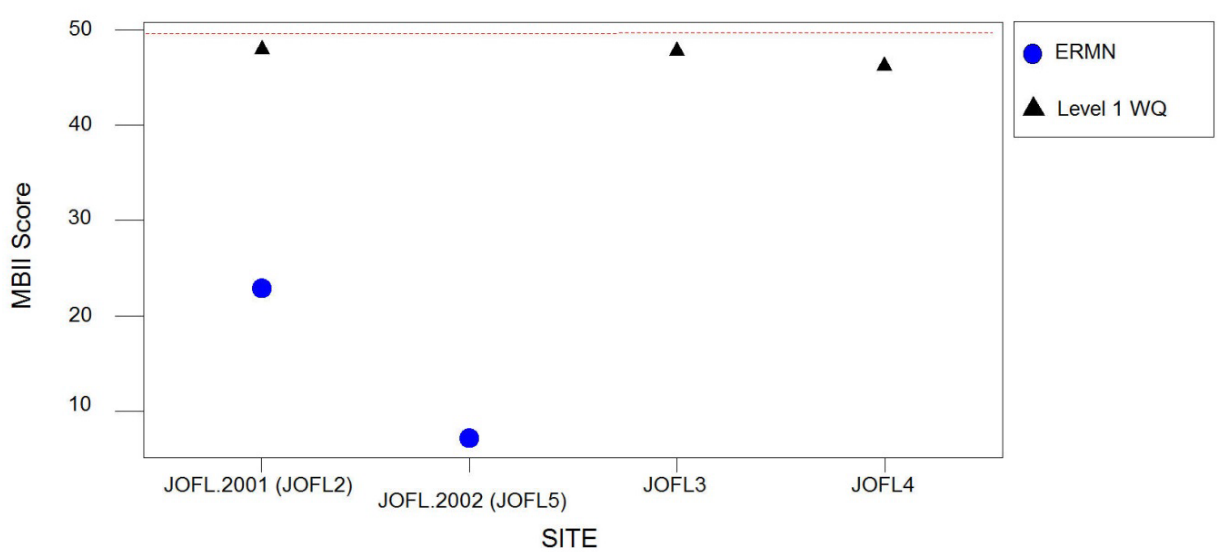


Figure 42. MBII scores (4-yr mean scores for ERMN) from benthic macroinvertebrate studies at each of the water quality monitoring stations at JOFL that were sampled for macroinvertebrates. The red dashed line represents the maximum value for significant concern (i.e. MBII scores < 49).

Table 25. Water quality condition assessment results for JOFL monitoring locations in the South Fork Little Conemaugh River (SFLCR) watershed using the Macroinvertebrate Biotic Integrity Index (MBII). Condition ratings for each sample location are based on the MBII score compared to the percent distribution of reference sites (MBII >63 = *good* condition; MBII 49-63 = *moderate concern*; MBII <49 = *significant concern*).

STREAM	SITE NAME	STUDY	YEAR	E	P	T	CF	% NI	% 5 dom	MTI	MBII Score	Condition Rating	Segment Condition Rating
	JOFL 2	Level 1 WQ	2005	5	5	5	16	3.0	83.0	4.49	47.95	Significant Concern	
	JOFL.2001	ERMN	2008	1	1	5	4	0.6	84.5	5.38	23.61	Significant Concern	
UNT SFLCR (upper trib)	JOFL.2001	ERMN	2009	1	3	4	5	2.9	82.9	5.09	23.82	Significant Concern	
	JOFL.2001	ERMN	2010	2	2	5	6	8.6	78.7	5.54	22.23	Significant Concern	
	JOFL.2001	ERMN	2011	2	2	5	4	3.8	86.2	5.28	21.73	Significant Concern	
UNT SFLCR (middle trib)	JOFL 3	Level 1 WQ	2005	3	1	5	9	2.0	85.0	3.2	47.78	Significant Concern	
UNT SFLCR (lower trib)	JOFL 4	Level 1 WQ	2005	3	1	5	9	4.0	86.0	3.55	46.20	Significant Concern	
SFLCR (downstream)	JOFL.2002	ERMN	2012	0	1	2	1	39.2	91.4	4.79	7.10	Significant Concern	

Data Gaps and Level of Confidence

Confidence in this assessment is *high*. Reference criteria are based on an expansive regional dataset and statistically valid methods. None of the datasets were from questionable sources and, although collection methods differed slightly by sampling device and number of kicks, a literature review indicated these differences were unlikely to affect MBII scores.

Sources of Expertise

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

Ecosystem Integrity

Forest/Wood/Shrubland

Relevance and Context

Forest, Woodlands, and Shrublands encompass 38.78% of park habitats. Shrublands occur mainly in the former lakebed area within the wetland mosaic and are not considered here. Only 28.6% of park habitats are classified as forest/woodland. Forested areas are largely second-growth, the result of repeated timber harvesting within the park and surrounding watershed over the past two centuries. These activities, along with the disastrous flood of 1889, have shaped both species composition and vegetation structure. Additionally, ozone pollution and atmospheric wet and dry deposition of nitrogen, sulfur and mercury may affect plant health and vigor, and all of these indicators were of significant concern at JOFL. However, as there have been no studies linking these atmospheric pollutants to forest health within the park it was considered beyond the scope of this document to attempt to extrapolate indirect or direct impacts as they relate to forest resource condition at JOFL. Perles et al. (2006) describe two natural forest associations: Red Maple–Black Cherry Successional Forest/Woodland and Eastern Hemlock–Northern Hardwood Forest within the park.

Most forests within the park are classified as Red Maple–Black Cherry Successional Forest/Woodland (RMBC). These areas are dominated by red maple (Acer rubrum), black cherry (Prunus serotina), and occasionally black locust (Robinia pseudoacacia). Other associated trees species include hawthorns (Crataegus spp.), white ash (Fraxinus americana), American beech (Fagus grandifolia), sweet birch (Betula lenta), and eastern white pine (Pinus strobus). The understory includes a variety of shrubs including fanleaf hawthorn (Crataegus flabellata), cockspur hawthorn (Crataegus crus- galli), northern spicebush (Lindera benzoin), Allegheny blackberry (Rubus allegheniensis), chokecherry (Prunus virginiana), Morrow's honeysuckle (Lonicera morrowii), and multiflora rose (Rosa multiflora). Although highly variable, the herbaceous layer includes many species typical of eastern deciduous forests including eastern hayscented fern (Dennstaedtia punctilobula), white wood aster (Eurybia divaricata), intermediate woodfern (Dryopteris intermedia), broadleaf enchanter's nightshade (Circaea lutetiana), Canadian white violet (Viola canadensis), and white avens (Geum canadense). Vines such as Virginia creeper (Parthenocissus quinquefolia) and eastern poison ivy (Toxicodendron radicans) are typically found in low abundance. Near the western boundary of the park, this forest type mixes with Old Field to create a mosaic of these two habitat types: Old Field and Red Maple–Black Cherry Successional Forest/Woodland Mosaic (OFRMBC).

Eastern Hemlock–Northern Hardwood Forest makes up the remaining natural forested areas of the park. Occurring on north-facing slopes on moderately well-drained soils, these forests are dominated by Eastern hemlock (Tsuga canadensis) with lesser amounts of other canopy associates including sugar maple (Acer saccharum), American beech (Fagus grandifolia), white ash (Fraxinus americana), northern red oak (Quercus rubra), black cherry (Prunus serotina), sweet birch (Betula lenta), and yellow birch (Betula alleghaniensis). The sub-canopy is typically sparse and may contain sugar and red maples (Acer rubrum), American beech, striped maple (Acer pensylvanicum), black cherry, and hophornbeam (Ostrya virginiana), northern spicebush (Lindera benzoin) and several species of raspberry (Rubus spp.). A diversity of species comprise the dense herbaceous layer including jewelweed (Impatiens capensis), silver false spleenwort (Deparia acrostichoides), mayapple (Podophyllum peltatum), wrinkleleaf goldenrod (Solidago rugosa), heartleaf foam flower (Tiarella cordifolia), white wood aster (Eurybia divaricata), Jack in the pulpit (Arisaema triphyllum), black bugbane (Cimicifuga racemosa), and New York fern (Thelypteris noveboracensis). Grape vines (Vitis spp.) are also present climbing on tall shrubs and subcanopy trees. This forest type is susceptible to invasion by Morrow's honeysuckle (Lonicera morrowii) and multiflora rose (Rosa multiflora). The balance of the park is comprised of five associations: Conifer Plantation (0.99%), Silky Willow Shrub Swamp (1.12%), Old Field (32%), Cattail Marsh (0.72%), and Riverine Scour Vegetation (0.45%).

Over the past 25 years, there have been six vegetation surveys within JOFL. Four of these surveys have studied and classified forested habitats: Melton (1982), Western Pennsylvania Conservancy (2003), Perles et al. (2006), and Perles et al. (2010). From 1981-1982, Melton mapped vegetation types within the park and provided a qualitative assessment of their extent and abundance. He described four forest/wood/shrubland cover composition types and recorded density, size class, and stand quality. Quality was expressed in terms of merchantable timber. The 2001-2002 Western Pennsylvania Conservancy survey identified six distinct forest/wood/shrubland communities (Western Pennsylvania Conservancy 2003) providing a qualitative description of each type and extensive species list. The report also provides management recommendations for invasive species control in forested areas of the park. In 2004, Perles et al. (2006) collected data from 17 plots located within different habitat types within the park and devised seven associations. Detailed information is provided for each association including distribution within the park, environmental characteristics, and species composition. They also recommend “continued inventory, monitoring, and management of invasive species” as a priority for the park’s resource managers, in particular, giant knotweed (Polygonum sachalinense), Japanese knotweed (Polygonum cuspidatum), Morrow’s honeysuckle, tatarian honeysuckle (Lonicera tatarica), multiflora rose, Japanese barberry (Berberis thunbergii), spotted knapweed (Centaurea maculosa), autumn olive (Elaeagnus umbellata), purple crownvetch (Coronilla varia), and Fuller’s teasel (Dipsacus fullonum).

In a Vital Signs monitoring study from 2007-2009, Perles et al. (2010) collected data at seven long-term monitoring plots as part of the ERMN Vital Signs Monitoring Program (Figure 42). Additional plots were sampled in 2010 (3 plots) and 2011 (2 plots). Only associations that are not managed by the park were included in this study. Therefore, it does not include the cultural landscapes at the lakebed area or Unger House Farm. At each plot, data was collected on species composition; forest stand structure; tree health, growth, and mortality; tree regeneration; coarse woody debris; shrubs; ground-story diversity; invasive species; and soil in two forest associations within the park: RMBC and OFRMBC. 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.

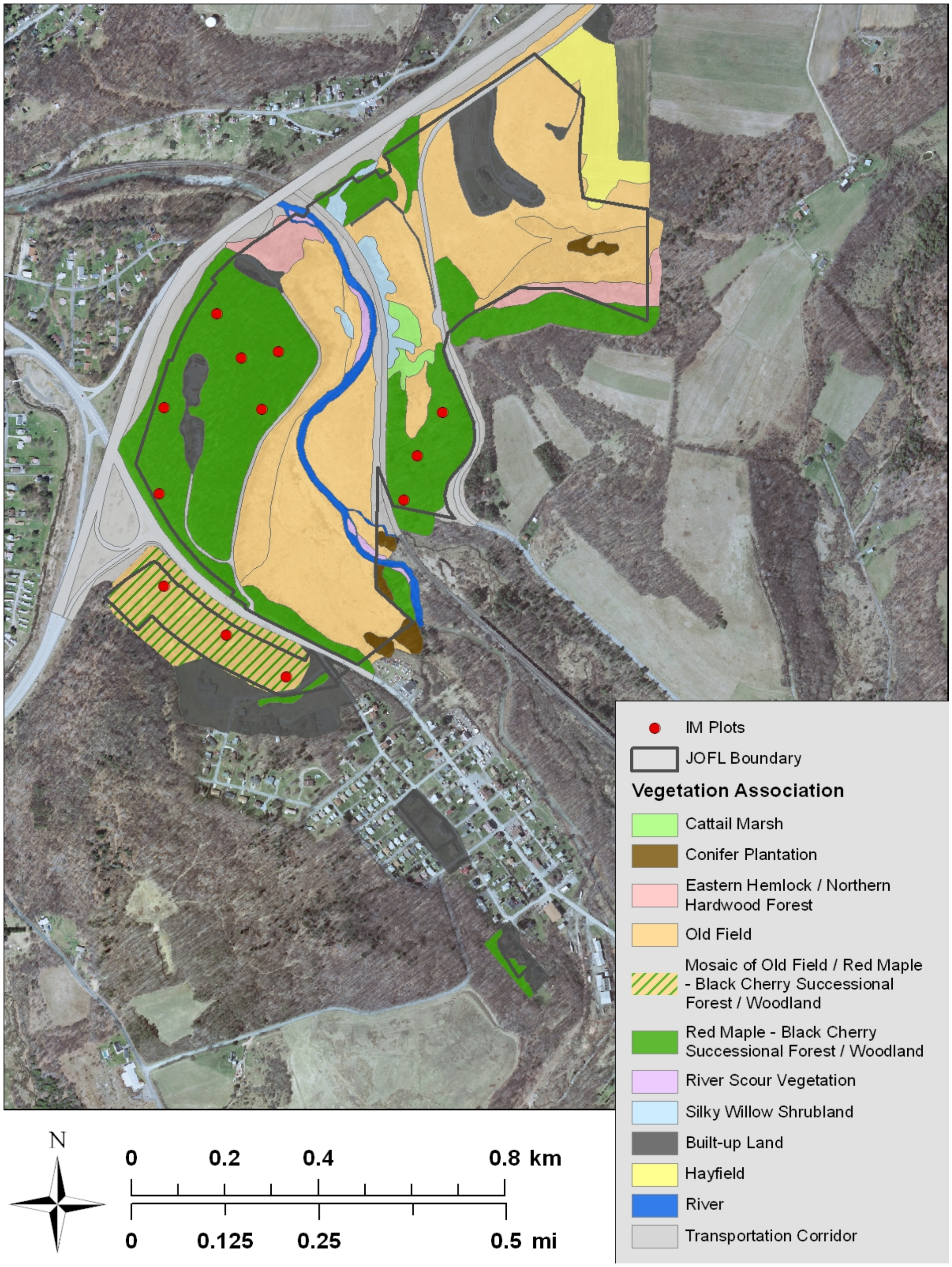


Figure 43. Locations of ERMN Vital Signs Monitoring Program plots in forested associations in JOFL.

Methods

We used Floristic Quality Assessment (FQA) - 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 (grasses, sedges, and rushes), 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 JOFL.

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):

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

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 12 plots sampled in two forested areas of the park. The data set was first divided into the two forest associations categorized by Perles et al. (2006): RMBC and OFRMBC. For each vegetation type, the adjusted FQI score and mean coefficient value were calculated.

Reference Condition

For floristic metrics, we used condition ranks developed for forested habitats in Allegheny Portage National Historic Park (ALPO). Forests in ALPO span a range of condition from highly to least disturbed and provide the closest approximation of a reference condition for forested upland habitats on the Allegheny Plateau. These values were trisected into three condition categories (Tables 26 and 27).

Table 26. Condition categories for Floristic Quality Index scores. Categories are based on reference sites from ALPO.

Adjusted Floristic Quality Assessment Score	Condition	Symbol
> 34	Good	
17 - 34	Moderate Concern	
< 17	Significant Concern	

Table 27. Condition categories for mean C. Categories are based on reference sites from ALPO.

Mean Coefficient of Conservatism	Condition	Symbol
> 4	Good	
2-Apr	Moderate Concern	
< 2	Significant Concern	

Current Condition and Trends

Table 28 shows floristic quality metrics for RMBC and OFRMBC forest associations. Both vegetation associations scored similarly for both metrics. The RMBC association scored *good* for floristic quality while the OFRMBC received a score of *moderate concern*, although ranks were approaching the good condition category (Table 28).

These forests contain many elements typical of forests on the Allegheny Plateau including a variety of oak (*Quercus*) and hickory (*Carya*) species and American beech. They also contain some moderate to highly conservative understory woody and herbaceous plants such as common serviceberry (*Amelanchier arborea*), mountain holly (*Ilex montana*), whorled wood aster (*Oclemena acuminata*), Canada mayflower (*Maianthemum canadense*), partridgeberry (*Mitchella repens*), and sessileleaf bellwort (*Uvularia sessilifolia*).

Both associations also support invasive shrubs, however, particularly multiflora rose and Morrow's honeysuckle and to a lesser extent Japanese barberry. Japanese knotweed, an aggressive invasive sub-shrub, was present in only one plot in the RMBC association.

Table 28. Condition Assessment Metrics for JOFL Forest Associations.

JOFL Metrics	Red Maple – Black Cherry Successional Forest/Woodland (n=9)	Condition Category	Mosaic of Old Field and Red Maple – Black Cherry Successional Forest/Woodland (n=3)	Condition Category
FQI	40.6		32.9	
$\bar{C}$	4.3		3.6	

Data Gaps and Level of Confidence

The confidence in the condition assessment was *low*. Because vegetation studies within JOFL (Melton 1982, Western Pennsylvania Conservancy 2003, Perles et al. 2006) 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 limited sampling timeframe does not allow an analysis of trends. Confidence was also rated low because of the lack of reference data for upland forests in the region. We used ALPO forests as our reference standard to assign condition ranks, but this data set is limited by a small sample size and may not be representative of all forests in the region.

Vital Signs monitoring is conducted annually. To date, 12 randomly-placed plots have been sampled in forested areas within the Park (three plots per year except 2007 and 2011 where one and two plots were sampled, respectively). This data set, albeit small and exclusive to forested habitats, provides a preliminary snapshot of overall condition for the largest forest associations within the park and can be used as a baseline for continuing monitoring efforts.

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.

Grasslands

Relevance and Context

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 18th and 19th 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. 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).

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

Currently, grasslands at JOFL represent 15.8 ha (39 ac) or 14.7% of land within the park. These areas are concentrated in the ‘Unger Farm Cultural Landscape’ near the visitor’s center (9.7 ha/24 ac or 9.0% of park land), where annual mowing is prescribed. In addition, some grassland areas (totaling 5.6 ha or 13.8 ac) are interspersed throughout the lakebed, the largest of which occurs as a narrow strip along the tree line near the western border of the lakebed. These habitats were characterized as old-fields by Perles et al. (2006) (Figure 43). The majority of the lakebed is quite saturated. Although the park previously attempted to convert this area to grassland habitat, the endeavor was unsuccessful due to the constant encroachment from shrubs and trees, especially meadowsweet and steeplebush (*Spirea spp.*) (K. Penrod, pers. comm.).

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.

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.

Henslow's Sparrow (Ammodramus henslowii)

Bird studies specifically focused on grassland species have not been conducted at JOFL. 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 short-distance migrants (mostly open-field and edge species) than permanent residents or long-distance migrants. Due to the large amount of early-successional and grass/forb habitat, the authors recommended managing for grassland and early-successional bird species and developing mowed lawns into unmowed grasslands, especially around the Visitors Center (Unger Farm Cultural Landscape). Point count surveys were also conducted during the spring-migratory, breeding, fall-migratory, and winter seasons from May 1999 – May 2001(Yahner et al. 2001). Despite the small size of the park and limited grassland habitat, most of the grassland bird species listed above were detected in the study, including Eastern Meadowlark (spring migration and breeding season), Grasshopper Sparrow (spring migration), Henslow's Sparrow (spring migration and breeding season), Savannah Sparrow (fall migration), Vesper Sparrow (spring migration, breeding season, and winter), and Bobolink (breeding season and fall migration). All species detected were considered rare, uncommon, or occasional (i.e. none were common or abundant), however, and many were detected only during migratory seasons.

This apparent lack of breeding grassland bird populations at JOFL is not surprising, considering the park provides only small patches of mostly managed grassland habitats and is in close proximity to urban areas. 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, Grasshopper Sparrows, and Eastern Meadowlarks (J. Hill and G. Stauffer, pers. comm.). Therefore, our focus here is primarily to evaluate the condition of JOFL's potential grasslands for providing habitat for these four 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 parks like JOFL, 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 if 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. Territory size for Eastern Meadowlarks is normally between 2.8 – 3.2 ha (Peterjohn 2006).

It is also important to define ‘contiguous’ habitat with respect to perceived barriers for the three passerine species noted for JOFL’s grasslands. Solid treelines or shrublines and large stream channels 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). Perimeter:area (P:A) ratio is a simple measure of shape complexity with simple shapes having smaller P:A ratios than more complex shapes. Hill and Diefenbach (*In Press*) found P:A ratio to be the most important co-variate for predicting the occupancy probability of Grasshopper and Henslow’s Sparrows. 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. Such a management regime would maintain an early successional state, preferred by Vesper, Savannah, and Grasshopper Sparrows. Eastern Meadowlarks prefer grasslands that are transitioning from young to mature stages and may take advantage of shrubs and trees in adjacent areas, including the lakebed, where they can perch.

<u>Methods</u>
We developed an ecological model from Peterjohn (2006) to summarize the evaluation of JOFL's grassland habitats (Figure 44). 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.

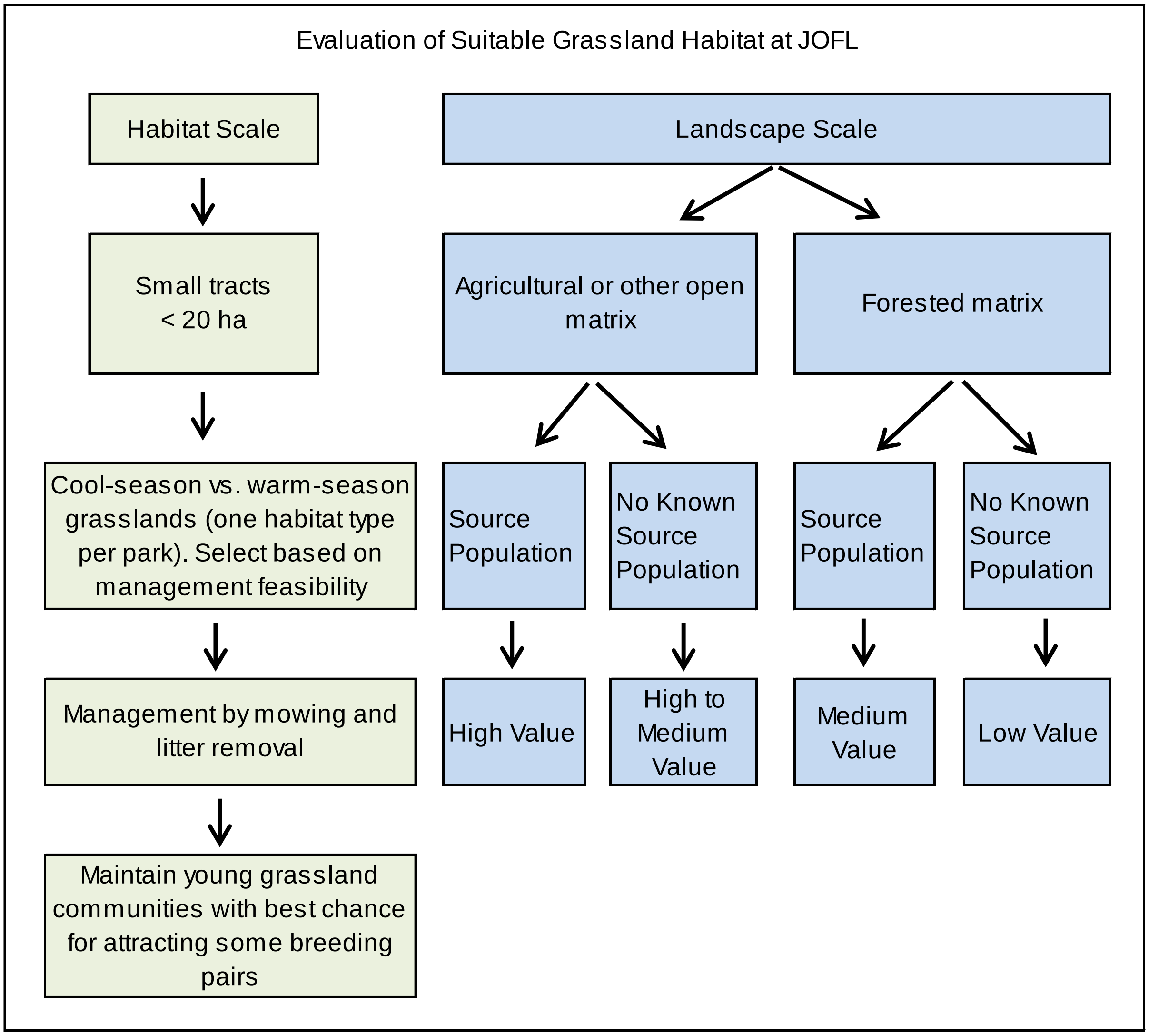


Figure 44. Ecological model for evaluating suitable grassland habitat at JOFL (adapted from Peterjohn 2006).

