National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Gettysburg National Military Park and Eisenhower National Historic Site Natural Resource Condition Assessment

Natural Resource Report NPS/NER/NRR—2017/1369

ON THE COVER
A view from Mississippi State Monument along West Confederate Avenue looking north towards the town of Gettysburg, including Henry Spangler Farm and Brian Farm and the fields beyond