JOFL is a very small park with even smaller grassland tracts (<20ha), which lie within an open agricultural/urban matrix (Figure 45). The nearest known occurrences of grassland bird species (mostly Grasshopper Sparrows and Eastern Meadowlarks) are in reclaimed strip mines approximately 9 to 11 km (6 to 7 miles) southeast of the park (e.g., Babcock Mine Area). This suggests JOFL's grasslands would have limited potential for supporting breeding grassland bird populations. However, proper management could provide potential habitat 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 44). We did not have sufficient information to conduct a trend analysis.

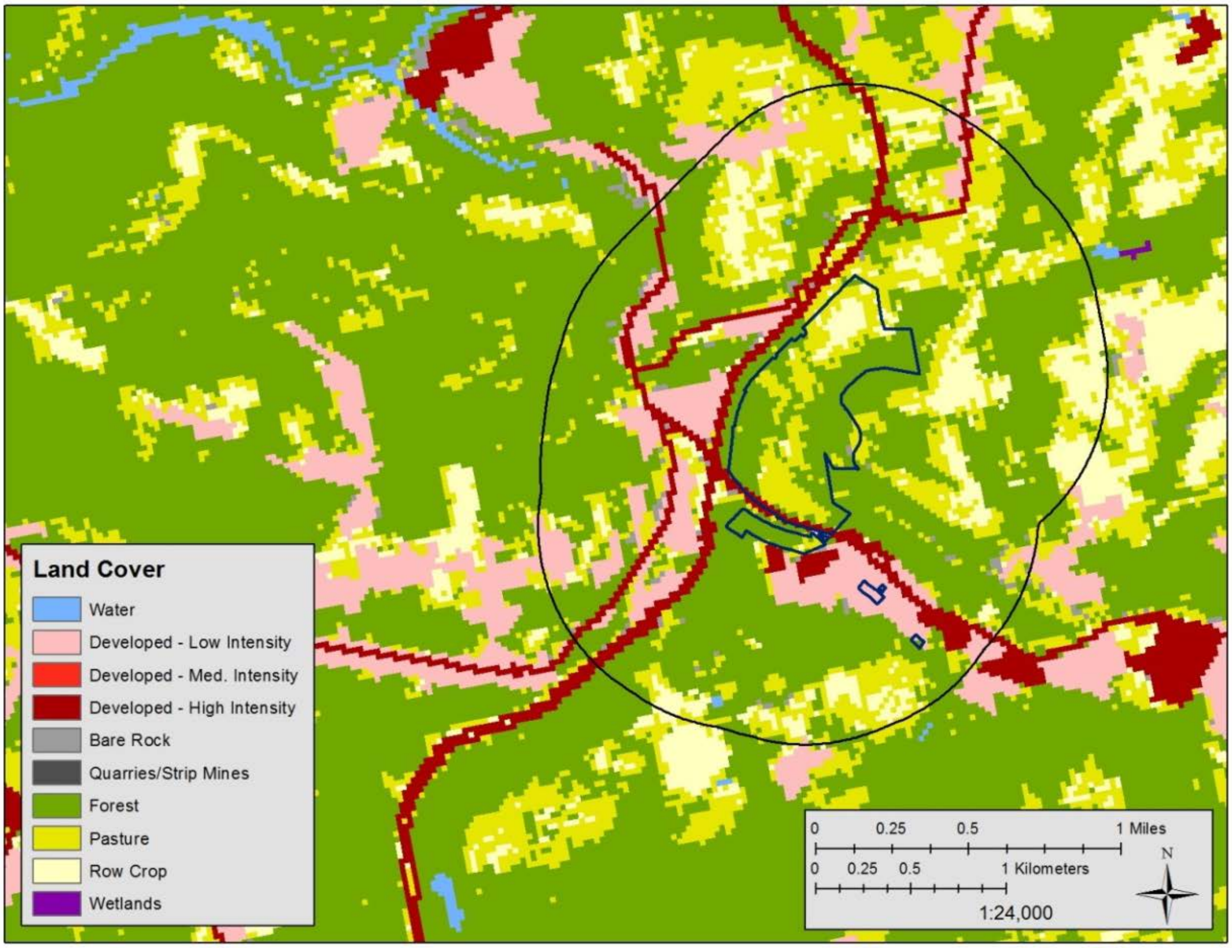


Figure 45. Anderson Level 1 land use interpretation (Anderson et al. 1976) for an area within a 1 km buffer zone around JOFL (NLCD 2006). Much of the area surrounding the park is developed land (both low and high intensity use) and agriculture with some forest patches interspersed.

We used the JOFL vegetation map from Perles et al. (2006) 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. The lakebed contained a mix of this formation with ‘Seasonally flooded cold-deciduous shrubland’, which was also mapped. These areas are mostly saturated, which would limit their habitat potential to those species tolerating wet areas (e.g., Henslow’s Sparrows and Bobolinks). Moreover, the suitability of these patches also depends on the species of forbs. This area of the lakebed is characterized by ‘Steeplebush-Blackberry species Seasonally Flooded Shrubland Alliance/Orchard Grass-Sheep-sorrel Herbaceous Alliance’. Grasshopper and Henslow’s Sparrows, and Meadowlarks avoid nesting in the vicinity of blackberries and raspberries (J. Hill, pers. comm.). This combined with the increasing shrub encroachment suggest the lakebed would not provide suitable habitat for grassland bird species. Thus, we did not consider these patch types, but rather selected only polygons delineated as ‘grassland’ (Figure 46).

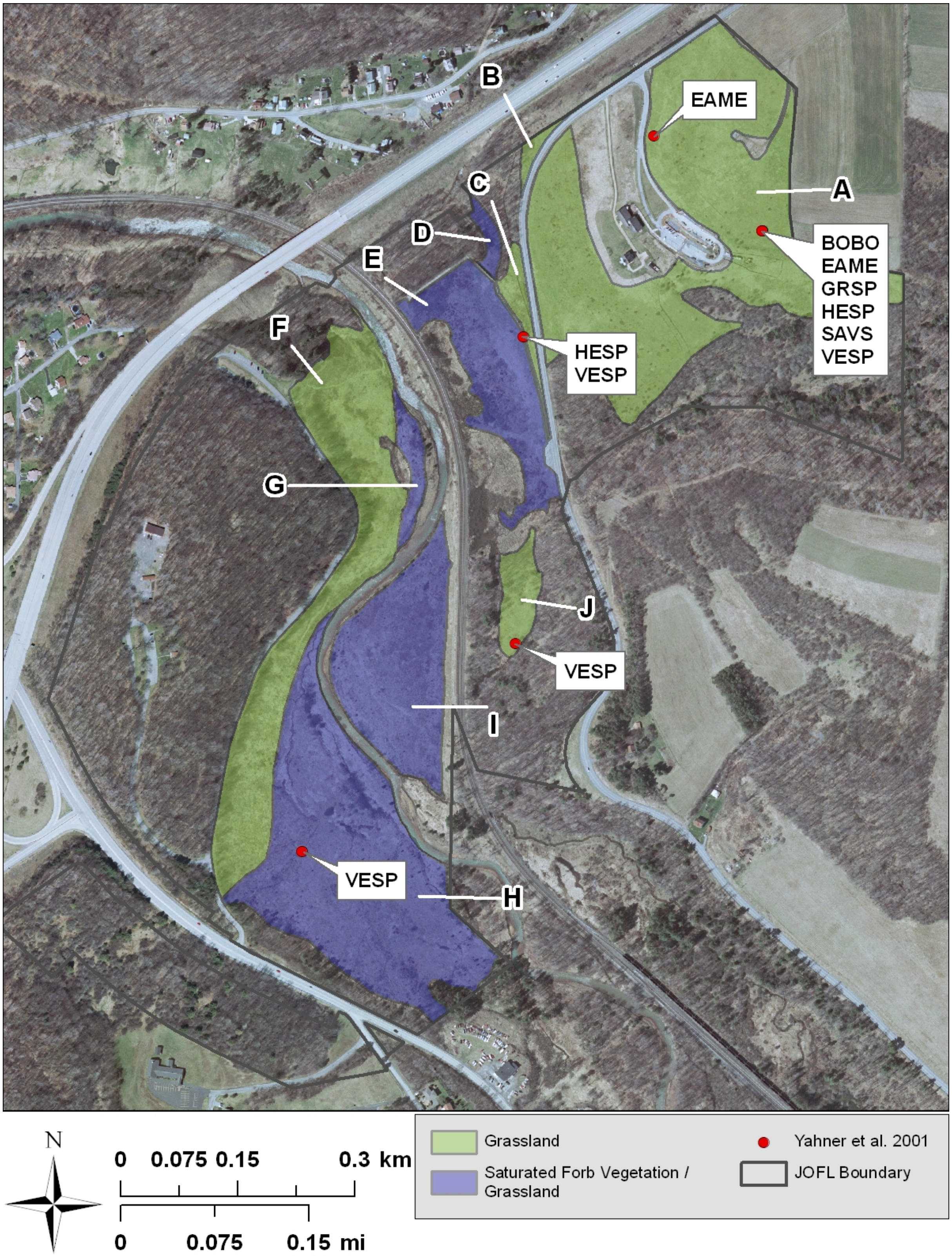


Figure 46. Location of potential grassland areas (green & purple) at JOFL. Note that the majority of grassland habitat is located near the visitor's center and former lakebed with the latter consisting mainly of saturated/wet areas. Also note that the majority of sitings from Yahner et al. 2001 occurred in Patch A.

To determine potential grassland habitat among the selected polygons, we considered several criteria (Table 29). These criteria originated from discussions with JOFL's Natural Resource Manager and from Hill (2012) and were determined from a combination of geospatial data calculations and confirmed with aerial photographs.

Table 29. Criteria used to select areas of potential grassland habitat at JOFL.

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 once per year in Sept/Oct	Good Condition	Rate as % of potential grassland habitats in each of these categories
	(2) Mow before nesting season & in Sept/Oct	Moderate Concern	
	(3) Mow weekly or no management plan	Significant Concern	

Of the total area in the park classified as grassland formation, only one polygon (9.7 ha or 24 ac) qualified as potential grassland habitat. This represents only 9% of the total land area of the park. This entire habitat was located within the Unger Farm Cultural Landscape, which also houses the Visitor's Center and was represented by one large patch designated Patch A (Figure 46). The only other potential grassland patch (Patch F) was located along the lakebed bordering the forested section of the park's natural zone. This patch was not selected, because it was long and narrow and would mostly be considered edge habitat, which grassland birds avoid.

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. 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 30 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 low frequency mowing (≤1 per year) in September/October in conjunction with haying to prevent the buildup of plant biomass (Figure 47). Currently the park mows but does not perform haying operations. We chose the latter, because cultural landscape management places some constraints on the natural resource management of grasslands at JOFL (i.e., prescribed burning poses many obstacles). The preferred management technique for warm season grasses is prescribed burning and the preferred management technique for cool season grasses is haying or mowing.

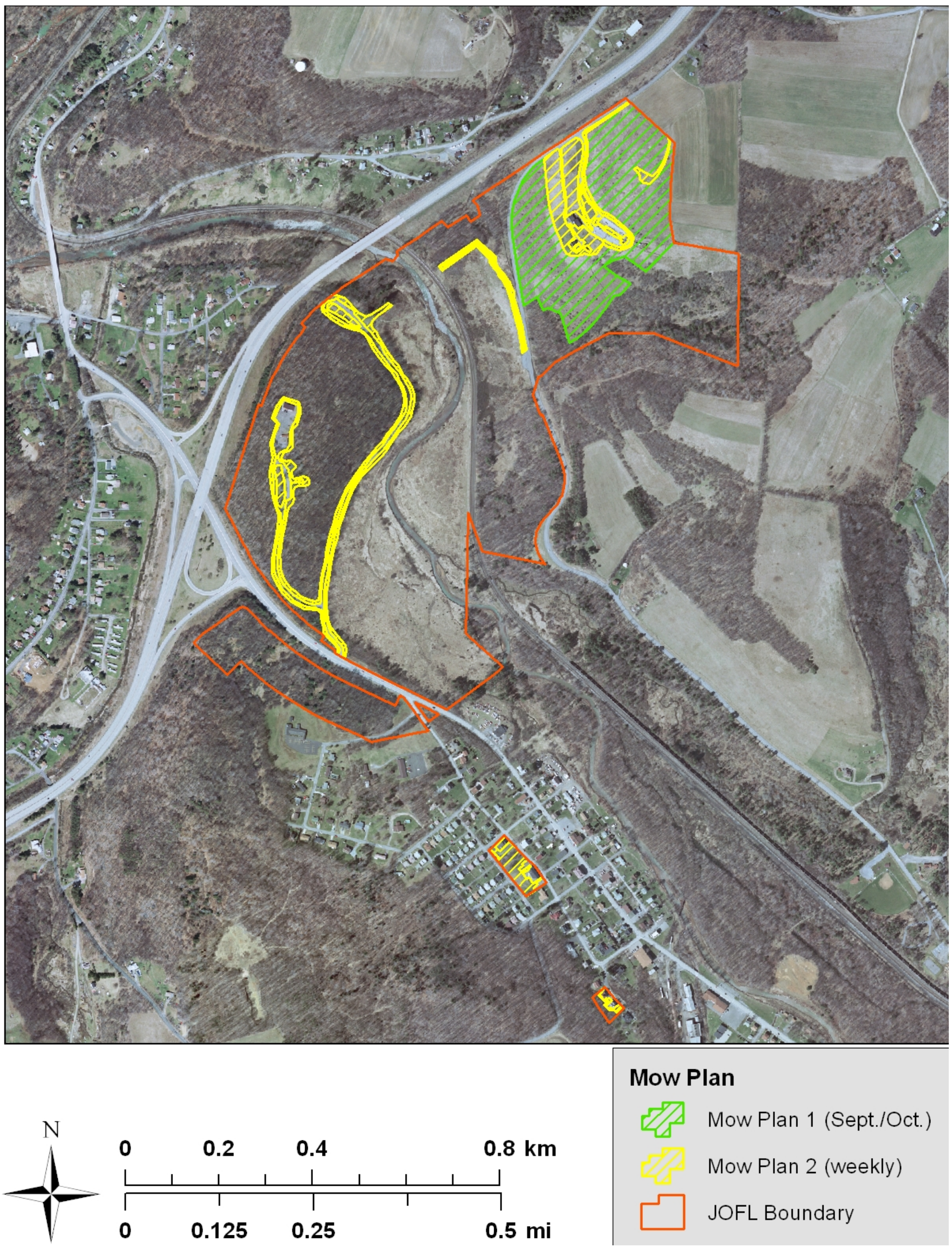


Figure 47. Scheduled Mow Plans at JOFL. Mow Plan 1 corresponds to the area designated as grassland Patch A.

Table 30. Descriptions of metrics and scoring criteria used to determine the condition of JOFL's grasslands.

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 or waterline 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.

Current Condition and Trends

Patch A (9.71 ha) represented all of the potential grassland area evaluated and was rated as 'moderate concern' for the minimum field size metric. Although the total patch size came close to the lower end of the good condition category (Table 31), the Visitor's Center nearly bisects Patch A, which may render this patch as two smaller patches. We chose to interpret Patch A as one patch; however, since a grassland strip connecting the patches remained (Figure 46). Despite the central location of the Visitor's Center, the perimeter to area ratio for Patch A was still relatively low (0.028), which corresponds to a condition score of 40.8 (*moderate concern*). Nearly 100% of the patch is mowed once in September/October. Thus, this metric rated as *good* condition (Table 31).

Table 31. Minimum field size, perimeter:area ratio, and mowplan metric results and condition categories for JOFL potential grassland habitats.

MINIMUM FIELD SIZE			
PATCH ID	Field Size (ha)	Condition Category	Condition Symbol
A	9.71	Moderate Concern	
PERIMETER:AREA RATIO			
PATCH ID	Condition Score (0-100 scale)	Condition Category	Condition Symbol
A	40.8	Moderate Concern	
MOWPLANS			
% Potential Grassland Area	Mowplan 1	Good Condition	

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 JOFL. However, considerable research has been conducted with respect to minimum field size requirements, area sensitivity, and mowing impacts on specific grassland species, including Eastern Meadowlarks, and 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 NHS/Johnstown Flood National Memorial

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

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

Wetlands

Relevance and Context

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. Wetlands at JOFL are likely impacted by atmospheric deposition of nitrogen, sulfur and mercury, waters impaired by acidic AMD, and other sources of anthropogenic pollution. All of these indicators were of significant concern at JOFL. However, as with the forest resources within the park, there are no studies that have been conducted within JOFL that can demonstrate the potential impact of the aforementioned pollutants and their interactions on park wetland resources. Therefore, at this point in the assessment we can only speculate with a reasonable degree of confidence that park wetland resources have been and are likely currently being impaired by one or more the anthropogenic factors mentioned above. To date, our best tool for assessing wetland health is the vegetation community. Hence, Floristic Quality Assessment (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.

The Johnstown Flood National Memorial (JOFL) is a mixture of forest, old field, and wetland habitats (Perles et al. 2006). Wetlands occur primarily along the South Fork Little Conemaugh River and include scrub shrub (Silky Willow Shrub Swamp) and emergent habitats (River Scour and Cattail Marsh) (Figure X). Other wet areas are found in old field habitats within the remnant lake bed and below the Unger Farm.

Over the past 25 years, there have been seven vegetation surveys within JOFL; five of these surveys have studied and classified wetlands: Melton (1982), Grund and Bier (2000) Western Pennsylvania Conservancy (2003), Perles et al. (2006), and Keller Engineers, Inc. (2009).

In his survey in 1981, Melton (1982) described the occurrence of "moist sites" within old field habitat in the park. The dominant species included rough-stemmed goldenrod (*Solidago rugosa*), jewelweed (*Impatiens capensis*), panicled aster (*Symphyotrichum lanceolatum*), panic grass (*Dichanthelium* sp.) wild rye (*Elymus riparius*), *Scirpus, Cyperus, Carex,* choke cherry (*Prunus virginiana*), elm-leaved goldenrod (*Solidago ulmifolia*) grass-leaved goldenrod (*Euthamia graminifolia*), trumpetweed (*Eutrochium fistulosum*), rice cutgrass (*Leersia oryzoides*) and Morrow's honeysuckle (*Lonicera morrowii*). In addition, he recorded 65 other species in these areas including native and non-native forbs, shrubs, trees, and vines.

Grund and Bier (2000) surveyed species of special concern in JOFL in 1998-1999. In their report, they describe an extensive wetland complex adjacent to the South Fork dominated by willow (*Salix* spp.) cattail (*Typha angustifolia*), rice cutgrass, tussock sedge (*Carex stricta*), aster (*Symphyotrichum* sp.) and rough-stemmed goldenrod. Other species observed included narrow-leaved goldenrod, woolgrass (*Scirpus cyperinus*), lurid sedge (*Carex lurida*), Canada goldenrod (*Solidago altissima*), roundleaf goldenrod (*Solidago patula*), watercress (*Nasturtium officinale*), soft rush (*Juncus effusus*), sensitive fern (*Onoclea sensibilis*), Allegheny blackberry (*Rubus allegheniensis*), arrow-leaved tearthumb (*Polygonum sagittatum*), blue vervain (*Verbena hastata*), rattlesnake grass (*Glyceria canadensis*) and ironweed (*Vernonia noveboracensis*).

The 2003 Western Pennsylvania Conservancy survey identified three distinct wetland communities, Mix-Shrub/Wet Meadow/Successional Herbaceous Opening Mosaic, Rocky Riverbank, and Wet Meadow/Cattail Marsh Mosaic, providing a qualitative description of each type, its distribution within the park, and a species list.

In a vegetation classification study in 2004, Perles et al. (2006) collected data from 17 plots located within different habitat types and devised four wetland associations: Cattail Marsh, River Scour Vegetation, Silky Willow Shrub Swamp, and Old Field (Wet Variation). In their report, they provide detailed information for each association including distribution within the park, environmental characteristics, and species composition (Figure 48).

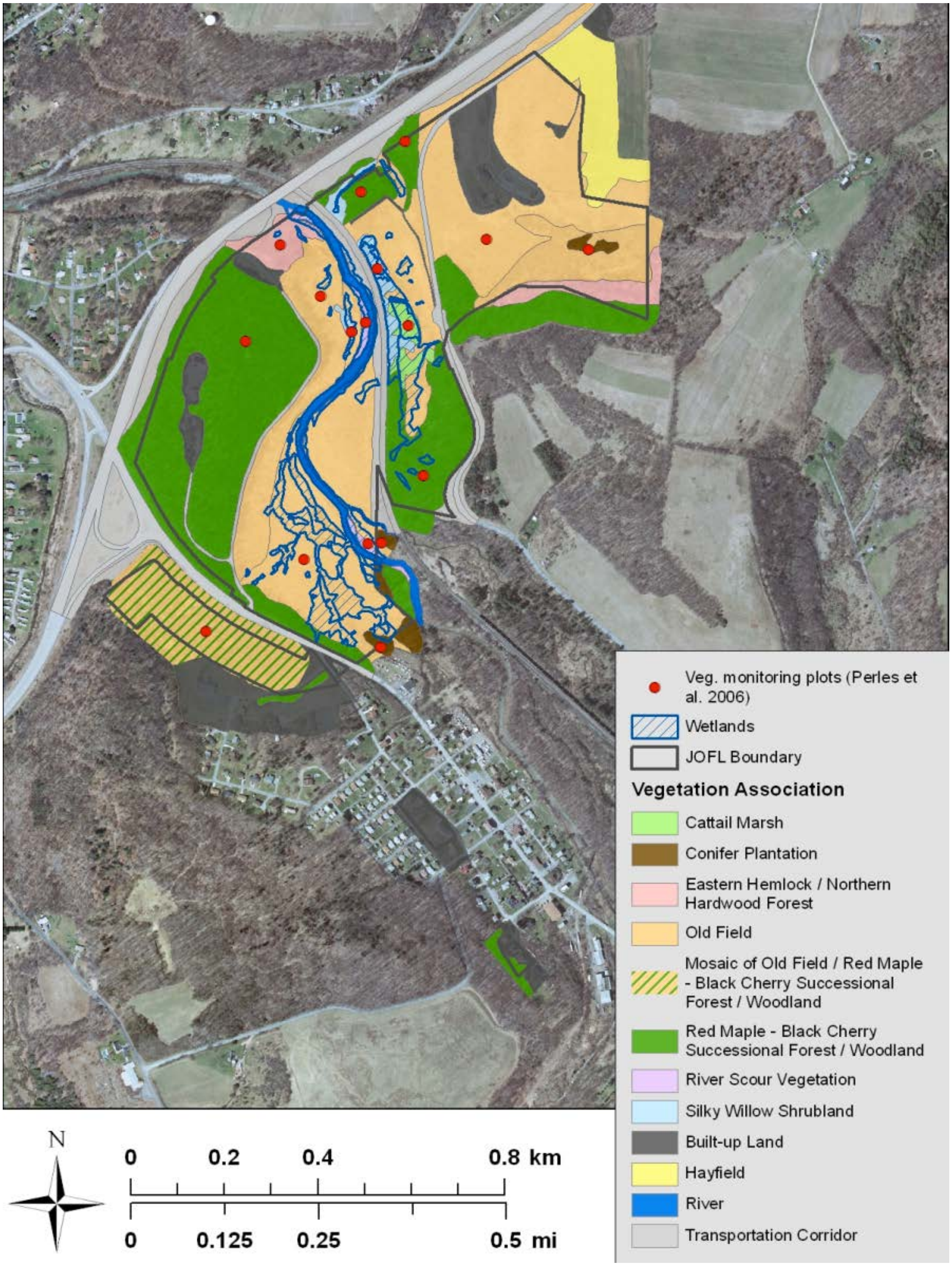


Figure 48. Wetland associations mapped within JOFL in 2004 (Perles et al. 2006) showing plot locations. Wetland boundaries are from a Keller Engineers wetland delineation study for JOFL performed in 2009.

In a concurrent study on invasive species in 2004, Zimmerman (2007) identified 21 non-native species in River Scour Vegetation, five in Cattail Marsh, 12 in Silky Willow Shrub Swamp and 42 in Old Field. In his tally, Zimmerman did not distinguish between the three subtypes described by Perles et al. (2006), so it is likely the number of actual non-native species in the wetter areas of Old Field is lower. The four wetland types classified by Perles et al. (2006): Cattail Marsh, River Scour Vegetation, Silky Willow Shrub Swamp, and Old Field (Wet Variation) are described briefly below. Wetlands were not sampled as part of the ERMN Vital Signs Monitoring Project in 2007-2009 (Perles et al. 2010).

Cattail Marsh is found in low-lying areas of JOFL adjacent to and partially impounded by the railroad berm. In these areas, standing water is present for most of the growing season and the underlying soil is a very poorly drained muck. The herbaceous layer is dense, covering approximately 85% of the association with broadleaf cattail (*Typha latifolia*), rice cutgrass (*Leersia oryzoides*), jewelweed (*Impatiens capensis*), and swamp verbena (*Verbena hastata*) as the dominant species. Other common plants include common rush (*Juncus effusus*), wool grass (*Scirpus cyperinus*), Allegheny monkeyflower (*Mimulus ringens*), watercress (*Rorippa nasturtium-aquaticum*), and climbing nightshade (*Solanum dulcamara*).

***River Scour* Vegetation** occurs on low terraces and cobble bars adjacent to the Little Conemaugh River channel. Vegetation cover in this area is highly variable and soils are well-drained sand and cobble. Where vegetation is sparse, these areas typically support a high percentage of bare sand and cobble. Scour events, the result of elevated water levels in the South Fork, are frequent and greatly influence plant species composition in this association. Scour events expose new substrate and allow new seed and propagules from a variety of sources to establish. Plants that establish in these areas are often disturbance-oriented and weedy. This includes species typical of floodplain scour zones and many non-native, invasive plants species typical of old fields and successional habitats.

Riverine Scour habitats in JOFL are a mixture of steeplebush (*Spiraea tomentosa*), river birch (*Betula nigra*), Scotch pine (*Pinus sylvestris*), autumn olive (*Elaeagnus umbellata*), black locust (*Robinia pseudoacacia*), red maple (*Acer rubrum*), Tatarian honeysuckle (*Lonicera tatarica*), Allegheny blackberry (*Rubus allegheniensis*), and black raspberry (*Rubus occidentalis*). The understory is comprised of spotted joepyeweed (*Eupatorium maculatum*), goldenrods (*Solidago canadensis, S. gigantea, S. speciosa, S. rugosa*), narrowleaf plantain (*Plantago lanceolata*), ox eye daisy (*Leucanthemum vulgare*), deertongue (*Dichanthelium clandestinum*), sweet vernalgrass (*Anthoxanthum odoratum*), common boneset (*Eupatorium perfoliatum*), jewelweed (*Impatiens capensis*), and common wood sorrel (*Oxalis stricta*). Perles et al. (2006) indicate that giant knotweed (*Polygonum sachalinense*) and spotted knapweed (*Centaurea biebersteinii*) can be invasive in this association.

Silky Willow Shrub Swamp occurs in a low-lying area adjacent to and partially impounded by the railroad berm. The area is very poorly drained and standing water persists for most of the growing season. Silky willow (*Salix sericea*) is the dominant species. This association also supports a dense herbaceous layer of hydrophytic (wetland) species, most notably fringed loosestrife (*Lysimachia ciliata*), broadleaf cattail (*Typha latifolia*), fowl mannagrass (*Glyceria striata*), rice cutgrass (*Leersia *oryzoides*), common rush (*Juncus effusus*), jewelweed (*Impatiens capensis*), flat-top goldentop (*Euthamia graminifolia*), and rough bedstraw (*Galium asprellum*). Other herbaceous species present to a lesser extent include swamp verbena (*Verbena hastata*), wrinkleleaf goldenrod (*Solidago rugosa*), sensitive fern (*Onoclea sensibilis*), climbing nightshade (*Solanum dulcamara*), sedges (*Carex stipata, C. stricta, C. rosea, C. crinita, C. folliculata, C. lurida*), steeplebush (*Spiraea tomentosa*), common boneset (*Eupatorium perfoliatum*), cinnamon fern (*Osmunda cinnamomea*), reed canary grass (*Phalaris arundinacea*), and skunk cabbage (*Symplocarpus foetidus*). Perles et al. (2006) indicate that this association is susceptible to invasion by Morrow's honeysuckle (*Lonicera morrowii*).

Old Field (Wet Subtype) is found in low-lying sections of the former Lake Conemaugh and includes a large contiguous patch near the southwest boundary of the park, as well as some additional scattered patches around the lakebed. These areas may be saturated for part of the year and the underlying hydrology, drainage outlets from nearby park roads and highways, as well as management activities in the lakebed, greatly influences vegetative species composition. Wrinkleleaf goldenrod (*Solidago rugosa*) is often the dominant forb with lesser amounts of arrowleaf tearthumb (*Polygonum sagittatum*), sedges (*Carex scoparia, C. lurida, C. vulpinoidea*), purplestem aster (*Symphyotrichum puniceum* var. *puniceum*), rice cutgrass (*Leersia oryzoides*), spikerush (*Eleocharis* spp.), common rush (*Juncus effusus*), hardstem bulrush (*Schoenoplectus acutus* var. *acutus*), creeping bentgrass (*Agrostis stolonifera*), and rough bentgrass (*Agrostis scabra*). Patches of broadleaf cattail (*Typha latifolia*) are present in this subtype as well as purple crownvetch (*Coronilla varia*) and reed canary grass (*Phalaris arundinacea*), two invasives that are present in abundance. Crownvetch is a non-native, invasive species but reed canary grass can be either native or non-native and requires expert identification to distinguish between the two species. Big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and switchgrass (*Panicum virgatum*) planted in the lakebed as part of restoration activities, are also prevalent throughout.

Methods

We evaluated wetland condition by first examining 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.

Wetland Habitat

Because wetland habitats were not sampled during the 2007-2009 ERMN Vital Signs Vegetation Monitoring (Perles et al. 2010), we used the 2004 vegetation classification data (Perles et al. 2006) to estimate wetland condition. This data set included five plots sampled in the four wetland associations mapped within the park (a single plot in Cattail Marsh, Silky Willow Shrub Swamp, and Old Field [Wet Subtype] associations each and two plots in the Riverine Scour Vegetation association). We used Floristic Quality Assessment (FQA) to assess wetland habitats within JOFL based on vegetation classification plots (Perles et al. 2006). 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 JOFL.

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). For each association, we calculated the FQI score and $\overline{C}$.

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) using wetland polygons delineated by Keller Engineers, Inc. (2009). 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 non-riverine 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 32. Non-riverine wetlands were scored similarly but for landcover within a 500-m buffer area surrounding the wetland.

Table 32. Classification of natural systems (based on Anderson Level 1 classifications) used to score landscape connectivity metrics for both riverine and non-riverine 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 JOFL. The surrounding land use index incorporated the rankings shown in Table 33, and the proportion of each land cover class found within the entire contributing watershed for JOFL (HUC-8 watershed boundary).

Table 33. 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

<u>Reference Condition</u>

Wetland Habitat

For FQA metrics (i.e. FQI and $\bar{C}$), we used condition ranks developed for headwater wetland habitats in the Allegheny Physiographic Province of Pennsylvania.This data set includes 25 headwater complex wetlands (floodplain, riparian depression and slope) sampled as part of Riparia's reference wetland collection of 227 sites throughout the Commonwealth (Brooks et al. 2004). Reference sites span a range of condition from highly to least disturbed and provide the closest approximation of a reference standard for headwater wetland habitats on the Allegheny Plateau. Headwater wetlands were selected as reference standard since wetlands mapped within JOFL fell within this hydrogeomorphic subclass (Keller Engineers, Inc. 2009).

We trisected reference data into three condition categories for both FQI and $\bar{C}$ (Tables 34 and 35). Trisection was accomplished by first calculating the 95% percentile of the population distribution, then trisecting the range from 0 (the lowest possible value) to the 95th percentile value (Karr et al. 1999). The top one-third of the range was assigned a rank of *good*, the middle a rank of *moderate concern* and the lower a rank of *significant concern*.

Table 34. Condition categories for Wetland Associations based on FQI score.

FQI Score	Condition	Symbol
36 - 53	Good	●
19 - 35	Moderate Concern	●
0 - 18	Significant Concern	●

Table 35. Condition categories for Wetland Associations based on $\bar{C}$ value.

$\bar{C}$	Condition	Symbol
3.4 – 5.3	Good	●
1.8 – 3.3	Moderate Concern	●
0 – 1.7	Significant Concern	●

Table 36. 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 200m 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

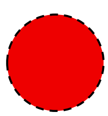
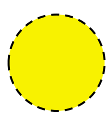
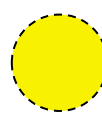
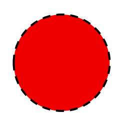
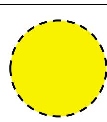
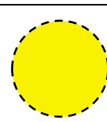
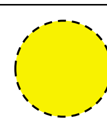
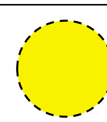
Wetland Habitat

Wetlands within JOFL ranged in condition from moderate to significant concern based on FQI score and moderate concern based on $\bar{C}$ value (Tables 37 and 38). Low to moderate condition ranks for wetland associations result from the presence of non-native species or a high number of species with low conservatism values. For example, although only two non-native species were observed in Cattail Marsh, most of the remaining native species had a coefficient rank of 3 or less. Taxa with coefficient ranks from 0-3 are considered weedy generalists and their presence indicative of low habitat quality. River Scour Vegetation was the only association to score significant concern. This association, in addition to supporting non-native species and native species with low conservatism, also contains two highly invasive species: Morrow's honeysuckle and Japanese knotweed. Intermittent flood scouring which is conducive to the establishment of weedy plants makes management efforts in this area challenging. Because the spread of knotweed to new sites is facilitated by disturbance (Beerling 1991), and the occurrence of large seed source populations upstream on the SFLCR, continued vigilance of this area is critical to manage this species and curtail its spread.

Table 37. Floristic Quality Metrics for wetland associations within JOFL (Perles et al. 2006).

JOFL Metrics	Cattail Marsh (n=1)	Silky Willow Shrub Swamp (n=1)	Old Field (Wet Subtype) (n=1)	River Scour Vegetation (n=2)
FQI	18.4	27.1	22.6	15.2
$\bar{C}$	2.1	3	2.6	1.9

Table 38. Condition Assessment Metrics for JOFL Wetland Associations.

JOFL Metrics	Cattail Marsh (n=1)	Silky Willow Shrub Swamp (n=1)	Old Field (Wet Subtype) (n=1)	River Scour Vegetation (n=2)
FQI				
$\bar{C}$				

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 as well as non-native 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 33). 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 river scour vegetated wetland areas (including some Morrow’s honeysuckle and Japanese knotweed) described by Perles et al. (2006), and are, therefore, reflected in the FQI score (higher for more natural communities), and to some extent in the lower $\bar{C}$ value scores for those two communities. The other more natural wetland types, Cattail, Silky Willow, and Old Field have scores suggesting a higher condition, but only slightly as these vegetation associations do not have entirely native species or species with high coefficient of conservatism ranks.

When comparing the wetland metrics to the landscape metrics, one can see that the surrounding landscape does contain significant proportions of natural habitat, including forest. 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 39). The landscape both within the park boundary and within the greater watershed boundary also contains anthropogenic land cover that affects the continuous connectivity of natural land cover and width of natural buffers around wetlands.

Table 39. Condition results for JOFL wetlands within a landscape context.

METRIC		METRIC RESULT	CONDITION RATING
Landscape Connectivity	Riverine	Non-buffer segments between 200 - 800m	
	Non-Riverine	53% natural habitat	
Buffer Index	Length	98% of occurrence perimieter	
	Width	50 - 99m	
Surrounding Land Use Index		Score = 0.91	

Data Gaps and Confidence in the Assessment

The confidence in this assessment is *low*. The Perles et al. (2006) survey was the only study to formally sample wetlands and the total number of plots for all wetland associations was five. Our assessment, therefore, is based on a single vegetation plot per association (two plots were sampled in River Scour Vegetation), sampled at a single point in time, and thus, providing minimal information on condition. The lack of sufficient time series data also precludes an analysis of trends. In order to draw meaningful conclusions on the condition of wetlands in JOFL, wetland associations should be added to the current Vital Sign multi-year monitoring effort. Nonetheless, our assessment provides a preliminary snapshot of overall condition for wetlands within the park and can be used as a baseline for continuing monitoring efforts.

Biological Integrity

Species of Concern

Relevance and Context

A continued concern with NPS 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 and habitat restoration and are evaluated for potential impacts from management actions. JOFL maintains a list of concern species that include plants, birds, mammals and other taxa. A subset of this species list was found during early special concern species survey efforts. These species included Appalachian blue violet (*Viola appalachiensis*), veiny-lined aster (*Symphyotrichum praealtum*), and northern myotis (*Myotis septentrionalis*). Three species of concern that were not included in the NRCA due to various reasons (e.g., uncertainties regarding their status within the park) were the Golden-winged Warbler (*Vermivora chrysoptera*), Blackpoll Warbler (*Dendroica striata*) and smooth green snake (*Liochlorophis vernalis*). Although we do not provide condition assessments for these latter species, we do include brief descriptions for each to recognize their importance and in the event of any future change in their status and importance to park management. 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, several species mentioned above are currently under consideration for federal listing by the US Fish and Wildlife Service under the Endangered Species Act of 1973. Management actions and projects within the park are coordinated with the appropriate state and federal agencies to ensure cross-boundary communication for special status species.

Appalachian Blue Violet – is a low growing herb that is often found in serpentine barrens and rich forests along the southern Appalachian Mountains. The Appalachian blue violet is a perennial herb that forms into mats during the late season, from upright growing stems that eventually lay flat and grow roots. It grows well in disturbed areas, and can be found in dirt roads, mowed areas and old farm fields. Its range is restricted to Pennsylvania, West Virginia, Maryland, and North Carolina. Appalachian blue violet is a Pennsylvania State imperiled (S2) plant species, globally vulnerable (G3) and is primarily imperiled due to its limited global range (See Table 40 for conservation ranking definitions). It is also thought that it is frequently overlooked and may be more common than records indicate; as it was once thought to be a hybrid species of Walker’s violet (*V. walkeri*) and American dog-violet (*V. consersa*).

Veiny-lined Aster **–** also known as willow aster, (*Symphyotrichum praealtum* a.k.a. *Aster praealtus*), has no current legal status in Pennsylvania, but the Pennsylvania Natural Heritage Program proposed ranking is Tentatively Undetermined. Veiny-lined aster grows in wet, but not inundated, open habitats throughout most of eastern North America. In general, wetland species in Pennsylvania have declined due to wetland draining and filling, and indirect impact to ecosystem health.

Northern Myotis **–** also known as Northern long-eared bat, 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 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. White-nose syndrome is a disease caused by a fungus that is believed to have originated in Europe. It affects hibernating bats and causes them to use all their winter fat 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). Recently the Fish and Wildlife Service announced a 12-month finding to list this species as endangered throughout its range is warranted and will receive protection under the Endangered Species Act with a final ruling anticipated for fall of 2014.

Northern myotis (Myotis septentrionalis). Photo by Josh Johnson

Golden-winged Warbler **–** is a small passerine that uses primarily early-successional habitat and requires a unique combination of sparse trees and shrubs with a dense understory of grasses, forbs or wetlands. They eat primarily insects, including moths, caterpillars, spiders and other insects found by probing with their sharp bill. Its breeding range was once expansive, covering the upper Midwest and Appalachian Mountains, but has since been restricted to a small portion of Minnesota and a small section of the Appalachians. The population in Minnesota is the stronghold of its current range, which retains the highest population density. Golden-winged warbler is ranked as a Pennsylvania State breeding secure (S4B) species, and globally secure (G4), but is declining due to habitat loss and fragmentation from early successional habitat growing to mature forest without replacement and human development in upland and wetlands areas. Competition and hybridizing with its close relative, the Blue-winged Warbler (*Vermivora cyanoptera*) has also contributed to its decline. Currently, the Golden-winged Warbler is considered a migratory species that may be present in the park. Final determination of its status from a park management perspective will depend on several factors, including (1) documentation of breeding populations in the park, (2) monitoring of hybridizing with the Blue-winged Warbler, which is known to breed in the park, and (3) changes to its conservation status at the state or federal levels. It is currently being considered for federal listing by the US Fish and Wildlife Service under the Endangered Species Act of 1973.

***Blackpoll Warbler* –**is a common bird in northern boreal forests that winters in the Caribbean. Although the global population of this species is considered stable, it was recently listed as endangered by the Pennsylvania Game Commission and has been detected at JOFL (Yahner et al. 2001). Timber harvesting and fragmentation from development and roads has greatly reduced the extent of its habitat. The birds nest in high elevation spruce forests, which are relatively rare in Pennsylvania. They eat a variety of insects, including budworms and other pests, and are considered beneficial to forest health. From a park perspective, managing for breeding habitat is not feasible or practical; at best, JOFL can provide migratory habitat for this species.

***Smooth Green Snake*—**this small, bright green snake can be found in both wetland (e.g., herbaceous and scrub-shrub) and terrestrial (e.g., grassland, old field) habitats where it can burrow into soil or loose debris. Groups of individuals may hibernate in abandoned ant mounds. Their primary diet is small invertebrates. Its global rank is considered secure (G5), due primarily to an extensive range, but it is common only in some local areas and is considered vulnerable in the state (S3). Grassy fields, wet meadows, stream edges, and other potential habitats for the smooth green snake exist throughout the park. Yahner and Ross (2006) detected four individuals of this species in 2004 and 2005.

Table 40. The conservation status of a species is represented by a combination of a letter, reflecting the appropriate geographic scale of the assessment and a number from 1 to 5, illustrating the level of conservation concern category.

Geographic Scale	Code	Conservation Status	Code
Global	G	Critically Imperiled	1
National	N	Imperiled	2
Subnational/State	S	Vulnerable	3
		Apparently Secure	4
		Secure	5

<u>Method</u>

The National Park Service Inventory and Monitoring Program commissioned several studies of rare plant and animal species. This included a 1998-1999 survey of rare plant and animal species at JOFL, which began with the Western Pennsylvania Conservancy conducting 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. Other species not targeted during field surveys were also found and recorded. A follow-up survey of plant communities and rare plant and animal species was initiated in 2001, also by The Western Pennsylvania Conservancy. In 2006, the Eastern Rivers and Mountains Network of the NPS Inventory and Monitoring Program contracted The Western Pennsylvania Conservancy to conduct an inventory of rare plant species found in the previous two studies.

The Eastern Rivers and Mountains Network of the NPS Inventory and Monitoring Program also contracted for a survey of bat species at JOFL through the Appalachian Laboratory of the University of Maryland Center for Environmental Science. Both acoustic and mist netting surveys of the bat community in 2004-2006 by Gates and Johnson (2007). The surveys focused on gaining basic information on the species distributions and activity of bats within the park.

Reference condition

Due to the limited quantitative data available for species of concern that occur within the boundaries of JOFL, our condition assessment was based on small scale surveys conducted in the park and relied primarily on best professional judgment. Threshold values for Appalachian blue violet, veiny-lined aster, northern myotis, or golden-winged warbler, 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-nose syndrome.

Current condition and Trends

***Appalachian Blue Violet* –** A small population of Appalachian blue violet was found at JOFL (WPC 2003). Additional surveys resulted in no additional colonies detected. The Western Pennsylvania Conservancy (2003) suggested that little suitable habitat was found for this species. The original population was discovered in nearly closed canopy habitat, which was unusual habitat for blue violets. Subsequent surveys of more appropriate habitat including open canopy and disturbed areas found two more small populations). Park monitoring has indicated that number of individual plants detected is highly variable from year to year, and the population overall may have declined slightly, likely due to changing mowing regimes.

***Veiny-lined Aster* –** A small population of veiny-lined aster was discovered during the survey initiated in 2001 by Western Pennsylvania Conservancy; however it was not a species of special concern at that time. Consequently, no additional documentation or survey detail was recorded for this species. Two thriving colonies of veiny-lined aster were documented when the WPC returned in 2006 to resurvey the area for rare plants.

***Northern Myotis* –** Surveys to examine bat use and activity were completed in 2004-2006 summer breeding seasons. Gates and Johnson (2007) surveyed using both acoustic and mist netting, but no buildings were examined for bat use. Northern Myotis, also known as Northern long-eared bats, were confirmed to be present in JOFL through both acoustic detection and mist-netting. There were two northern myotis captured from mist-netting, and their calls were recorded at 17% and 33% of acoustic monitoring locations surveyed in 2005 and 2006 respectively (Gates and Johnson 2007). Population estimates from these data were not included in the Gates and Johnson report (2007).

These records occurred prior to the widespread decline seen in bat populations throughout the northeast attributed to white-nose syndrome. White-nose syndrome was first detected in Pennsylvania in 2009. The US Fish and Wildlife Service have been petitioned to list northern myotis along with several other species, for federal protection under the Endangered Species Act of 1973 due to the precipitous decline in the bat community. The US Fish and Wildlife Service have since determined that the northern long-eared bat should be listed as endangered throughout its range due to white-nose syndrome. 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 the recent finding by the FWS to list the species as endangered (Table 41).

Table 41. Condition Assessment Metrics for JOFL Species of Concern. The condition assessments for Appalachian Blue Violet and Veiny-lined Aster are based on very little data and have a very low confidence measure. Northern Myotis (now called the northern long-eared bat) has a medium confidence measure due to the recent listing for endangered status by the US Fish and Wildlife Service.

Appalachian Blue Violet	Veiny-lined Aster	Northern Myotis
		

Data Gaps and Confidence in the Assessment

Special status and management species data were limited for JOFL. 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. Also, data for the northern myotis was collected prior to the white-nose syndrome decline, and no species specific surveys for golden-winged warbler were conducted to establish initial condition.

Source of expertise

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

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; Owens et al. 2003). Intermediate frequency echolocation used by the silver-haired bat, eastern red bats, or tricolored bat formerly known as the Eastern pipistrelle), 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. The National Park Service 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). 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. 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).

<u>Method</u>

The park commissioned an 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. The Gates and Johnson (2007) study was completed using acoustic detection and mist netting techniques. Mist net surveys were completed at 2 sites totaling 26 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 49). Acoustic surveys were conducted at 6 sites using the AnaBat II (Titley electronics, Ballina, Australia) for 20 minutes at each site between sunset and 0200 hours (Gates and Johnson 2007).

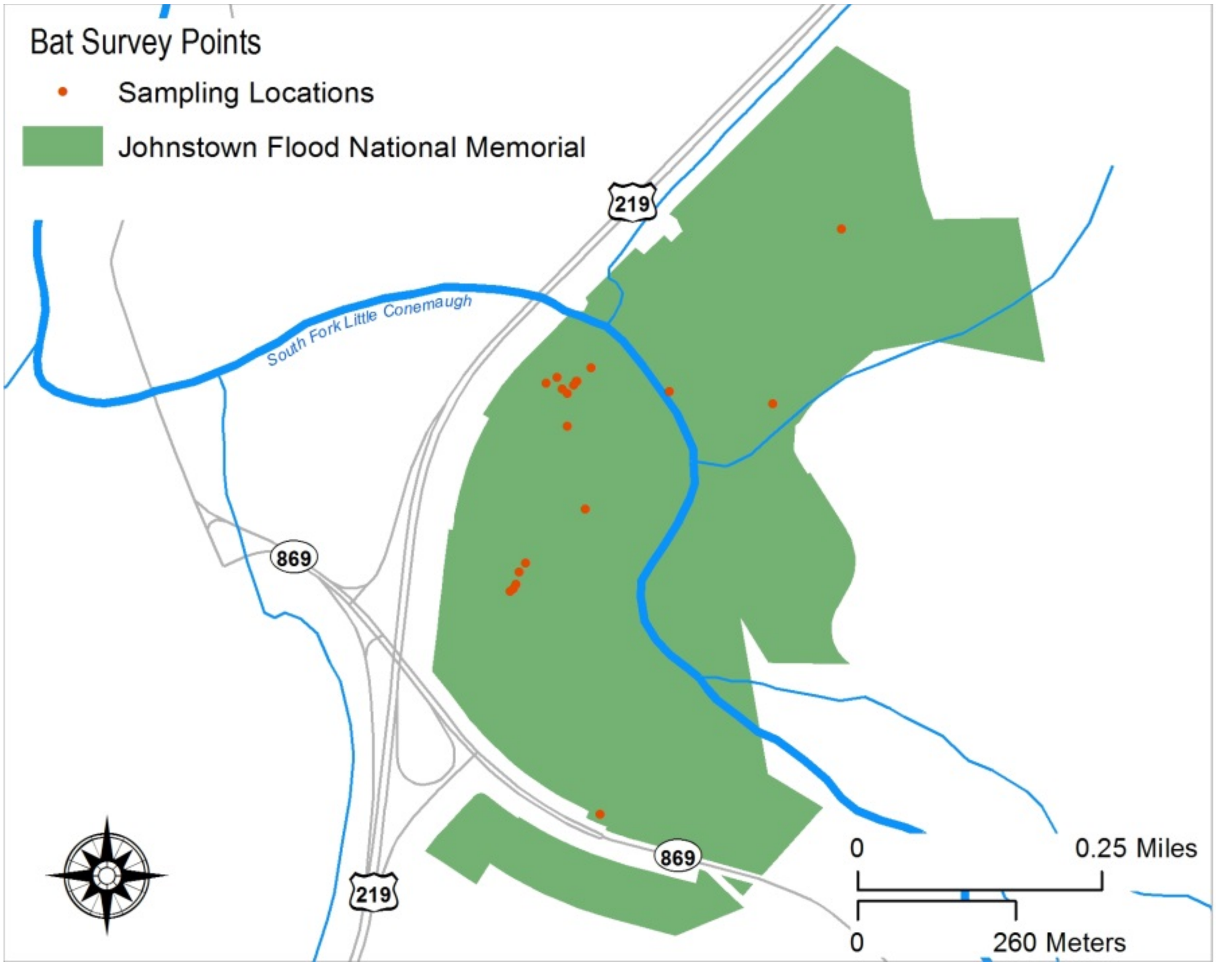


Figure 49. Mist-netting and acoustic detection sites administered to survey the bat community during the Gates and Johnson study in 2005-2006.

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 on known habitat requirements or species commonly occurring in the state during the summer months (Gates and Johnson 2007). These nine species 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. Condition categories for the percentage of species found within the park are listed below (Table 42). The species identified as potentially occurring within JOFL 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*) also known as the northern long-eared bat, Indiana bat (*M. sodalis*), and tricolored bat (*Perimyotis subflavus*) formerly known as the eastern pipistrelle (*Pipestrellus subflavus*).

Table 42. 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

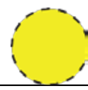
The park-wide inventory completed by Gates and Johnson in 2005-2006 resulted in 26 mist-net nights and 473 echolocation passes recoded through acoustic monitoring. They captured 24 bats including: nine little brown bats, 13 big brown bats, and two northern myotis from mist-netting. Eastern red bats were recorded at more acoustic monitoring sites than any other species of bat, but big brown bats had the highest activity levels as they were the most commonly detected species from the acoustic monitoring. The same species captured in mist-nets plus three additional species, the eastern red, hoary and tri-colored bats (formerly known as eastern pipistrelle) were detected during the acoustic monitoring.

Bat communities scored as *moderate concern* for species diversity park-wide (Table 43). Acoustic and mist-netting surveys completed in 2004-2006 found that 6 of the 9 species found in Pennsylvania, occur within the park. 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.

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

JOFL had among the lowest species richness measured during mist-netting, likely due to the difficulty in siting nets. There were no forested or riparian corridors to place nets that typically provide excellent habitat for capturing bat species (Gates and Johnson 2007). However, Indiana bats and eastern small-footed bats are very rare in Pennsylvania, and were unlikely to be detected in only 26 net nights. Gates and Johnson (2007) calculated the Simpson's diversity index as 0.583 and a Simpson's measure of evenness as 0.756, indicating low species diversity, but high 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 2004-2006 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 43. Condition Assessment Metrics for JOFL Bat Communities.

Metric	Park-wide
Bat Species Diversity	

Data Gaps and Confidence in the Assessment

The Gates and Johnson surveys conducted over the 2004-2006 sampling period was the only intensive bat inventories that have been conducted within the park, therefore, no trend data are available for this metric. Future monitoring should occur on a regular schedule and include both potential roost inspection and acoustic monitoring during the breeding season.

Source of expertise

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

Bird Communities

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. Although not reported here, state-wide monitoring efforts conducted by researchers and assisted by skilled amateurs have provided regional population trend data for southwest Pennsylvania.

The ERMN considers streamside bird monitoring to be a vital sign indicator of condition. Streamside refers to bird species that occur within the area surrounding streams within a park, and 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). Unfortunately, JOFL does not have sufficient wadeable stream length within the park to conduct streamside bird surveys. Thus, we do not have ERMN monitoring data for this indicator at JOFL. However, two inventory reports (Yahner and Keller 2000; Yahner et al. 2001) were previously conducted for JOFL. In addition, regional bird surveys for the area around JOFL were conducted for the Breeding Bird Atlas (BBA) during two time periods (1983-89) and (2004-09) (Brauning 1992, Wilson et al. 2012). Although the inventory surveys and BBA data were not designed to monitor condition, they represent the only data available at JOFL for this important indicator of ecological condition and do contain sufficient information to calculate a BCI, albeit with low confidence.

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

Method

The JOFL bird community assessment consists of two parts: 1) results from breeding season point-count data (n=10) in the Yahner et al. (2001) report were used to calculate a BCI and estimate condition within the park, and 2) results from the two BBA surveys (experienced field teams and volunteer data) were used separately to calculate BCIs and estimate regional condition. Experienced field teams conducted point counts at eight locations within each BBA block. BCI scores were processed for each of the nine BBA blocks nearest to and including JOFL to facilitate comparisons to the data reported by Yahner et al. (2001). To provide a more general assessment of the regional condition BCI scores were calculated from the volunteer collected data for all BBA blocks within 30 km of JOFL.

Inventory Surveys

The avian community was surveyed at JOFL 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 (i.e. breeding) seasons (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). Only the summer point-count data from the Yahner et al. (2001) report was used in the condition assessment.

This information was incorporated into the BCI to evaluate the condition of the bird community. The BCI 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 44). 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 (O'Connell et al. 1998a).

Table 44. 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 JOFL. Each block corresponds to 1/6th of a USGS topographic quad map (~24 sq km). BBA records (species detections) collected during spring-summer breeding season using experienced birders were used for this analysis. Survey protocols involved identifying eight randomly located road-side points and conducting 3-minute counts at each point. 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).

As a means of comparison with the inventory data collected by Yahner et al. (2001) BCI scores were also calculated based on the point count data collected by the experienced field teams. Due to the data volume this analysis was restricted to the nine BBA blocks nearest JOFL. Point count data were collected during the spring-summer breeding season using experienced birders. Survey protocols involved identifying eight randomly located road-side points within each BBA block and conducting 3-minute counts at each point. These scores were later compared to the inventory data collected within the park by Yahner et al. (2001).

We did not report trends within the park due to limited monitoring data. We did report a regional condition based on the 2004-2009 BBA results.

Reference Conditions

Reference conditions for 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 45). The final condition rating was based on the condition with the highest percentage of blocks/points.

Table 45. BCI Scores and associated condition ratings used in the JOFL NRCA.

BCI Score	Condition Rating	Symbol
52.1 – 77.0	Good	(green circle)
40.1 – 52.0	Moderate Concern	(yellow circle)
20.0 – 40.0	Significant Concern	(red circle)

Current Condition and Trends

Inventory Results

Avian community surveys were completed in the spring of 1997 to assess bird communities present during spring migration within the park (Yahner and Keller 2000). They detected 67 species during the four breeding season surveys along the JOFL transect. The eight most abundant species overall were red-winged blackbird, chimney swift, yellow warbler, chestnut-sided warbler, song sparrow, American goldfinch, indigo bunting, and common yellowthroat. During summer breeding season Yahner and Keller (2000) detected 43 species during the surveys along the JOFL transect. The 10 most abundant species of spring migration were red-winged blackbird, song sparrow, red-eyed vireo, indigo bunting, common yellowthroat, American robin, chestnut-sided warbler, eastern towhee, yellow warbler, and American goldfinch. Yahner and Keller (2000) found that during spring and breeding seasons they detected more short-distant migrants and resident species than long-distance migrants. When avian surveys were conducted two years later they found 94 species at JOFL (Yahner et al. 2001). These surveys documented 39 species not previously documented in the park, although differences may be due to different detection methods.

Yahner et al. (2001) conducted several surveys in the park including seasonal point counts and special roadside and owl surveys. BCI scores were calculated based on the spring breeding season point counts collected between April 30 and June 30. Point counts were conducted at 10 point locations and BCI scores ranged between 35.5 and 55.5 (mean = 44.25, S.D. = 6.1) (Fig. 50). One point location was in *good condition* while six points had a *moderate concern* and three were a *significant concern*. The overall BCI for JOFL placed it in *moderate concern*.

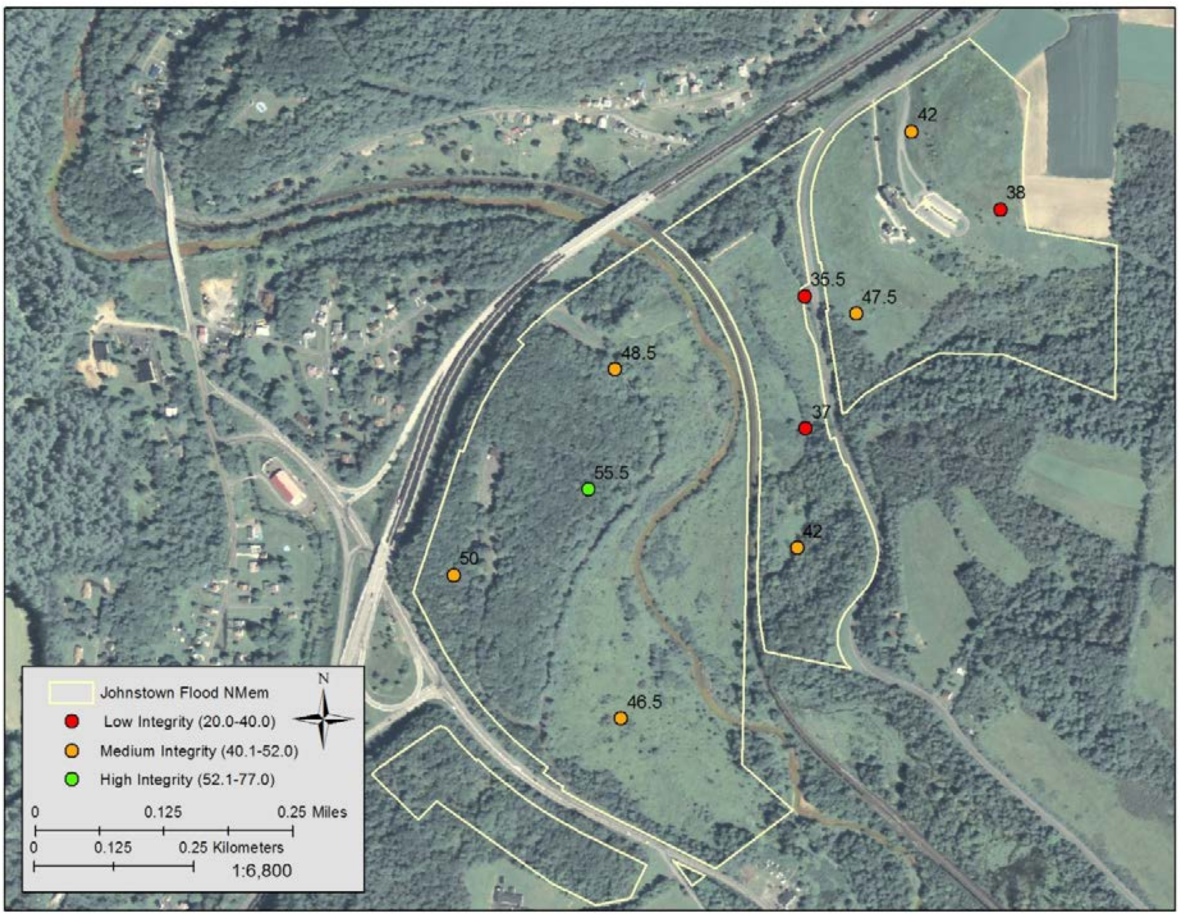
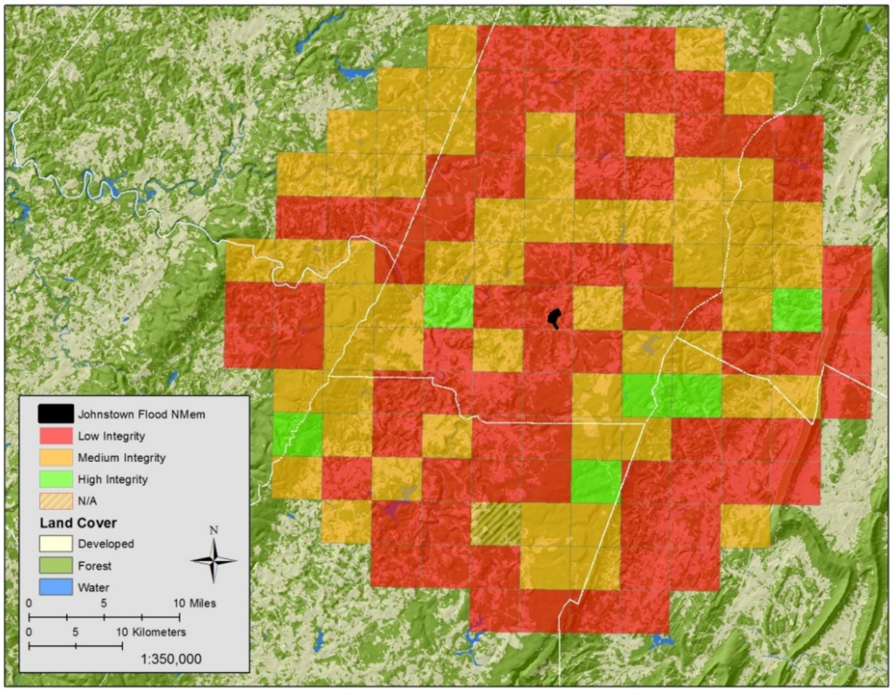
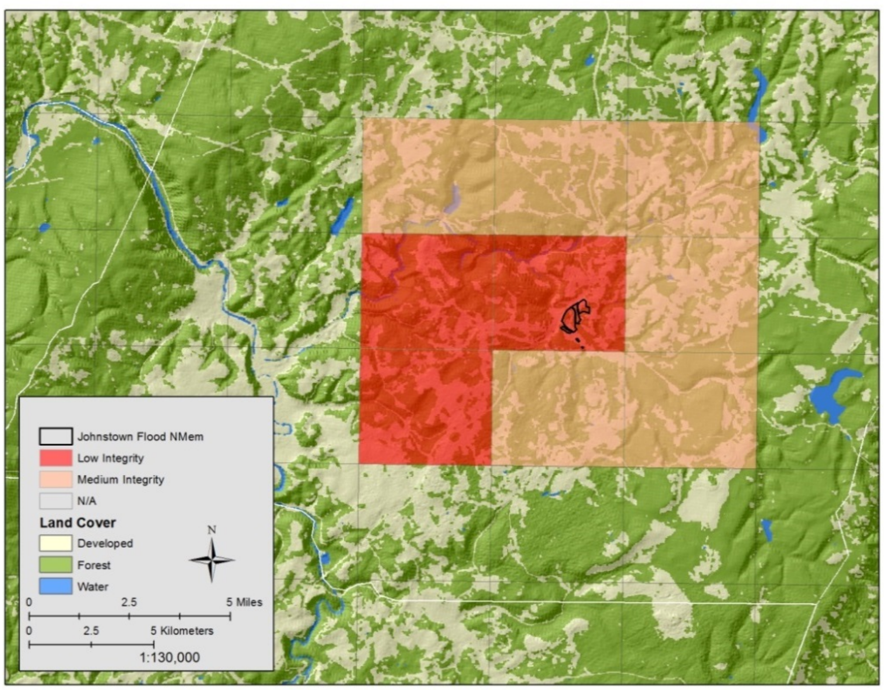


Figure 50. Map depicts the point count locations reported by Yahner et al. (2001) BCI scores were calculated for each point and shaded here to reflect condition.

Regional Survey Results (BBA)



a.)



b.)

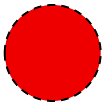
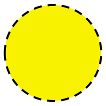
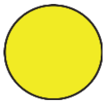
Figure 51. Regional results from the 2nd Pennsylvania Breeding Bird Atlas (BBA) study showing a) condition of each block from the 2004-09 volunteer data. The shading indicates condition based on each block's BCI score. b) Represents condition near to JOFL based on point count data collected by experienced field teams. Data were collected from eight point locations within each BBA block.

BCI scores for BBA blocks in the 2004-09 study were, based on data from atlas volunteers, primarily rated as warranting *moderate concern* or *significant concern* (Figure 50). This corresponds to the largest proportion of blocks (54.3%) as warranting *significant concern* and (41.3%) of the blocks with a moderate concern (Fig. 51a) (Tables 46 and 47). Based on data collected by the experienced field teams the nine BBA blocks closest to, and including, JOFL; six blocks were of moderate concern and three were a significant concern (Fig. 51b).

Table 46. Number and percentage of Breeding Bird Atlas (BBA) blocks from the 2004-09 study from the volunteer data and from the experienced field teams in each NRCA condition and trend category. Table includes BCI scores from the Yahner et al. (2001) report as well.

Condition Rating	Volunteer Data		Experienced Field Teams (Nearest to JOFL)		Point Counts (Yahner et al. 2001)	
	BCI (2004-09)	% of Blocks	BCI (2004-09)	% of Blocks	BCI (2004-09)	% of Blocks
Good	6	4.3	0	0.0	1	10
Moderate Concern	57	41.3	6	67.0	6	60
Significant Concern	75	54.3	3	33.3	3	30

Table 47. Condition assessment results (green = good and yellow = moderate concern) for JOFL inventory point-count surveys and 2004-09 Breeding Bird Atlas (BBA) study based on BCI scores. Regional condition represents the overall condition and trend from the BBA study results. The BBA data is based on species lists collected by both experienced birders following set protocols or volunteer birders (regional), as such, received a lower confidence rating (dashed border) than the park assessment.

Survey	Volunteer Data (Regional)	Experienced Teams (Nearest to JOFL)	Yahner et al. (2001) Inside JOFL
Condition			

Data Gaps and Confidence in Assessment

Avian community data were sparse for JOFL, and none of the data were intended for park-wide condition assessments. With the exception of point count data from Yahner et al. (2001), 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 due to few, if any, of the BBA point count locations completed by experienced observers occurred inside JOFL and that no avian monitoring or inventories have been completed for JOFL since 2001. One point of encouragement, as visible in Table 47, both BCI scores from data from experienced birders between

2004-2009 and reported by Yahner et al. (2001) reported similar results. Both of these analyses reflect the prevailing forest fragmentation inside and near to JOFL and future analyses should include processing the BBA data for a larger area. Inventory and monitoring surveys should be initiated and conducted at regular intervals to maintain trend data for species of interest. The BBA data provide a good regional view; however, 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 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

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

The National Park System may serve as 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. JOFL is known to support a wide variety of reptiles and amphibians that require both aquatic and terrestrial habitats, including the smooth green snake (*Liochlorophis vernalis*) which is listed as species of special concern in Pennsylvania by the Pennsylvania Fish and Boat Commission (Yahner and Ross 2006).

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

Method

Herptofauna were surveyed at JOFL from March to October in 2004 and 2005 by Yahner and Ross (2006) (Figure 52). The information presented in this report is the summary of their findings. Based on distribution maps and historic records of species occurrence, 45 species of herptofauna potentially occur within JOFL. These species include 17 species of salamander, 10 frogs and toads, 4 species of turtles, two lizards and 12 species of snakes (Table 48). 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).

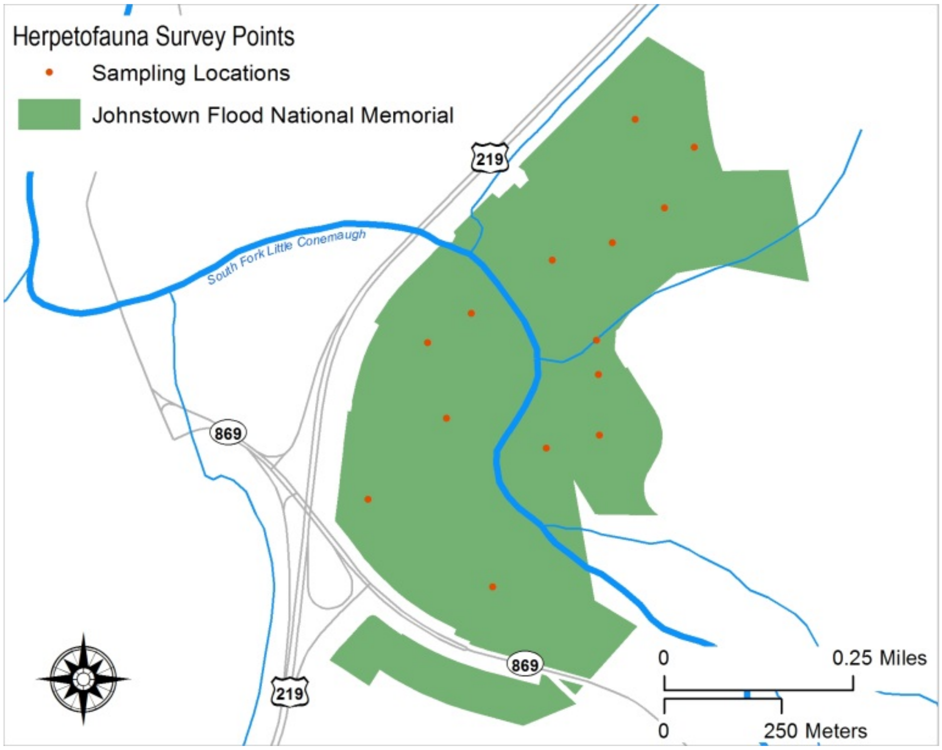


Figure 52. Herpetofauna sampling locations for the 2004 – 2005 inventory (Yahner and Ross 2006).

Table 48. 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*	1
Northern dusky salamander	*Desmognathus fuscus*	3
Seal salamander	*Desmognathus monticola*	0
Mountain dusky salamander	*Desmognathus ochrophaeus*	30
Northern two-lined salamander	*Eurycea bislineata*	5
Longtailed salamander	*Eurycea longicauda*	0
Northern spring salamander	*Gyrinophilus porphyriticus*	2
Four-toed salamander	*Hemidactylium scutatum*	1
Redback salamander	*Plethodon cinereus*	1
Northern slimy salamander	*Plethodon glutinosus*	80
Valley and ridge salamander	*Plethodon hoffmani*	0
Wehrle's salamander	*Plethodon wehrlei*	26
Northern red salamander	*Pseudotriton ruber*	0
Eastern American toad	*Bufo americanus*	22
Fowler's toad	*Bufo fowleri*	0
Gray treefrog	*Hyla versicolor*	0
Mountain chorus frog	*Pseudacris brachyphona*	0
Northern spring peeper	*Pseudacris crucifer*	665
Bullfrog	*Rana catesbeiana*	5
Green frog	*Rana clamitans*	39
Pickerel frog	*Rana palustris*	5
Northern leopard frog	*Rana pipiens*	0
Wood frog	*Rana sylvatica*	115

Reptiles

Common Name	Latin Name	Number Observed
Common snapping turtle	*Chelydra serpentina*	0
Painted turtle	*Chrysemys picta*	0
Wood turtle	*Glyptemys insculpta*	0
Eastern box turtle	*Terrapene carolina*	0
Northern fence lizard	*Sceloporusundulates hyacinthinus*	0
Five-lined skink	*Eumeces fasciatus*	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*	10
Northern water snake	*Nerodia sipedon*	1
Smooth green snake	*Opheodrys vernalis*	4
Northern brown snake	*Storeria dekayi*	1
Northern redbelly snake	*Storeria occipitomaculata*	12
Eastern garter snake	*Thamnophis sirtalis*	73
Northern copperhead	*Agkistrodon contortrix mokasen*	0
Timber rattlesnake	*Crotalus horridus*	0

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. Condition categories for the percentage of potential species that were found within the park are listed below (Table 49).

Table 49. 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 Rating	Symbol
>85%	Good	(green circle)
50 – 85%	Moderate Concern	(yellow circle)
<50%	Significant Concern	(red circle)

Current condition and Trends

The inventory survey completed by Yahner and Ross in 2004-2005 sampling period found 59% of expected amphibians and 44% of expected reptiles. Overall there was a 53% success rate of confirming the presence for 24 of the 45 expected species occurrence within the park (Figure 53). Ratios of observed to expected species were as follows: 6/10 frogs (60%); 10/17 salamanders (59%); 0/4 turtles (0%); 0/2 lizards (0%); and 8/12 snakes (67%). Northern slimy (n = 80) and Wehrle's salamanders (n = 26) were the most commonly captured terrestrial salamanders, whereas mountain dusky (n = 30) and northern two-lined salamanders (n = 5) were the most abundant aquatic salamanders captured at JOFL (Yahner and Ross 2006). Herptofauna communities scored as *moderate concern* for the limited success rate of species confirmed park-wide from those expected due to their range (Table 50).

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. The park is at the geographic boundary of several species distributions (e.g., mudpuppy, northern leopard frog, and northern fence lizard) and although habitat exists for these species, it is unlikely that they were present during the inventory (Yahner and Ross 2006). Additionally, painted turtle and gray treefrog are conspicuous species that went undetected during two years of surveys indicating that these species likely do not occupy the park. These non-detections are reducing the overall success rate of the inventory without evidence that they ever existed within the park. Additional surveys at regular intervals will inform future lists of potential species as more data become available. No trend assessment is currently possible for this metric due to the single sample period.

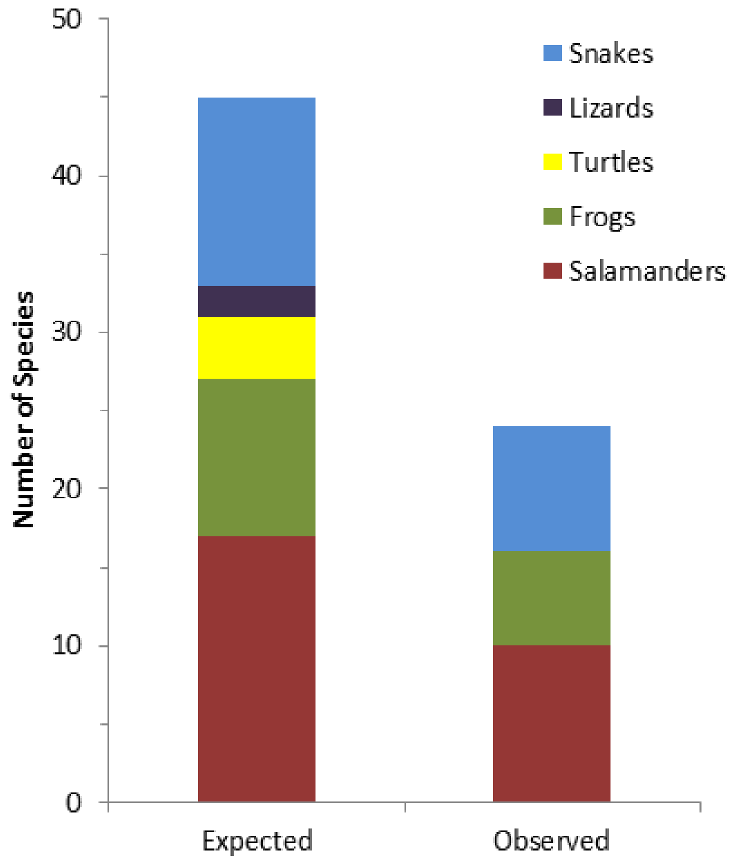
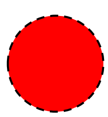
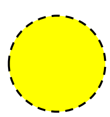


Figure 53. Number of herpetofauna species expected and observed within JOFL (Yahner and Ross 2006).

Table 50. Condition Assessment Metrics for JOFL Reptile and Amphibian Communities

	Reptiles	Amphibians
Success rate of expected number of species		

Data Gaps and Confidence in Assessment

Herptofauna data were limited for JOFL. 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*.

Data Gaps and Confidence in Assessment

Herptofauna data were limited for JOFL. 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

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).

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 JOFL supports a broad assemblage of mammals given the sustained early-successional habitat. 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 red fox (*Vulpes vulpes*).

Method

The NPS Inventory and Monitoring Program 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 JOFL from March to October in 2004 and 2005 by Yahner and Ross (2006) (Figure 54). 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 sampling points used for herptofauna surveys were also used for mammal survey locations (see Figure 54). Bats, large carnivores and wide-ranging species were not specifically targeted during these surveys.

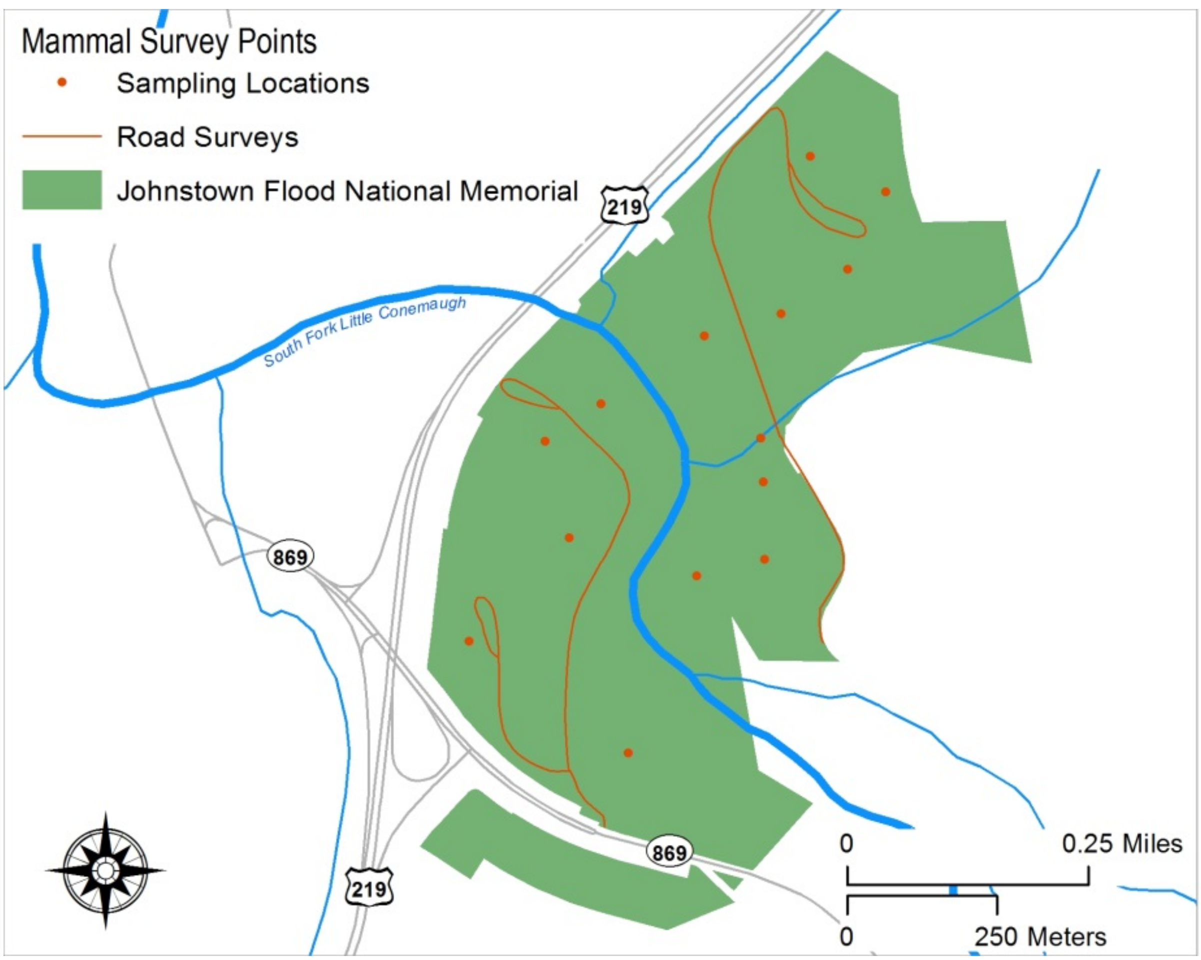


Figure 54. Mammal sampling locations for the 2004 – 2005 inventory (Yahner and Ross 2006).

Based on distribution maps of species occurrence, 54 species of mammals potentially occur within JOFL (Table 51). Reference lists of mammals in the park were compiled from the NPSpecies database which held no additional information on mammal species previously documented in the park. All 16 species documented within the park boundary occurred as a result of this study (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 52).

Table 51. Mammalian species that could potentially occur within the Johnstown Flood N Mem and the number observed during the 2004-2005 inventory (Yahner and Ross 2006). Bats and large ranging species such as black bear were not targeted in survey methodologies. Asterisks (*) indicate species not specifically targeted with survey methodologies employed during the 2004-2005 inventory.

Common Name	Latin Name	Number Observed
Virginia opossum*	Didelphis virginiana	0
Masked shrew	Sorex cinereus	3
Smokey shrew	Sorex fumeus	0
Long-tailed shrew	Sorex dispar	0
Pygmy shrew	Sorex hoyi	0
Northern short-tailed shrew	Blarina brevicauda	11
Least shrew	Cryptotis parva	0
Hairy-tailed shrew	Parascalops breweri	0
Star-nosed shrew	Condylura cristata	0
Little brown bat*	Myotis lucifugus	0
Northern long-eared bat*	Myotis septemtrionalis	0
Indiana bat	Myotis sodalis	0
Eastern small-footed myotis*	Myotis leibii	0
Silver-haired bat*	Lasionycteris noctivagans	0
Tri-colored bat*	Perimyotis subflavus	0
Big brown bat*	Eptesicus fuscus	0
Red bat*	Lasiurus borealis	0
Hoary bat*	Lasiurus cinereus	0
Eastern cottontail	Sylvilagus floridanus	7
New England cottontail	Sylvilagus transitionalis	0
Snowshoe hare	Lepus americanus	0
Eastern chipmunk	Tamias striatus	44
Woodchuck	Marmota monax	1
Gray squirrel	Sciurus carolinensis	3
Fox squirrel	Sciurus niger	0
Red squirrel	Tamiasciurus hudsonicus	5
Southern flying squirrel	Glaucomys volans	0
Northern flying squirrel	*Glaucomys sabrinus*	0
American beaver*	*Castor canadensis*	0
Deer mouse	*Peromyscus maniculatus*	1
White-footed mouse	*Peromyscus leucopus*	22
Appalachian woodrat	*Neotoma magister*	0
Southern red-backed vole	*Clethrionomys gapperi*	1
Meadow vole	*Microtus pennsylvanicus*	20
Woodland vole	*Microtus pinetorum*	0
Southern bog lemming	*Synaptomys cooperi*	scat
Muskrat	*Ondatra zibethicus*	0
Norway rat	*Rattus norvegicus*	0
House mouse	*Mus musculus*	0
Meadow jumping mouse	*Zapus hudsonius*	0
Woodland jumping mouse	*Napaeozapus insignis*	0
Porcupine*	*Erethizon dorsatum*	0
Coyote*	*Canis latrans*	0
Red fox*	*Vulpes vulpes*	1
Gray fox*	*Urocyon cinereoargenteus*	0
Black bear*	*Ursus americanus*	0
Raccoon*	*Procyon lotor*	4
Ermine	*Mustela erminea*	0
Least weasel	*Mustela nivalis*	0
Long-tailed weasel	*Mustela frenata*	0
Mink	*Mustela vison*	0
Striped skunk	*Mephitis mephitis*	1
Bobcat*	*Lynx rufus*	0
White-tailed deer	*Odocoileus virginianus*	3

Table 52. 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 Rating	Symbol
>85%	Good	(green circle)
50 – 85%	Moderate Concern	(yellow circle)
<50%	Significant Concern	(red circle)

Current Condition And Trends

Ratios of observed to expected species were as follows: 2/8 shrews and moles (Soricomorpha 25%); 9/21 mice, squirrels, and voles (Rodentia 43%); 1/3 rabbits and hares (Lagomorpha 33%); 0/1 opossum (Didelphimorphia 0%); 0/9 bats (Chiroptera 0%); 3/11 fox, bear, weasel and bobcats (Carnivora 27%); and 1/1 deer (Artiodactyla 100%) (Figure 55). Bats were not sampled during the Yahner and Ross (2006) survey. Medium-sized mammals often have sizable home ranges and can be secretive making this group difficult to inventory, and no scat, track, or sign surveys were employed to detect these species if they happen to occur within the Park. 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. Mammal communities scored as *significant concern* for species diversity and success rate of detection park-wide, however there is very low confidence in this assessment due to its bias nature (Table 53).

This score was based on the success rate of species documentation and professional judgment. Because there were no historical records for this park, all 16 species detected during the Yahner and Ross study are the only documentation of mammals present within the park. Overall there was a 30% success rate of confirming the presence for 16 of the 54 expected species occurrence within the park (Figure 55). This success rate measure is biased low due to incomplete survey methodologies. For example, while bat species were included in the list of potential species that could occur within the park, they were not surveyed for specifically during the 2004-2006 inventory, and therefore were very unlikely to be detected. Similarly, large species and wide-ranging species such as black bear and coyotes were again listed as potential species that may occur in the park, but no specific survey methods were employed to observe these species.

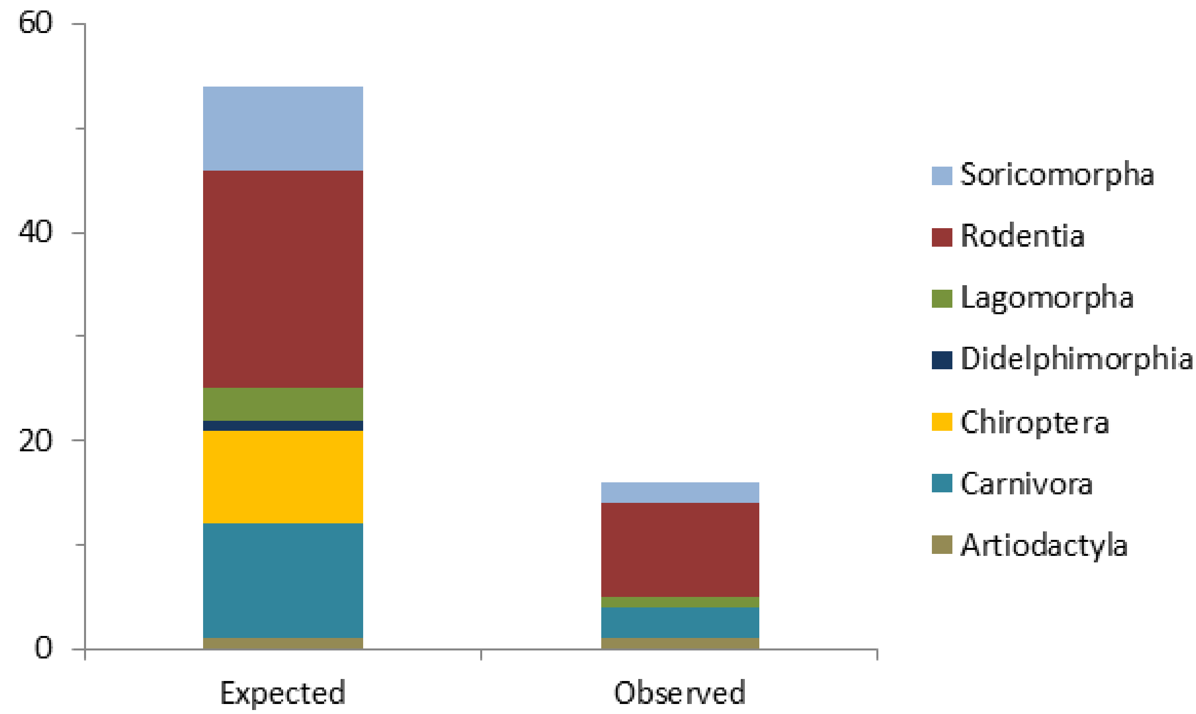


Figure 55. Number of mammalian species expected and observed within the JOFL NM (Yahner and Ross 2006).

Table 53. 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	

Data Gaps and Confidence in Assessment

Mammal data were limited for JOFL. 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

Non-native Invasive Animals

<u>Relevance and Context</u>

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 JOFL have identified five non-native invasive animal species of concern, which are described in more detail below. These species include the gypsy moth (*Lymantria dispar*), emerald ash borer (*Agrilus planipennis*), Asian longhorn beetle (*Anoplophora glabripennis*), viburnum leaf beetle (*Pyrrhalta viburni*), 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.

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. 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 (McManus et al. 1989).

Emerald Ash Borer

The emerald ash borer in an Asian species discovered in southeastern Michigan in 2002 (USDA 2013a). No one is certain how is arrived in North America, but likely, it was unknowingly transported in ash wood used in cargo ships or packing materials. Emerald ash borer pose a significant problem to North American Ash species, because they aggressively kill healthy trees within two to three years of infestation (USDA 2013b). This species was first discovered in Pennsylvania in Cranberry Township, Butler County in 2007, and has since spread to more than 30 counties (DCNR 2012). The state has embarked on an aggressive response including tree removal, chemical treatment and biological control to limit damage to urban and forested areas from this species (DCNR 2012).

Asian Longhorn Beetle

The Asian longhorn beetle was first discovered in New York in 1996, and has been documented in six more states since that time (USDA 2013b; DCNR 2012). This species was also unknowingly introduced into North America through wood pallets and other packing materials transported from Asia (USDA 2013b). This species poses a significant problem to maple and other hardwood trees as it bores into the trunk and branches disturbing the flow of sap and ultimately killing the tree. Control methods include tree removal and chemical treatment with injected insecticide or general pesticides.

Viburnum Leaf Beetle
The viburnum leaf beetle is a European species that was first detected in Canada in the 1940's, but has also been documented in New York, Maine, and Pennsylvania (Hoover and Barr 2008). It is possible that this species could become a problem in nurseries and landscaped areas in Pennsylvania. Viburnum leaf beetle may also pose a problem for viburnum species in natural forests and wetlands within Pennsylvania. The species, both in larval and adult form, feed on viburnum showing a slight preference for species with little hair, leading to defoliation and potentially death of the target plant (Hoover and Barr 2008).

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).

Method
This report summarized data and information available in other reports gathered for this assessment. Gypsy moth surveys were conducted by the DCNR across the state of Pennsylvania on an annual basis to identify and monitor trends. Surveys in 2012 were conducted at 2,411 sampling sites focused on egg mass detection. Park specific surveys have not been completed. Emerald ash borer, Asian longhorn beetle, and viburnum leaf beetle were selected by the Park Service to be included in an early detection campaign completed by the NPS Eastern Rivers and Mountains Network (ERMN) beginning in 2009. Early detection activities in JOFL were primarily conducted by the ERMN vegetation monitoring team while sampling permanent vegetation plots.

Crayfish were sampled at two sites within JOFL 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).

Reference Condition
Reference conditions were not established for non-native species. Ideally they should not be present within the park boundaries. Quantitative metrics and thresholds for condition assessments for 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.

Current Condition and Trends

Between the winter of 2011 and spring of 2012, gypsy moth egg masses were found at 458 of the 2,411 sites sampled. This detection rate equates to approximately 19% of surveyed sites across Pennsylvania (DCNR 2012). Gypsy moth was not included in ERMN early detection list, as it has been present in western Pennsylvania for decades. Aerial treatments by state and county agencies, mostly in the 1990's, have generally resulted in good control of the gypsy moth in western Pennsylvania. However, egg cases and larvae are occasionally observed in the park, and the species is considered to be present at low levels in JOFL. While JOFL forests are not ideal habitat for gypsy moth invasion, the lack of a major outbreak of gypsy moth defoliation, this invasive species was scored as *good* (Table 54).

To date, emerald ash borer, and Asian longhorned beetle have not been found at JOFL through the ERMN surveys. Emerald ash borer was detected in Cambria County, PA in 2013. The viburnum leaf beetle was discovered within JOFL by the ERMN vegetation monitoring crew in 2010 and 2012. Since that time it has cause considerable damage to native arrowwood shrubs and early successional woodlands within the Park (*per. Comm. K. Penrod*), however, the habitat is not ideal for this species, and therefore limited.

Crayfish were captured at both sites surveyed. Only native species of crayfish were captured during survey collections at JOFL (Lieb et al. 2007). The Allegheny crayfish (*Orconectes obscurus*) was the most commonly detected species in JOFL, followed by the common crayfish (*Cambarus bartonii*). 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 54. Condition assessment metrics for JOFL non-native animal invasions. Viburnum leaf beetle has become a severe problem within the park and gypsy moth populations continue to be monitored. The other three species have yet to be found within the park

JOFL Metrics	Gypsy Moth	Emerald Ash Borer	Asian Longhorn Beetle	Viburnum Leaf Beetle	Crayfish
% Non-Native Species	●	●	●	●	●

Non-native invasive species data were limited for JOFL. 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 emerald ash borer. 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
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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).

Human activities over the past two centuries have markedly altered the landscape of JOFL (Zimmerman 2007) resulting in large areas of successional habitat that are particularly vulnerable to invasion. Plantings of non-native species in the surrounding watershed for gardens, as ornamentals, along agricultural hedgerows, or for wildlife habitat, erosion prevention, and bank stabilization have provided sources of potential invasives. Over time, several non-native, invasive species have colonized the woodlands and managed landscapes at the park. The dry bed of the former Lake Conemaugh is especially vulnerable to invasion, and to a lesser extent the fields at the Unger Farm cultural landscape and the forest at the Picnic and Maintenance area.

Park managers at JOFL have identified and mapped (Figure 56) four non-native invasive plant 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 Invasive Species Early Detection (ISED) Monitoring Program (Manning and Keefer 2013) identified 16 potentially problematic taxa that are not known to occur in the park, but should be looked for to prevent their establishment and spread (Table 55). Early detection of non-native invasive plants has been shown to increase the efficacy of control measures and reduce the costs associated with their treatment. The NPS ERMN vegetation monitoring crew annually looks for these early detection plant species while conducting their vegetation monitoring work. The park is responsible for implementing the early detection rapid response effort. If rapid response efforts are unsuccessful then long-term control is the responsibility of the park.

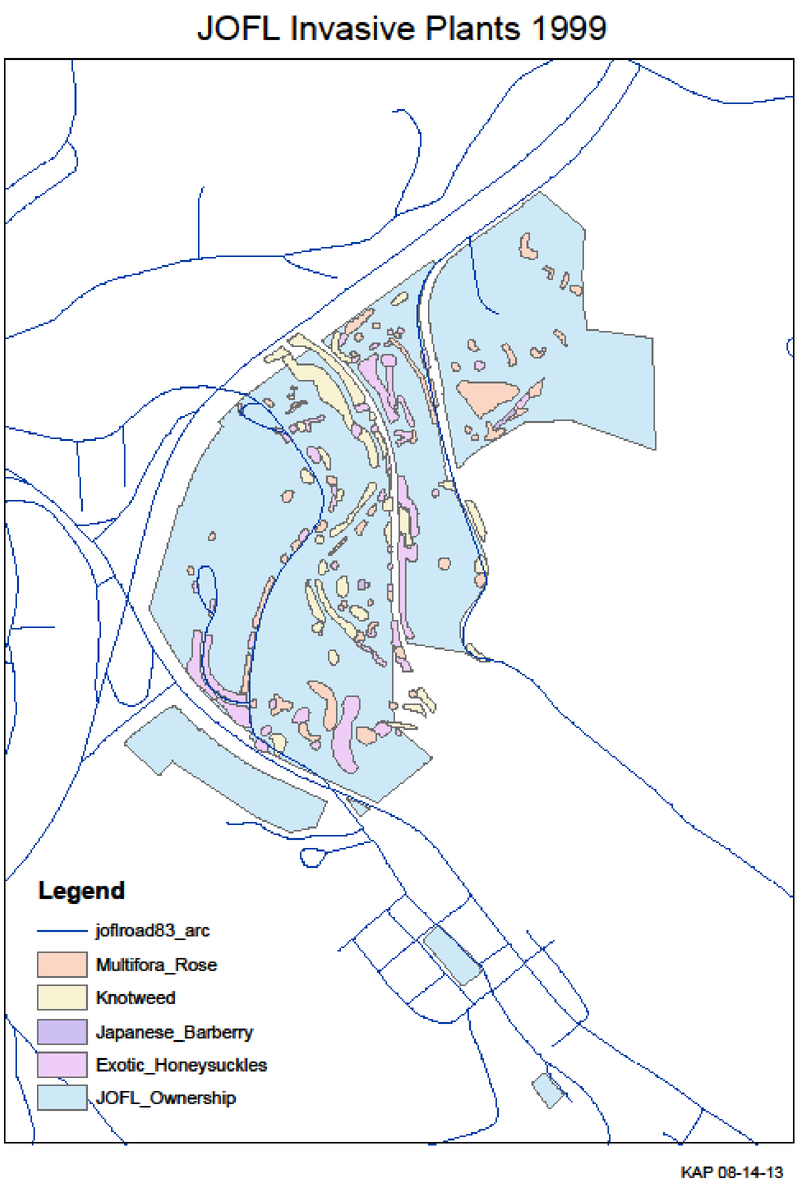

Figure 56. Locations of four non-native plant species at JOFL in 1999 as mapped through a park survey.

Table 55. 2010 list of plant species included in the Invasive Species Early Detection (ISED) Program for the Eastern Rivers and Mountains Network (ERMN).

Scientific Name	Common Name
Ailanthus altissima	Tree-of-Heaven
Cardamine impatiens	Narrowleaf bittercress
Celastrus orbiculatus	Oriental bittersweet
Didymosphenia geminata	Didymo
Frangula alnus	Glossy buckthorn
Humulus japonicus	Japanese hops
Heracleum mantegazzium	Giant hogweed
Lonicera japonica	Japanese honeysuckle
Microstegium vimineum	Japanese stiltgrass
Oplismenus hirtellus ssp. *undulatifolius*	Wavyleaf basketgrass
Polygonum perfoliatum	Mile-a-minute
Pueraria montana var. *lobata*	Kudzu
Ranunculus ficaria	Lesser celandine
Rhamnus cathartica	Common buckthorn
Rhodotypos scandens	Jetbead
Viburnum dilitatum	Linden viburnum

Invasive Species of Concern

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.

Alliaria petiolata (Chris Evans, Illinois Wildlife Action Plan)

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.

Garlic mustard was present in two of the three forest associations in JOFL. The park has initiated volunteer control projects for this invasive herb, but the spread of the plant cannot be matched with sufficient effort to keep it under control. The park nature manager monitors it's spread and control efforts annually.

Shrub Honeysuckles (*Lonicera morrowii* and *L. tatarica*) 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 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.

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

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.

Shrub honeysuckles are found in most associations in JOFL, although primarily as subdominants. These invasive shrubs appear to tolerate a wide range of conditions, including saturated soils. Efforts to remove shrub honeysuckles have been ongoing since 2001. A contractor was provided by the NPS Exotic Plant Management Team program in 2007 to remove shrub honeysuckle from the Unger Farm cultural landscape and an area of the former lakebed along the North Abutment trail.

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 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).

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

In JOFL, multiflora rose occurs in most habitats, but is more prevalent in drier sites within the park. Some stands of multiflora rose within the lakebed were treated in 2003, but seasonal flooding prevented a complete treatment of this area. A contractor was provided by the NPS Exotic Plant Management Team program in 2007 to remove multifora rose from the Unger Farm cultural landscape.

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 readily hybridize making identification difficult and are thus grouped together. 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. Knotweed is found within JOFL, but management actions have greatly reduced its occurrence and spread.

JOFL Vegetation Studies

In one of the earliest vegetation studies of the park, Melton (1982) indicated that Morrow's honeysuckle was common in vicinity of spillway and relic dam and also occurred in wet and dry grasslands. Melton also documented the presence of knotweed on the "cut end of the old dam" and tatarian honeysuckle (*Lonicera tatarica*) along the "old river channel". Park staff noted that by 1995, Morrow's honeysuckle (*Lonicera morrowii*), knotweed, and multiflora rose were all well established in the lakebed. In 1999, they began a formal process to inventory and map large infestations of shrub honeysuckles, multiflora rose, Japanese barberry (*Berberis thunbergii*) and knotweed. This inventory noted that by 1999, multiflora rose and honeysuckle had invaded the Unger Farm cultural landscape fields surrounding the Visitor Center and Unger House and portions of the dry bed of Lake Conemaugh, while knotweed species and/or hybrids were common in the dry lakebed. A small amount of Japanese barberry was also discovered and mapped (Figure 56).

Studies commissioned by the NPS in 1998 and 2001 with the Western Pennsylvania Conservancy focused on species of special concern, but also indicated that non-native species were well established in the park making up a significant component of the flora. Morrow's and tatarian honeysuckle, as well as multiflora rose had invaded most forested areas. In addition, garlic mustard was recorded in three of the five forest associations.

Removal of woody invasive plants within the lakebed was undertaken from 1995-2000 and again in 2003. Exotic shrub honeysuckles were controlled at upland (non-wetland) areas of the dry lakebed and along the Picnic Area Road. Treatment of knotweed was conducted from 2000 through 2007 along roads, in the former lakebed, and near the river. Although still present, it is now a minor occurrence in the park. In 2007, multiflora rose and honeysuckle were removed from the Unger Farm cultural landscape. Invasive plant species, particularly exotic shrub honeysuckle, remain a problem in the area south of Route 896. This section of the park was not mapped in 1999. Other non-native species that pose a threat at JOFL include teasel and garlic mustard. Although not mapped in 1999, teasel is commonplace. Recently, garlic mustard has increased rapidly along the Picnic Area and South Abutment Roads.

The first formal inventory of non-native invasive plant species was undertaken by Zimmerman in 2005-2006 (Zimmerman 2007). He sampled 50 25-m radius circular plots throughout the park and recorded the both presence and abundance of non-native taxa. Fifty-four non-native species were identified within park boundaries, of which 12 were considered a moderate to serious threat. The most abundant non-native species were Morrow's honeysuckle, crown vetch (*Coronilla varia*) and multiflora rose. Forested areas with closed canopies had fewer non-native invasives than more open systems. At the time of the report, the invasive status of Morrow's honeysuckle and multiflora rose were listed as serious threats, but crown vetch was not considered a threat, as assessed by the Pennsylvania Department of Conservation and Natural Resources.

In 2004, Perles et al. (2006) collected data from 17 plots located within different habitat types in JOFL and devised seven vegetation associations. Plot data from this study indicated that invasives were present in most associations in the park. Of the three forest associations described (Eastern Hemlock-Northern Hardwood Forest, Conifer Plantation, Red Maple-Black Cherry Successional

Forest), invasives were present in only the latter, although Perles et al. (2006) indicated that Conifer Plantation and Eastern Hemlock-Northern Hardwood Forest were both susceptible to invasion by woody and herbaceous plants including multiflora rose, shrub honeysuckle, Japanese barberry, and garlic mustard. With the exception of Cattail Marsh, wetland areas within the park (Silky Willow Shrub Swamp, River Scour and the wetter portions of Old Field) were heavily invaded by both native reed canary grass (*Phalaris arundinacea*), and non-native invasives including Morrow's honeysuckle, crown vetch, and knotweed. Although survey data indicate that invasives were not observed in the drier portions of Old Field habitat, Perles et al. (2006) cautioned that these areas were vulnerable to invasion by crown vetch.

From 2007-2011, Perles et al. (2010 and additional unpublished data) collected plant data at 12 long-term monitoring plots as part of the ERMN Vital Signs Monitoring Program (Figure 57). Plots were established in two forested habitat associations. This latter study provides the most up-to-date assessment of non-native invasive species in forested associations within park boundaries.

<u>Methods</u>
The ERMN monitoring data set (Perles et al. 2010 and additional unpublished data) was used to estimate condition. This data set includes 12 sample plots within two variants of one forest association categorized by Perles et al. (2006): Red Maple–Black Cherry (RMBC) and Old Field-Red-Maple-Black Cherry (OFRMBC). It is important to note that this dataset excludes managed areas of the park including the former lakebed area and Unger Farm cultural landscapes. For each of these associations, we calculated two metrics, the average number of non-native invasive species by plot (invasibility) and the overall percentage of non-native species. For the first metric, non-native plant species were weighted by their respective threat level (none, moderate, severe), a designation given by the Pennsylvania Department of Conservation and Natural Resources to indicate their relative invasibility (see Zimmerman 2007). Plants designated as a serious threat were given a weight of 10 and those considered a moderate threat a weight of 5. Non-native plants considered to be no threat were given a weight of 3 to underscore their negative impact on habitat quality regardless of invasibility.

To score invasibility, we used a rating system established for the NETN Vital Signs Program (Miller et al. 2010) (Table 56). For % non-native species, we used condition ranks developed for forested habitats in Allegheny Portage Railroad National Historic Site (ALPO). Forests in ALPO span a range of condition from highly to least disturbed and provide the closest approximation of a reference condition for forested upland habitats on the Allegheny Plateau. These values were trisected into the three condition categories (Table 57). Trisection was accomplished by first calculating the 95% percentile of the population distribution, then trisecting the range from 0 (the lowest possible value) to the 95th percentile value (Karr et al. 1999). The top one-third of the range was assigned a rank of *good*, the middle a rank of *moderate concern* and the lower a rank of *significant concern*.

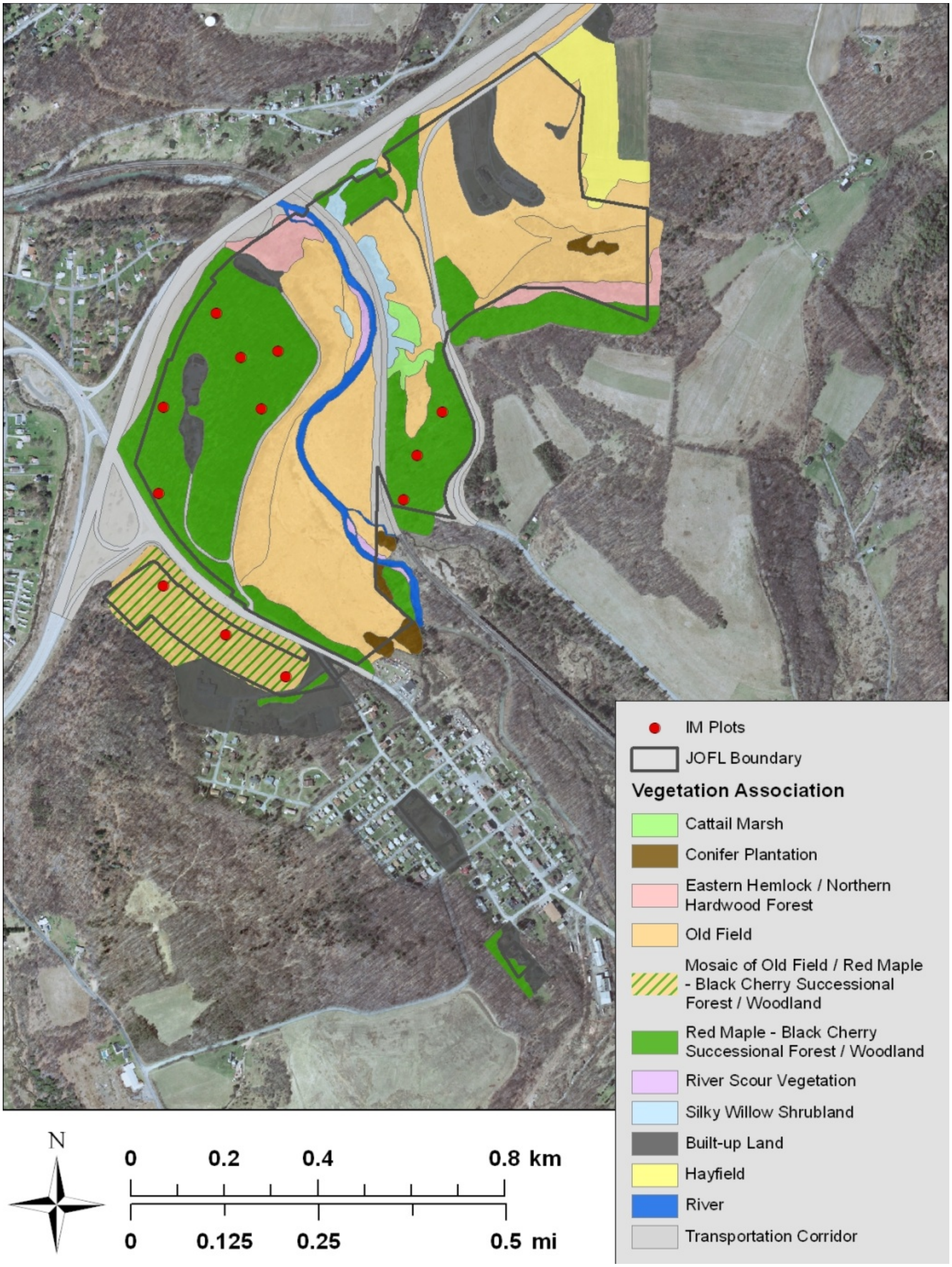

Figure 57. Locations of ERMN Vital Signs Monitoring Program plots in forested associations in JOFL.

Table 56. Condition categories for invasibility based on the thresholds defined by the NETN Vital Signs Program.

Average Target Non-Native Invasive Species/Plot	Condition Rating	Symbol
< 0.5 target species/plot	Good	
0.5 to < 3.5 target species/plot	Moderate Concern	
≥ 3.5 target species/plot	Significant Concern	

Table 57. Condition categories for percentage of non-native species. Categories are based on reference sites from ALPO.

% Non-Native Species	Condition Rating	Symbol
< 8	Good	
8 - 16	Moderate Concern	
> 16	Significant Concern	

Current Condition and Trends

Table 58 shows non-native invasive species metrics for RMBC and OFRMBC forest associations. In JOFL, both associations support invasive shrubs, particularly multiflora rose and Morrow's honeysuckle and to a lesser extent Japanese barberry. While Morrow's honeysuckle and multiflora rose were observed in each of the three plots sampled in the OFRMBC association, they were present in less than half (4) of the plots sampled in the RMBC association. In fact, three plots within the RMBC association contained no non-natives. Japanese knotweed, was present in only one plot in the RMBC association.

Table 58. Non-native invasive plant species metrics for two forest associations in JOFL.

JOFL Metrics	Red Maple – Black Cherry Successional Forest/Woodland (n=9)	Mosaic of Old Field and Red Maple – Black Cherry Successional Forest/Woodland (n=3)
# of Invasive Target Species by Plot	.32	1.2
% Non-Native Species	5.8	11.5

Both vegetation associations scored similarly for both metrics. The RMBC association scored *good* for non-native invasive species while the OFRMBC received a score of *moderate concern*, although ranks were approaching the good condition category (Table 59). Moderate to good condition rankings likely reflect aggressive control and maintenance activities over the past decade that have greatly reduced individual plants, but also curtailed a primary source of seed and propagules. Knotweed, in particular, which has been targeted for control since 2000, now poses a minor threat to park habitats. Continuing vigilance and management is critical in assuring these highly invasive species do not become problematic in the future.

Table 59. Condition Assessment Metrics for JOFL Forest Associations

JOFL Metrics	Red Maple – Black Cherry Successional Forest/Woodland (n=9)	Mosaic of Old Field and Red Maple – Black Cherry Successional Forest/Woodland (n=3)
# of Invasive Target Species by Plot		
% Non-Native Species		

Data Gaps and Level of Confidence

The confidence in the condition assessment was *low*. Because vegetation studies within JOFL (Melton 1982, - Zimmerman 2007, Perles et al. 2006, and NPS-commissioned rare species studies) 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 limited sampling timeframe does not allow an analysis of trends. Confidence was also rated low because of the lack of reference data for upland forests in the region. We used ALPO forests as our reference standard to assign condition ranks, but this data set is limited by a small sample size and may not be representative of all forests in the region.

Vital Signs monitoring is conducted annually. To date, 12 randomly-placed plots have been sampled in forested areas within the Park (three plots per year except 2007 and 2011 where one and two plots were sampled respectively). This data set, albeit small and exclusive to forested habitats, provides a preliminary snapshot of overall condition for the largest forest associations within the park and can be used as a baseline for continuing 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 invasives (USFWS Managing Invasive Plants – Concepts, Principles and Practices; http://www.fws.gov/invasives/stafftrainingmodule/assessing/inventory.html).

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

Landscapes

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 (1988) 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 and Simberloff 1997). 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 JOFL. 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 JOFL we looked at the landscape conditions from within three boundaries; 1) JOFL park boundary; 2) a 1 km buffer distance around JOFL; 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. 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 South Fork Little Conemaugh River (SFLCR) catchment area 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 Table 61 will, however, reveal the differences reported by our three land cover data layers.

Reference Condition

Table 60. 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%	25-25%	< 25%
	% Core Forest	Modifier: Decreasing trend in an amount of core forest within 1-km surrounding the park lowers % Foredt metric by one condition category for %		
	Road Density	> 0.66	0.34 – 0.66	0 – 0.33
Catchment	% Developed Land	< 10%	10-15%	> 15%

Current Condition and Trends

The following figures show the current landscape conditions for land cover (Figures 58, 59, and 60) and core vs. edge forest (Figures 61, 62, and 63). Although not used for the condition assessment, maps for the 30-km buffer around the park (Figures 58 and 61) were included for comparison, since this spatial scale has been used by NPS in other endeavors. The remaining maps refer to the spatial scales used in the condition assessment: JOFL park boundary and 1-km buffer around JOFL (Figures 59 and 62), and the SFLCR catchment area (Figures 60 and 63).

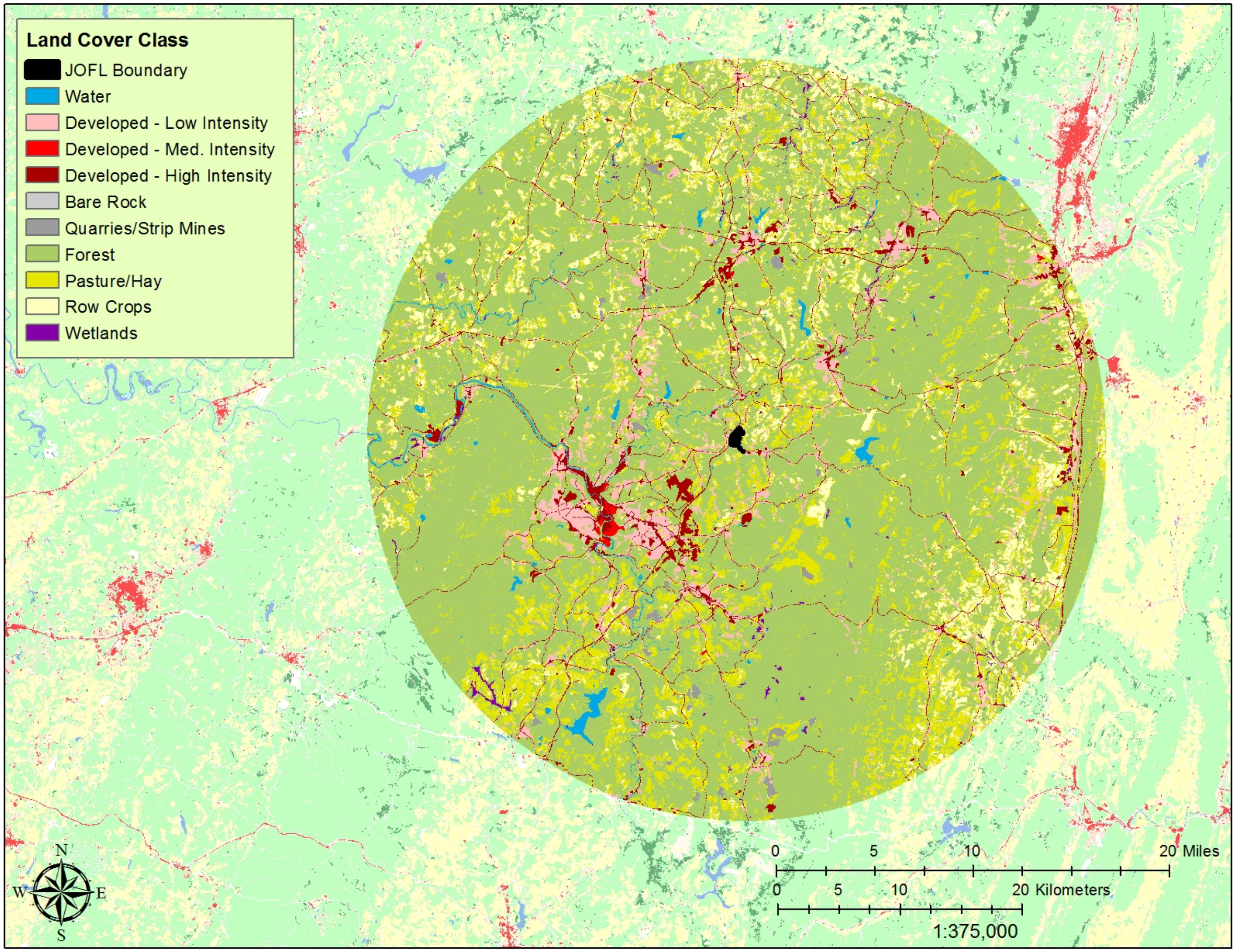


Figure 58. Depiction of the NLCD Land Cover for the 30 km zone around JOFL. This version shows the larger landscape view and helps to illustrate its proximity to urbanized areas like the city of Altoona located NE of the park Main Unit and the city of Johnstown to the SW.

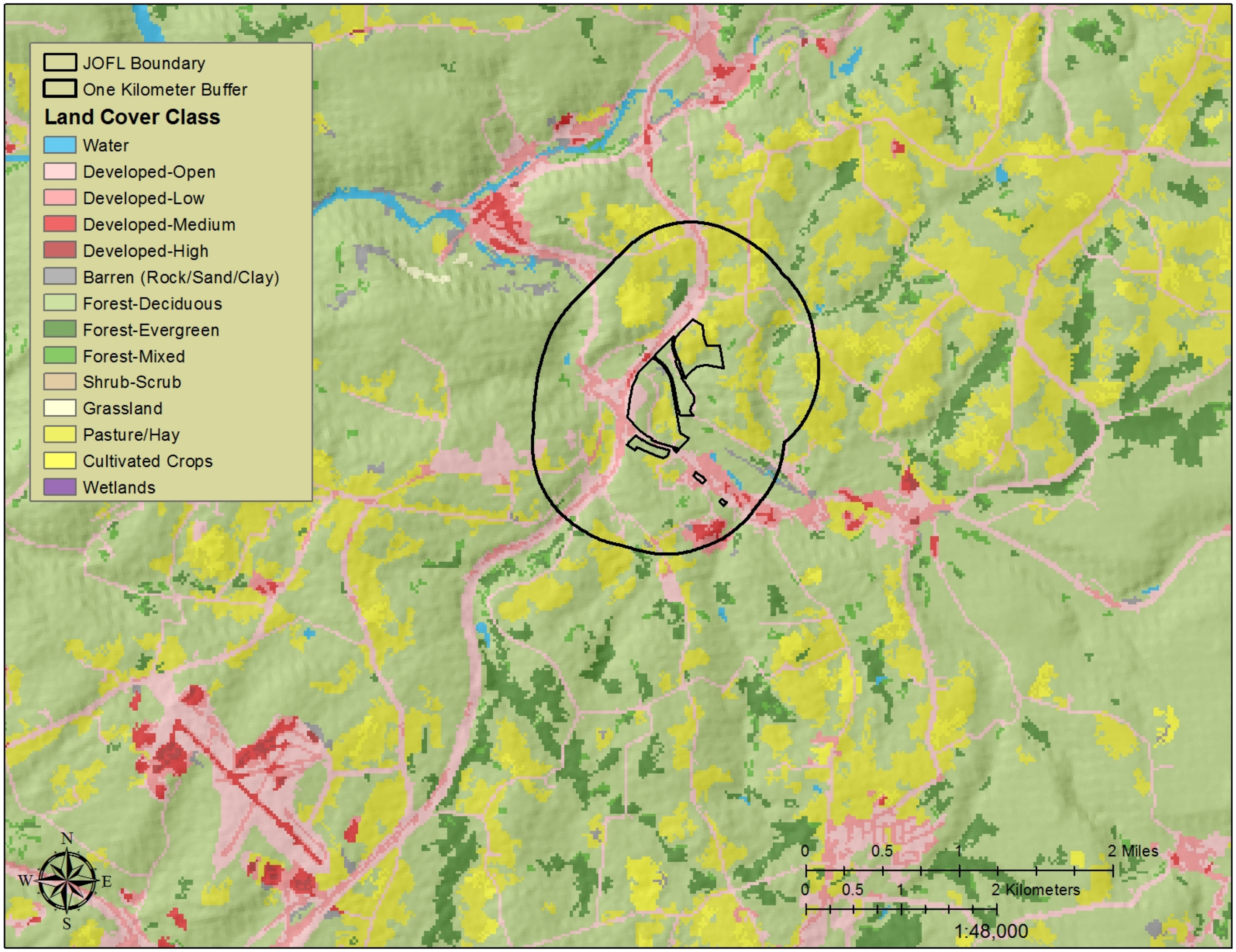


Figure 59. This graphic shows the NLCD Land Cover “zoomed in” on JOFL to better interpret the land cover conditions in and near the park. The second boundary represents the 1 km buffer zone used to help evaluate conditions near to the park.

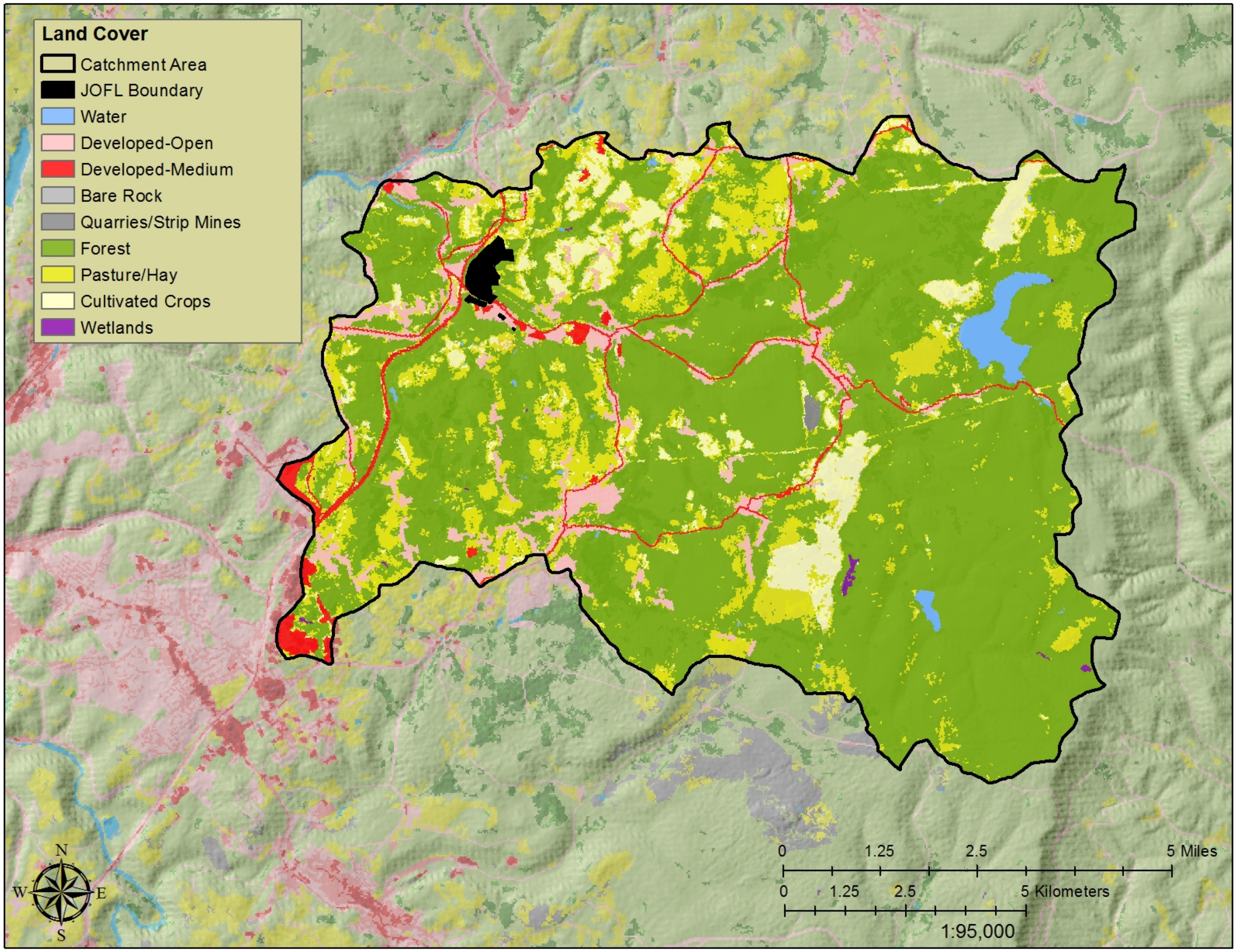


Figure 60. This graphic shows the NLCD Land Cover for the SFLCR catchment area to better interpret the land cover conditions upstream of the park. JOFL is represented by the black boundary.

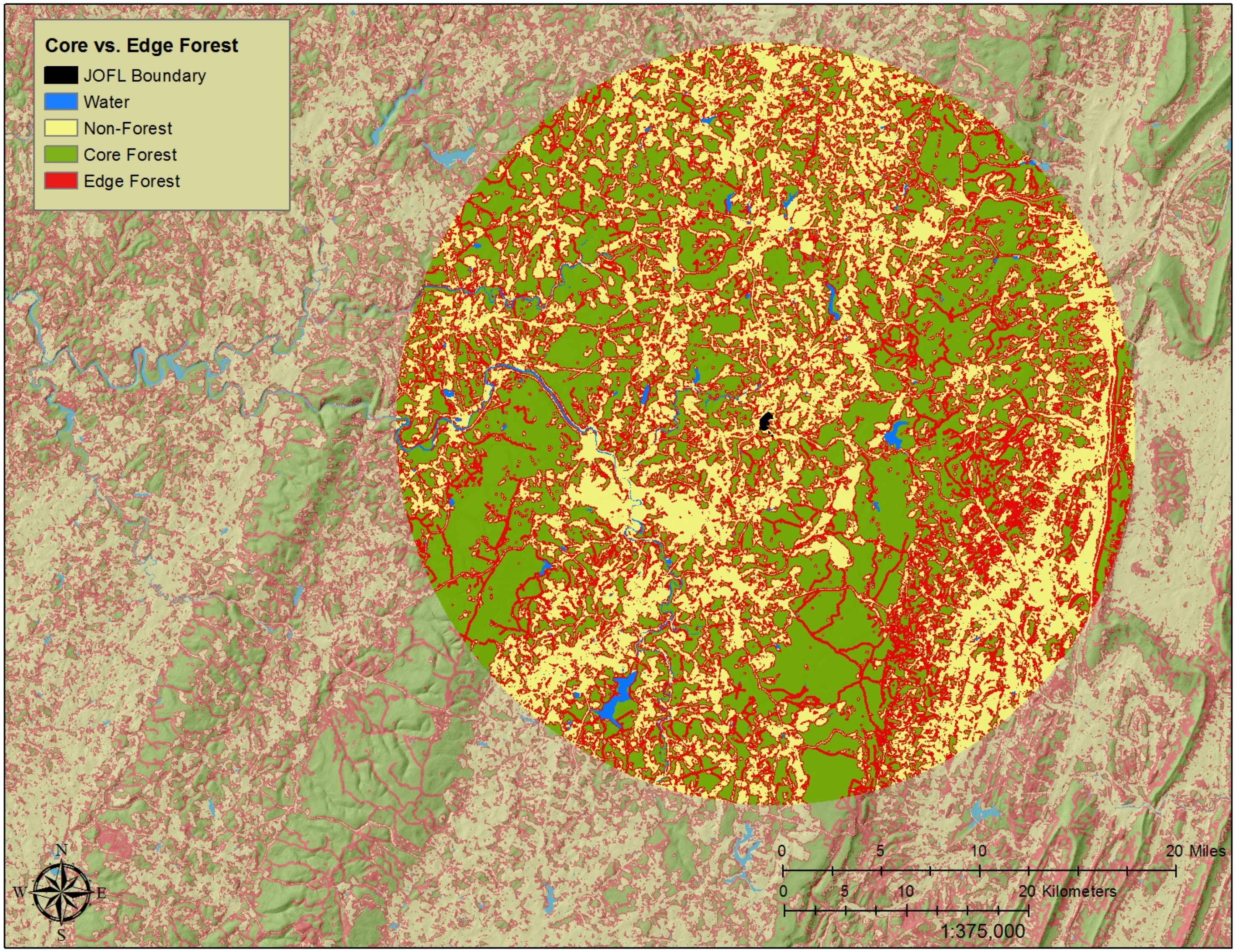


Figure 61. This mapped version of the NLCD Land Cover shows the value-added data isolating Core vs. Edge Forest in the 30 km buffer zone around JOFL. Edge forest is that forested cover found within 100 meters of a disturbance, such as agriculture and roads.

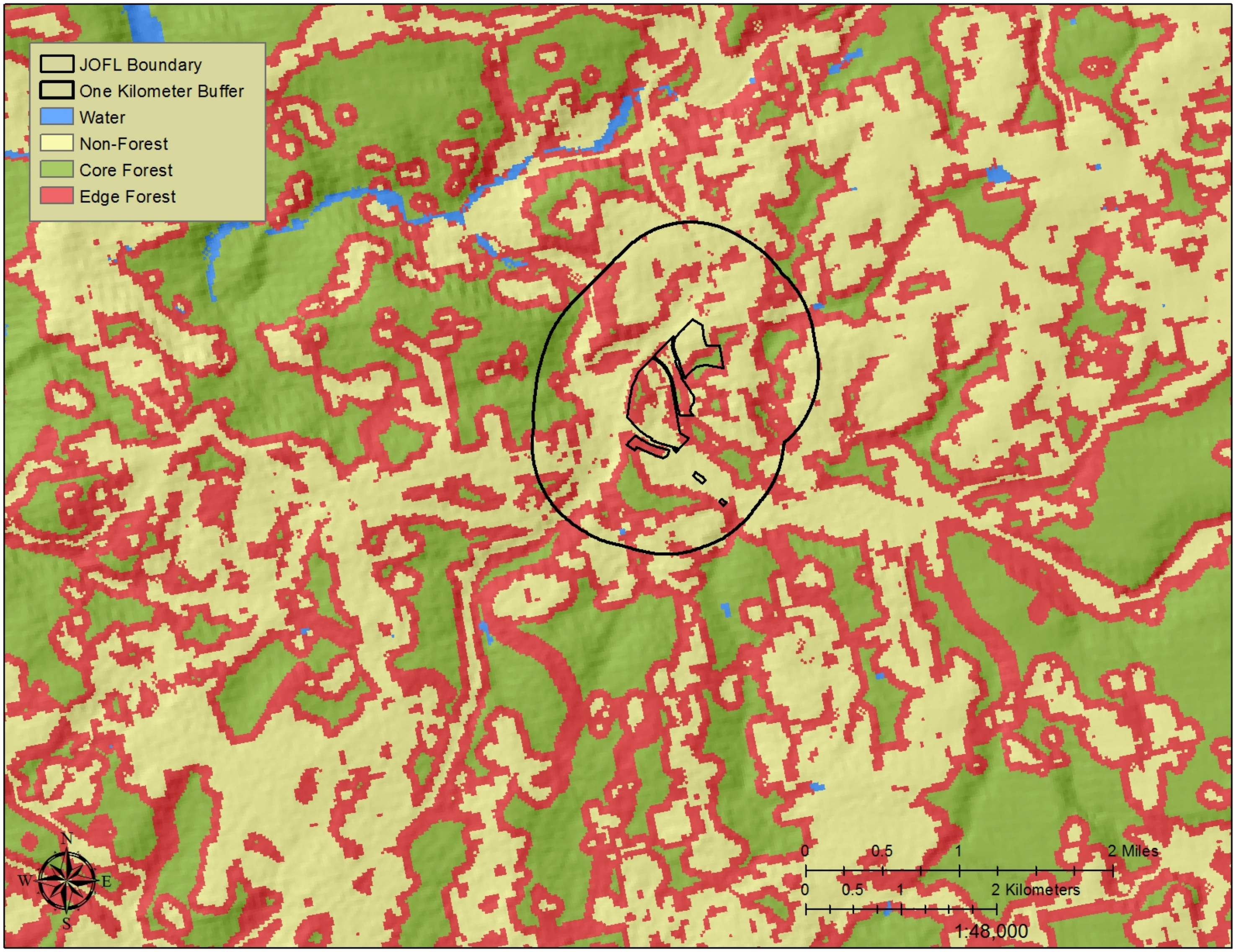


Figure 62. This image is a “zoomed in” version of the “Core vs. Edge Forest distinction for the areas inside and near JOFL. The extra boundary represents the 1 km buffer zone around the park.

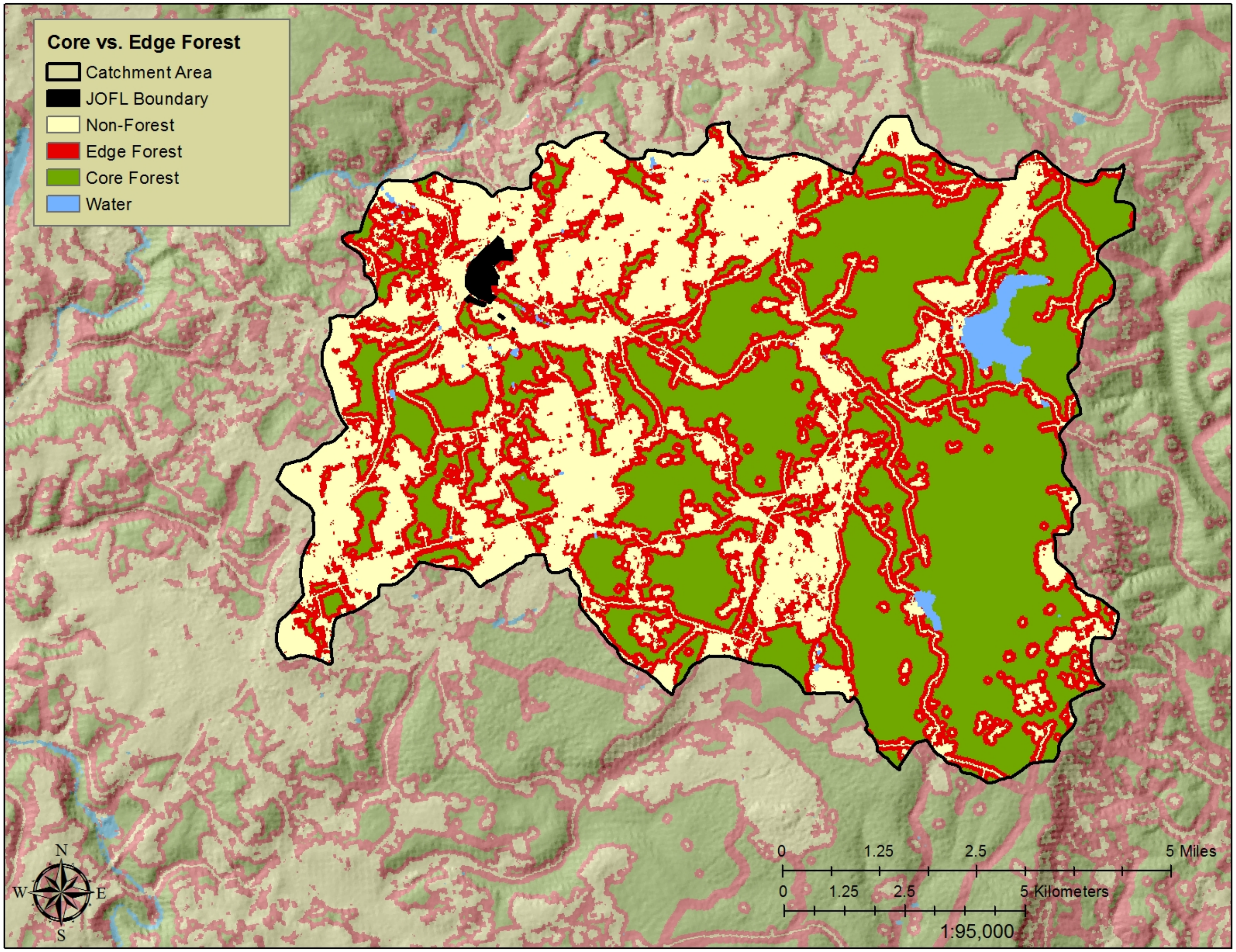


Figure 63. This image shows the “Core vs. Edge Forest distinction for the SFLCR catchment area. JOFL is shown in black.

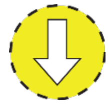
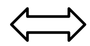
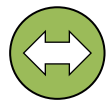
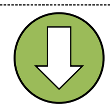
Land cover conditions differed inside the park boundary and within the 1-km buffer zone. While developed land increased somewhat within the park, there also appears to be improvement within the park's forest and core forest cover (both increased). Percent forest increased from 41.09% in 1992 to 55.44% in 2006 within the JOFL boundary but decreased from 59.31 % to 49.47 % inside the 1 km buffer surrounding the park (Table 61). Core forest increased approximately 4% from 2.31% to 6.37% in the JOFL boundary. Despite the reduction in total forest cover in the 1-km buffer zone, core forest increased 3% from 6.89% in 1992 to 10.00% in 2006. Road density has remained relatively unchanged. Greater changes probably occurred prior to 1992 when the adjacent highway (Rt. 219) was constructed. Although not used in the condition assessment, we also provide landscape results for a 30-km buffer surrounding the park (Table 61).

Table 61. Summary land cover metrics for JOFL covering three time periods (1992, 2001, and 2006) and the four spatial extents used in the study (within park, 1-km area surrounding park, watershed or catchment, and park + 30-km area surrounding the park). 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			PARK + 30-km BUFFER		
CLASS	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**	**1992**	**2001**	**2006**
Water	0.00	0.11	0.00	0.00	0.58	0.05	1.02	1.28	1.29	0.49	0.67	0.85
Developed	1.74	5.21	4.63	6.57	9.19	16.57	2.66	3.68	7.82	3.76	4.57	8.29
Barren	0.58	n/a	0.35	4.53	n/a	0.94	0.88	n/a	0.30	1.03	0.91	0.30
Agriculture	29.98	39.47	39.58	29.59	43.15	32.97	20.46	25.19	21.02	24.19	28.14	23.19
Forest	41.09	45.83	55.44	59.31	47.08	49.47	57.67	65.54	69.57	70.53	65.7	67.38
Core Forest	2.31	1.39	6.37	6.89	3.50	10.00	23.18	37.66	41.73	30.47	33.04	35.36
Road Density	0.91	0.89	0.87	0.90	0.85	0.85	0.96	0.92	0.93	*	*	*

Table 62 shows 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. The percent forest metric scored *moderate concern* with a deteriorating trend, road density is *good* condition with an unchanging trend and percent developed land in the catchment is *good* but deteriorating. The percentage of core forest increased only slightly from 7% to 10% (unchanging trend) and still represents an unsubstantial percentage of core forest compared to edge forest.

Table 62. Condition assessment results for landscape metrics at JOFL.

EXTENT	METRIC	CONDITION RATING
1-km	% Forest	
	% Core Forest	
	Road Density	
Catchment	% Developed Land	

Data Gaps and Level of Confidence

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.

Sources of Expertise

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

Chapter 5. Discussion

Like Chapter 4, condition assessment results are presented by resource in order to compile information for the data sources and references used to assess the condition of each indicator (Tables 63 – 69). JOFL is a small park; therefore, all results are presented at the park-wide spatial scale rather than broken down into smaller units. However, 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. Although landscape-level indicators also extend beyond park boundaries, landscape condition results may vary inside and outside of the park and should be evaluated within this context in order to properly characterize park-wide natural resource conditions.

Each resource summary includes the indicators of condition, specific measures used to estimate that condition, followed by the condition result for that indicator. In addition descriptions are provided for the rationale, reference criteria, and data sources for each indicator. A final condition rating for each indicator and resource is also provided. To determine the overall assessment of condition for an indicator or resource (i.e. 'scaling up'), we followed the DRAFT_NRCA guidelines provided by NPS in July 2013. These guidelines were as follows:

1) Condition—to determine combined condition, each red symbol is assigned zero points, each yellow symbol is assigned 50 points, and each green symbol is assigned 100 points. Calculate the average, and apply the following scale to determine the resulting color: score 0 to 33 (red); score 34 to 66 (yellow); score 67 to 100 (green).
2) Trend—to determine the overall trend, subtract the total number of down arrows from the total number of up arrows. If the result is 3 or greater, the overall trend is up. If the result is -3 or lower, the trend is down. If the result is between 2 and -2, the overall trend is unchanged.

A State of the Park Summary Table follows in order to provide a broad overview of JOFL's natural resources and their overall condition. 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.

Air Quality

Air quality, although beyond the ability of the park to control, is an important concern to JOFL, potentially affecting both cultural (e.g., eroding buildings) and natural (e.g., injuring sensitive plant species) resources. Important indicators include ozone, visibility, total wet deposition of nitrogen (N) and sulfur (S), and mercury (Hg). In addition, night skies and soundscapes are also important natural resources to the park. Overall air quality condition for JOFL was considered to be of *significant concern* with an *improving* trend (Table 63).

Results for specific air quality indicators include the following:

- Ozone is considered to be of *moderate concern* with an *improving* regional trend (2006 – 2010 estimate for the interpolated 4^{th}-highest daily maximum 8-hour ozone concentration = 72.3ppb).
- ERMN's risk assessment of ozone-induced foliar injury to sensitive plant species (Sum 06 & W126 indices) is of *moderate concern*.
- Visibility is an area of *significant concern* with no apparent (*unchanging*) trend in condition (2006 – 2010 interpolated visibility values = 11.4 dv).
- Wet S and N deposition are both considered to be of *significant concern* with an *improving* trend (Station PA13 estimates for nitrogen and sulfur wet deposition are N-(NH_4 + NO_2) = 6.3 kg/ha/yr and S – (SO_4) = 8.77 kg/ha/yr, respectively.
- Acidification risk is considered to be very high; nutrient enrichment risk is high. Condition rating for both metrics is *significant concern*.
- Mercury wet deposition is of *significant concern* with an *unchanging* trend (Hg concentrations from 1997 – 2011 have ranged from 7.06 to 9.37 ng/L with a 2011 estimate of 8.55 ng/L).
- Night skies are considered to be of *moderate concern* (region surrounding JOFL corresponds to a 4 on the Bortle Dark-Sky Scale).
- Desired condition for soundscapes at JOFL cannot be assessed due to lack of data.

We recommend continued monitoring, especially of wet nitrogen, sulfur, and mercury deposition within the park. In addition, further monitoring of dry mercury deposition is highly encouraged, since this component may represent at least half of the total mercury entering the system.

Table 63. JOFL air quality summary, including indicators of condition, 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			**Average condition score for air quality metrics is 20 indicating *significant concern* with an overall trend of *improving* 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]	$\leq$ 60 ppb[2]
	Sum06		Ozone exposure (SUM06) was considered *moderate concern* at 13.3 ppm-hrs	< 8 ppm-hrs[3]
	W126		Ozone exposure (W126) was considered *moderate concern* at 10.1 ppm-hrs	< 7 ppm-hrs[3]
Visibilty	average current visibility - estimated average natural visibility		The most recent JOFL 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 sulfur deposition[1,4]	< 1 kg/ha/yr[2]
	Acidification risk		Pollutant exposure & ecosystem sensitivity to acidification very high, park protection moderate, giving JOFL 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 moderate, and park protection moderate, giving JOFL 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		JOFL is located in a region corresponding to a 4 on the Bortle scale[9]	Minimum Quality definition approximates a Bortle Class 6[8]
Soundscapes	Desired Condition for Natural and Cultural Zones		DATA GAP--Condition status unknown	

[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. Note that although ARD guidance uses different scoring criteria, the overall condition score for Air Quality is the same.
[3]NPS ERMN. 2004. Assessing the risk of foliar injury from ozone on vegetation in parks in the ERMN.
[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.

Weather and Climate

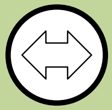
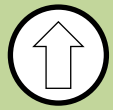
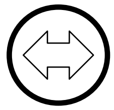
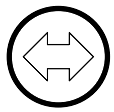
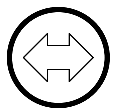
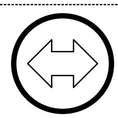
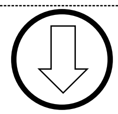
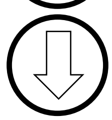
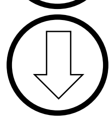
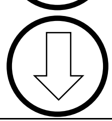
As mentioned in Chapter 4, we did not conduct a condition assessment on weather and climate, primarily because these indicators represent drivers of change in the condition of natural resources. Thus, assessments of condition do not make sense. Rather, we reported the trends in precipitation and temperature 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 JOFL 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 64. Summary results for weather and climate at JOFL, 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		↔ ↑	**Temperature trend unchanged, although winters are milder with less snow cover and growing season length is increasing; precipitation as snow decreasing**	
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 $\leq$ 0° F is decreasing[1]	
	Growing Season Length	↑	Growing season length is increasing[1]	

Table 64. (continued) Summary results for weather and climate at JOFL, 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		 	**Temperature trend unchanged, although winters are milder with less snow cover and growing season length is increasing; precipitation as snow decreasing**	
Indicator of Condition	**Specific Measure**	**Condition Status/Trend**	**Rationale and Data Sources**	**Reference Condition and Data Source**
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.

Water Quality

Past land use has substantially impacted water quality at JOFL. Historical land use upstream in the watershed included surface and subsurface mining activities that resulted in severe AMD pollution of the South Fork Little Conemaugh River (SFLCR). Water quality results from two stations sampled along the SFLCR indicated *significant concern*. The macroinvertebrate community was severely depleted (MBII = 7.01 on a 0 to 100 scale with scores <49 indicating *significant concern*). These results are not surprising given the long-term impacts that AMD pollution has on macroinvertebrate communities. Low pH and high conductivity measurements are also consistent with AMD effects and support the biological condition results (Table 65).

This regional pollution detracts from the water quality and biological integrity of the park's resources. However, the three unnamed tributaries flowing through the park do not appear to be as affected by AMD as the SFLCR. Water pH values were higher, specific conductance was lower, and MBII scores, while still warranting *significant concern*, were also higher (average MBII score = 27.87) than in the SFLCR. While obviously affected by the connection to the SFLCR, it is likely that local stressors within and immediately surrounding JOFL influenced tributary scores. These include Rt. 219 (a four-lane divided highway) that follows the northwest border of the park and crosses the SFLCR just downstream of the park boundary. In addition an active railroad runs parallel to the SFLCR bisecting the park. Agricultural practices and urban development upstream in the watershed most likely affect JOFL water quality results, as well (Table 65).

As aquatic macroinvertebrates represent a more reliable and robust indicator of water quality than discrete water chemistry measurements, the overall water quality rating for JOFL is based primarily on the MBII results, which corresponds to *significant 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 65. Summary results for water quality at JOFL, 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 *significant concern* given the results of the biological indicator**	
Indicator of Condition	**Specific Measure**	**Scale**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Water Chemistry Core	pH	Park		100% of samples from UNT SFLCR (JOFL.2001) fell within the 6 - 9 pH range criteria for supporting aquatic life[1, 2, 3, 4]	Cannot exceed Pennsylvania's and US EPA's standards for water bodies[5, 6]
		Region		61.5% of samples from SFLCR were within the 5-6 pH range for aquatic life [1, 4]	
	DO	Park		~100% of samples from UNT SFLCR (JOFL.2001) were above the threshold value for the aquatic life use and time of year[1, 2, 3, 4]	> 8 mg/L good for aquatic life; cannot fall below 5 for CWF or 4 for WWF and TSF (8/01 to 2/14)[5, 7]
		Region		~100% of samples from SFLCR were above the threshold value for the aquatic life use and time of year[1, 4]	
	Temperature	Park		72.7% of samples from UNT SFLCR (JOFL.2001) were below the threshold criteria for temperature[1, 2, 3, 4]	Threshold criteria depends on aquatic life use and time of year. See Table 21
		Region		53.3% of samples from SFLCR were below the threshold criteria for temperature [1, 4]	
	Specific Conductivity	Park		100% of samples from UNT SFLCR (JOFL.2001) warranted *moderate concern*[1, 2, 3, 4]	Specific conductance should be below 100 µS/cm to protect sensitive species, between 100 - 300 µS/cm to protect 95% of native species from extirpation[8]
		Region		100% of samples from the SFLCR were >300 µS/cm2 warranting *significant concern*[1, 4]	
Aquatic Macroinvertebrates	MBII	Park		Average MBII score for UNT SFLCR (JOFL.2001) was 27.87 indicating a condition rating of *signficant concern*[1, 2, 3, 4]	MBII Scores: > 63 = Good 49 - 63 = Moderate Concern <49 = Significant Concern[9]
		Region		MBII score for SFLCR was 7.01 indicating a condition rating of *significant concern* [4]	

[1]Sheeder and Tzilkowski 2006. Level I water quality inventory and aquatic biological assessment of ALPO and JOFL.
[2]Tzilkowski et al. 2011. Wadeable stream monitoring in the ERMN: 2009-2010 summary report.
[3]Tzilkowski et al. 2011. Wadeable stream monitoring in ALPO, DEWA, JOFL, and UPDE.
[4]Tzilkowski. Unpublished ERMN monitoring data.
[5]Chapter 93 (Water Quality Standards) of the Pennsylvania Code, Title 25 (Environmental Protection).

[6]US EPA Redbook (1976).
[7]US EPA (1986). Ambient water quality criteria for dissolved oxygen.
[8]USEPA. 2011. A field-based aquatic life benchmark for conductivity in Central Appalachian streams.
[9]Klemm et al. 2003. Development and evaluation of a macroinvertebrate biotic integrity index (MBII) for regionally assessing mid-Atlantic highland streams.

Ecosystem Integrity

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, including severe disturbances (e.g., extensive logging) followed by a long period of no physical land disturbance, coupled with increasing acid deposition from industrialization. As a result, the dominant fire-adapted trees species have been replaced with later successional, shade- and acid-tolerant species (e.g., red maple and striped maple). In JOFL, these factors, along with the disastrous flood of 1889, have shaped both forest species composition and vegetation structure in the park.

The two forest associations within JOFL ranked *moderate concern* to *good* for floristic quality with an overall rating of *good* for the resource. Both associations, however, contain multiflora rose, Morrow's honeysuckle and Japanese barberry. Continued vigilance of these non-native, invasive species is critical to control and prevent their spread to other areas in of the park (Table 66).

Table 66. Summary results for forest/wood/shrubland communities at JOFL, 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), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

ECOSYSTEM INTEGRITY			**Combined condition score for Ecosystem Integrity 71 indicating good condition**	
Indicator of Condition	**Specific Measure**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Forest/Wood/ Shrubland Overall rating of good condition as indicated by a combined condition score of 75	Floristic Quality Index Score	(green)	Mean FQI was 36.8 (*good condition*)[1, 2, 3, 4]	FQI Score (trisecte): > 34 = good; 17 - 34 = moderate concern; < 17 = significant concern[5, 6]
	Mean C	(yellow)	*Mean C* was 3.95 (*moderate concern*)[1, 2, 3, 4]	Mean C condition categories: >4 = good; 2 - 4= moderate concern; <2 = significant concern[5, 6]

[1]Perles et al. 2010. Condition of vegetation communities in ALPO and JOFL.
[2] Swink, F. and G. S. Wilhelm. 1979. Plants of the Chicago Region, 3rd ed. Morton Arboretum, Lisle, IL. 922 pp.
[3]Swink, F. and G. S. Wilhelm. 1994. Plants of the Chicago Region, 4th ed. Indiana Academy of Science, Indianapolis, IN.
[4]Chamberlain and Ingram. 2012. Developing coefficients of conservatism to advance FQA in Mid-Atlantic Region.
[5]ALPO NRCA Chapter 4, Section 4.4.1 Forest/Wood/Shrubland.
[6]Karr, J.R., Chu, E.W., 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington, DC, 206 pp.

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 park's small area and surrounding urban development, along with encroaching shrubs in wetland habitats 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 patch around the visitor center and Unger House fields. 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 67).

Table 67. Summary results for grassland communities at JOFL, 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, the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

ECOSYSTEM INTEGRITY			**Combined condition score for Ecosystem Integrity 71 indicating good condition**	
Indicator of Condition	**Specific Measure**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Grassland Combined condition score was between 66 and 67 or borderline between two condition categories. Given 2 of 3 metrics were in the lower condition category, grasslands were rated as moderate concern	Medium Field Size		JOFL contained one contiguous patch of potential grassland habitat equal to 9.7 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		Perimeter:area ratio of Patch A scored 40.8 indicating moderate concern[1]	Ratio of Reference P:A / Actual P:A >66 = good; 33 - 66 = moderate concern; <33 = significant concern[6]
	Mowplan		Patch A is mowed annually in Sept/Oct[7]	Reference condition: Areas of potential grassland habitat mowed no more than once per year in Sept/Oct[4, 5]

[1]Perles et al. 2006. Vegetation classification and mapping at JOFL.
[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]JOFL Mowplan Maps.

Wetlands

Wetlands within JOFL ranged in floristic quality from *significant* to *moderate concern*. The average FQI score was 27, while the average mean C score was 3. Both equate to an average condition score of *moderate concern.* Lower rankings for floristic quality occurred either from (1) the presence of non-native species, including Scots pine (*Pinus sylvestris*), autumn olive (*Elaeagnus umbellate*), Morrow's honeysuckle (*Lonicera morrowii*), tatarian honeysuckle (*Lonicera tatarica*), ox eye daisy (*Leucanthemum vulgare*), sweet vernalgrass (*Anthoxanthum odoratum*), giant knotweed (*Polygonum sachalinense*), spotted knapweed (*Centaurea biebersteinii*), creeping bentgrass (*Agrostis stolonifera*), and purple crownvetch (*Coronilla varia*) or, (2) the presence of a high number of species with low conservatism values, as in the case of Cattail Marsh. Landscape metrics ranked wetlands in *good* condition with an overall rating of *good* for the resource. Individual landscape metric scores ranged between *good* condition and *moderate concern.* For example, landscape connectivity scored *good* for the combined length of all non-buffer segments but *moderate concern* for the proportion of non-riverine buffer as natural habitat. Buffer Index scores followed a similar pattern with buffer lenth and buffer width scoring as *good* condition and *moderate concern*, respectively. Surrounding Land Use Index was rated as *good* condition (Table 68).

Minimal information exists regarding wetlands within JOFL. The Perles et al. (2004) study and a recent wetland delineation conducted in the fall of 2009 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. Of primary concern is the River Scour Vegetation area. This area contains two highly invasive species: Morrow's honeysuckle and Japanese knotweed. Both of these were addressed by JOFL staff following the Perles et al. (2004) inventory; however, management efforts in this area remain challenging. Drastic year-to-year change from intermittent flood scouring is conducive to the establishment of weedy plants. Because the spread of knotweed to new sites is facilitated by disturbance (Beerling 1991), continued vigilance and control of knotweed in this area is critical to managing this species and curtailing its spread within the park.

Table 68. Summary results for wetland communities at JOFL, 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), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

ECOSYSTEM INTEGRITY			**Combined condition score for Ecosystem Integrity 71 indicating good condition**	
Indicator of Condition	**Specific Measure**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Wetlands --Combined condition score for all wetland metrics was 71 indicating good condition	FQI		Average FQI score = 27 (moderate concern)[1]	FQI Score (trisected): 30-41 = good; 15-29 = moderate concern; 0-14 = significant concern[2, 3, 4, 5]
	Mean C		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, 4, 5]
	Landscape Connectivity		Combined length of all non-buffer segments met reference criteria for good condition; 53% of non-riverine buffer natural habitat (moderate condition); combined metric score was good[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]
	Buffer Index		98% of buffer length met reference criteria; buffer width was between 50 - 99m moderate concern). The combined condition score was good[6, 7]	Reference condition defined as: buffer length >50-100% of perimeter; average buffer width >100m[8]
	Surrounding Land Use Index		Surrounding land use score was 0.91 (good condition)[6, 7]	Reference condition defined as: average land use score = 0.80 - 1.0[8]

[1]Perles et al. 2010. Condition of vegetation communities in ALPO and JOFL.
[2] Swink, F. and G. S. Wilhelm. 1979. Plants of the Chicago Region, 3rd ed. Morton Arboretum, Lisle, IL. 922 pp.
[3]Swink, F. and G. S. Wilhelm. 1994. Plants of the Chicago Region, 4th ed. Indiana Academy of Science, Indianapolis, IN.
[4]Chamberlain and Ingram. 2012. Developing coefficients of conservatism to advance FQA in Mid-Atlantic Region.
[5]Brooks R.P., D. H. Wardrop, and J. A. Bishop. 2004. Assessing wetland condition on a watershed basis in the Mid-Atlantic region using synoptic land cover maps. Envir Manag & Assess 94:9-22.
[6]Keller Engineers, Inc. 2009. Wetland delineation draft document for JOFL.
[7]National Land Cover Database (2006)
[8]Faber-Langendoen. 2009. Freshwater wetlands monitoring and assessment framework for the Northeast Temperate Network

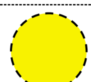
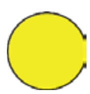
Biological Integrity

The wildlife focused biological integrity indicators were rated across a variety of condition levels. Very little data (inventory or monitoring) was available for these species; therefore, in many cases condition was assigned based on the best professional judgment of JOFL's Natural Resource Manager and the authors of this NRCA.

Six species of concern were selected for JOFL due to their special status given by state or federal agencies. Appalachian blue violet is a Pennsylvania State imperiled and globally vulnerable plant species. Veiny-lined aster has no current legal status in Pennsylvania but is considered to be Tentatively Undetermined by the Pennsylvania Natural Heritage Program. Northern myotis (northern long-eared bat) is a federally Proposed Endangered bat species. The Golden-winged Warbler is currently under consideration for federal listing, while the Blackpoll Warbler is listed as PA Endangered and the smooth green snake is a Species of Special Concern in Pennsylvania. We did not assign condition to these last three species due to uncertainty of their status and/or lack of data. Appalachian blue violet was rated as *moderate concern* with a *deteriorating* trend, since only a small population was detected and little suitable habitat could be found within the park. A thriving colony of veiny-lined aster was documented within the park on both sides of the Little Conemaugh River; this species is considered to be in *good* condition but the trend is unknown. The northern myotis was considered to be of *significant concern* with a *deteriorating* trend, primarily due to the fact that park surveys were conducted prior to the detection of white-nosed syndrome, which has caused substantial population declines in this species (Table 69).

The condition of bat, bird, amphibian, reptile, and mammal communities ranged from *moderate concern* to *significant concern*. No trends were determined due to limited data. In many instances, condition was assigned based on results from a single inventory. This makes it very difficult to determine condition and resulted in the low confidence and possibly lower condition ratings assigned to many of the indicators, especially considering the unlikelihood of detecting many of these species during a single survey. Overall the bat community at JOFL was considered to be of *moderate concern*. Although nine to eleven species were found to potentially occur within the park, these results were collected prior to white-nosed syndrome. Present results may show a decline in the number of potential species. The condition of bird communities at JOFL warranted *moderate concern* (60% of points within the park had BCI scores between 40.1 and 52.0). Combined condition results for amphibians and reptiles indicated *significant concern* with 59% of expected amphibians and 44% of expected reptiles expected to occur within JOFL. Only 30% of expected mammal species occurred within the park warranting *significant concern* (Table 69).

Table 69. Summary results for biological integrity indicators (species of special concern, bats, birds, amphibians, reptiles, and mammals) at JOFL, 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			**Combined condition score for species of concern, bat, bird, amphibian, reptile, and mammal communities was 35 warranting moderate concern**	
Indicator of Condition	**Specific Measure**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Species of Concern	Appalachian Blue Violet		Only a small population detected with little suitable habitat within the park[1, 2]	Reference conditions based on small scale surveys conducted in the park and best professional judgment
	Veiny-lined Aster		Thriving colony documented within the park on both sides of the South Fork Little Conemaugh River[1, 2]	
	Northern Myotis		Species present in 2005-2006 summer breeding season; deteriorating trend due to well-documented regional declines from white-nose syndrome[4, 5]	
	Golden-winged Warbler Blackpoll Warbler Smooth Green Snake		Condition not assessed due to uncertainties of species' status and limited survey data for breeding populations[6, 7]	
Bat Communities	Bat Species Diversity		9 of 11 species found in PA potentially occur within the park[4]	Reference conditions determined to be the potential species that could occur within the park[4]
Bird Communities	BCI		67% of BBA blocks and 60% of points within the park had BCI scores indicating moderate concern[6, 8, 9]	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]
Amphibians & Reptiles	Herpetofauna Diversity		59% of expected amphibians and 44% of expected reptiles were surveyed within the park[7]. Combined condition results indicate significant concern	Reference conditions determined to be the potential species that could occur within the park[7]
Mammals	Mammal Diversity		30% of expected mammal species occurred within the park[7]	Reference conditions determined to be the potential species that could occur within the park[7]

1Western Pennsylvania Conservancy. 2000. Park-sensitive data.
2Western Pennsylvania Conservancy. 2003. Park-sensitive data.
3Pennsylvania Natural Diversity Inventory (PNDI).
4Gates and Johnson. 2007. Bat inventory of four ERMN parks..
5USFWS. 2012. White-nose syndrome; the devastating disease of hibernating bats in North America.
6Yahner et al. 2001. Comprehensive inventory for birds at six Pennsylvania National Parks.
7Yahner and Ross. 2006. Inventory of amphibians, reptiles, and mammals at ALPO and JOFL.
8O'Connell et al. 1998b. The bird community index: a tool for assessing biotic integrity in the Mid-Atlantic Highlands report.
9Breeding Bird Atlas Surveys (2004-09).

Five species of non-native invasive animals were included in the JOFL NRCA: gypsy moth, emerald ash borer, Asian longhorn beetle, viburnum leaf beetle, and non-native crayfish species. Although gypsy moth detections are presently at low levels, continuous monitoring is necessary due to the possibility of future outbreaks and warrants *moderate concern*. Emerald ash borer has been devastating native ash trees in several Pennsylvania counties; however, it has not been detected within JOFL during the ERMN early detection surveys. As a result, the species rated as *good* condition for the park but given the ability of emerald ash borer to decimate stands of healthy ash trees within a few years of infestation, this species should be monitored closely. The viburnum leaf beetle was first detected at JOFL in 2010. Rapid response measures failed to control populations, which have decimated native arrowwood shrubs in early successional woodlands of the park. Consequently, this species was considered to be of *significant concern*. Crayfish populations continue to show relatively high abundances of native species with no non-natives detected and were considered to be in *good* condition (Table 70).

Previous studies of non-native plants within JOFL identified a total of 54 species, of which 12 were considered to be moderate or serious threats by DCNR. In addition, four target non-native invasive plant species (garlic mustard, shrub honeysuckles, multiflora rose and knotweed) were identified in park surveys, all of which still occur within park boundaries. The overall condition ranking for non-native invasive plants, therefore, is *moderate concern* (Table 70).

Aggressive control and maintenance activities over the past decade have greatly reduced individual plants and curtailed a primary source of seed and propagules. Knotweed, in particular, which has been targeted for control since 2000, now poses a minor threat to park habitats. We recommend that control measures be continued to restrict the spread of target non-native invasive species. A management plan should be developed for each target 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. Park managers should 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.

Table 70. Summary results for biological integrity indicators at JOFL (non-native animals and plants), 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), the rationale for the determined result, and explanation of reference condition (the latter complete with data sources).

BIOLOGICAL INTEGRITY			**Combined condition score for Non-native Biological Integrity metrics was 64 indicating moderate concern**	
Indicator of Condition	**Specific Measure**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Non-native Invasive Animals	Gypsy Moth		Gypsy moth eggs detected at 19% of surveyed stands across Pennsylvania between 2011 and 2012; presently at low levels but continuous monitoring necessary due to possiblity of future outbreaks[1, 2]	Low detection rate with no major outbreaks[1]
	Emerald Ash Borer		No detection within park during ERMN surveys[2, 3]	Low detection rate with no major outbreaks[1]
	Asian Longhorn Beetle		No detection within park during ERMN surveys[2, 3]	Low detection rate with no major outbreaks[1]
	Viburnum Leaf Beetle		Detected in 2010; rapid response failed to control populations which have decimated native shrubs; present condition unknown but was of *significant concern* to park management during last monitoring activity.[2, 3]	Low detection rate with no major outbreaks[1]
	Crayfish		Relative abundance of native populations ~high; no non-natives detected[4]	Reference condition defined as lack of non-native crayfish species[3]
Non-native Invasive Plants	Invasibility		Average metric score for invasibility was 0.76 indicating *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]
	% of Non-Native Species		Average metric score for % non-native plant species was 8.65 indicating *moderate concern*[5]	Based on % non-native species: 0-10 = good; > 10-20 = moderate concern; > 20 = significant concern[7, 8]

[1]Pennsylvania Department of Conservation and Natural Resources forest health report.
[2]Park Natural Resource Manager personal communication.
[3]Manning, D. R. and J. S. Keefer. 2013. Early detection of invasive species: ERMN 2011-2012 summary report.
[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]Zimmerman, E. 2007. Distribution and abundance of nonnative plant species at JOFL and ALPO.
[7]ALPO NRCA Chapter 4, Section 4.5.7 Non-native Invasive Plants.
[8]Karr, J.R. and Chu, E. W. 1999. Restoring life in running waters: better biological monitoring.

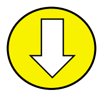
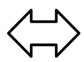
Landscapes

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.

Land cover conditions differed inside the park boundary and within the 1-km buffer zone. Percent forest increased from 41.09% in 1992 to 55.44% in 2006 within the JOFL boundary but decreased from 59.31 % to 49.47 % inside the 1 km buffer surrounding the park. Core forest increased approximately 4% from 2.31% to 6.37% in the JOFL boundary. Despite the reduction in total forest cover in the 1-km buffer zone, core forest increased 3% from 6.89% in 1992 to 10.00% in 2006. Road density has remained relatively unchanged. Greater changes probably occurred prior to 1992 when the adjacent highway (Rt. 219) was constructed. Average condition score and trend results for landscapes was 83 indicating *good* condition with an *unchanging* trend (Table 71).

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, despite forest increase within the park, 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 71. Summary results landscape indicators at JOFL, 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				**Combined condition score and trend for measures of land use, landscape pattern and fragmentation was 83 indicating good condition with an *unchanging* trend**	
Indicator of Condition	**Specific Measure**	**Extent**	**Condition Status**	**Rationale and Data Sources**	**Reference Condition and Data Source**
Land Use, Patterns, & Fragmentation	% Forest	Park + 1-km Buffer		% Forest decreased 9.84% from 1992 to 2006, falling below the threshold criteria for good condition and indicating *moderate concern* with a *deteriorating trend*[1, 2]	Reference condition based on the following criteria: >50% = good; 25 - 50% = moderate concern; <25% = significant concern[2, 4, 5, 6]
	% Core Forest	Park + 1-km Buffer		% Core Forest increased 3.11% from 1992 to 2006 (*unchanging trend*)[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]
	Road Density	Park + 1-km Buffer		Road Density remained ~unchanged from 1992 to 2006 remaining in good condition[3]	Reference condition based on the following criteria: >0.66 = good; 0.34 - 0.66 = moderate concern; 0 - 0.33 = significant concern[6]
	% Developed Land	Catchment		% Developed Land in the catchment increased from 2.66% in 1992 to 7.82% in 2006 indicating *good condition* with a *deteriorating trend*[1,2]	Reference condition based on the following criteria: <10% = good; 10 - 15% = moderate concern; >15% = significant concern[2, 4, 5, 6]

[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.

State of the Park Summary Table

Table 72. The State of the Park Summary Table provides a broad overview of the state of JOFL's natural resources and includes the overall condition status (green = *good*; yellow = *moderate concern*; red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging*, or *deteriorating* (downward arrow)), followed by the rationale for the determined result.

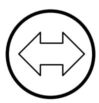
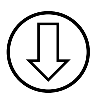
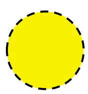
Priority Resource or Value	Condition Status/Trend	Rationale
Natural Resources		
Air Quality		Average condition score for air quality metrics was 20 indicating *significant concern* with an overall trend of *improving* condition. Estimated values for **ozone** were of *moderate concern* with an *improving* trend. Estimates for **visibility** warranted *significant concern* with an *unchanging* trend. Estimates of **wet deposition of nitrogen and sulfur** warranted *significant concern* with *improving* trends. Estimates of **wet mercury deposition** were of *significant concern* with an *unchanging* trend. **Night skies** were rated as *moderate concern* based on the Bortle Dark-Sky Scale.
Weather and Climate		Although **temperature trend** is *unchanged*, the lowest recorded temperature during the calendar year increased throughout the entire period of record, while the number of sub-zero days decreased. Overall results indicate JOFL has been experiencing milder winters with less snow cover. In accord with these milder temperatures, the growing season length has increased.
		Cumulative annual **precipitation** has remained unchanged but precipitation as snow, including annual snowfall, measurable snow days, moderate snow days, and heavy snow days, is decreasing.
Water Quailty		Water resources at JOFL include the South Fork Little Conemaugh River (SFLCR) and small unnamed tributaries (UNT). Wetlands are also an important resource but are not monitored for water quality. The ERMN monitors water quality using **benthic macroinvertebrates** (BMI) at one of the UNTs in the park. Due to the long history of AMD pollution to the SFLCR, the river was not monitored except for one year (2012). AMD watershed impacts affect the condition of JOFL's tributaries, but to a lesser degree than the SFLCR. BMI monitoring results confirmed impairment at both park (UNT) and regional (SFLCR) scales warranting *significant concern,* although the UNT was found to be in better condition than the SFLCR. **Core water chemistry** results for specific conductance supported the biological results, warranting *moderate concern* in the UNT and *significant concern* in the SFLCR.
Ecosystem Integrity		**Forests** occur south of the dam in JOFL's natural zone and consist primarily of Red Maple-Black Cherry Successional Forest/Woodland, which was considered to be in *good* condition for both floristic quality and conservatism. A Mosaic of Old Field/Red Maple-Black Cherry Successional Forest/Woodland is present to a lesser extent and warranted *moderate concern*. Early-successional **grasslands** occur within the Unger Farm fields surrounding the visitors center and warranted *moderate concern* based on minimum field size, perimeter:area ratio, and mowplan metrics. **Wetlands** occur throughout the former lakebed as a mosaic of early successional wetlands, grasslands, and shrubland and warranted *moderate* to *significant concern* for floristic quality and conservatism but scored higher for landscape condition ranging from *good* to *moderate concern*. The combined condition score for ecosystem integrity metrics was 71, indicating *good* condition.

Table 72 (cont'd)**.** The State of the Park Summary Table provides a broad overview of the state of JOFL's natural resources and includes the overall condition status (green = *good*; yellow = *moderate concern*; red = *significant concern*; and trend, if known (*improving* (upward arrow), *unchanging*, or *deteriorating* (downward arrow)), followed by the rationale for the determined result.

Priority Resource or Value	Condition Status/Trend	Rationale
Natural Resources		
Biological Integrity		Very little data existed for biological integrity indicators necessitating best professional judgment for many of the associated condition assessments. **Species of concern** at JOFL include rare plant species (Appalachian blue violet and veiny-lined aster), northern myotis (northern long-eared bat), Golden-winged Warbler, Blackpoll Warbler, and smooth green snake. The suspected status of the Appalachian blue violet was *moderate concern* with a *deteriorating* trend (due to small population and lack of suitable habitat), while that of the veiny-lined aster was considered to be in *good* condition with thriving colonies on both sides of the river. Northern myotis warranted *significant concern* due to widespread species declines from white-nose syndrome. The remaining species were not assessed for condition due to their uncertain status and lack of suitable habitat within the park. **Bat communities** at JOFL warranted *moderate concern*, also due to regional declines from white-nose syndrome. **Streamside birds** are not monitored by the ERMN due to lack of sufficent stream length, but results from Yahner et al. 2001 revealed Bird Community Index scores warranting *moderate concern*. **Amphibians, reptiles,** and **mammals** warranted *significant concern*. **Non-native invasive animals** at JOFL include the gypsy moth (*moderate concern*), emerald ash borer (*good*), Asian longhorn beetle (*good*), viburnum leaf beetle (*significant concern*), and non-native crayfish (*good*). **Non-native invasive plants** include garlic mustard, shrub honeysuckle, multiflora rose and knotweed. JOFL condition assessment for these plant species was conducted using the ERMN monitoring data collected within the park's natural zone. Red Maple-Black Cherry Successional Forest/Woodland scored *good* for invasibility and % non-native species metrics; Mosaic Old Field and Red Maple-Black Cherry Successional Forest/Woodland scored *moderate concern* for each metric. The average condition score for all biological integrity indicators was 50 indicating *moderate concern.*
Landscapes		JOFL is a small park surrounded by a largely agricultural and urban matrix. This was reflected by differing land cover conditions inside the park vs. within a 1-km buffer zone surrounding the park. Percent forest has increased within the park from 1992 to 2006 but decreased within the buffer zone during that same time period. Due to the influence of the surrounding buffer, the park plus the 1-km buffer zone was the spatial scaled used for most of the landscape metrics, which showed percent forest warranted *moderate concern* with a *deteriorating* trend, percent core forest remained relatively unchanged, and road density was in *good* condition with an *unchanging* trend. Percent developed land in the catchment indicated *good* condition with *a deteriorating* trend. The average condition score and trend results for landscapes was 83 indicating *good* condition with an *unchanging* trend.

Data Gaps

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 data for soundscapes
- Lack of water quantity data for the SFLCR and its tributaries
- Lack of sufficient water chemistry data for the SFLCR and its tributaries to track long-term changes in water quality resulting from AMD remediation activities
- Insufficient monitoring data on fish communities
- Lack of data on breeding 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 recent data on gypsy moth, emerald ash borer, Asian longhorn beetle, and viburnum leaf beetle 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.

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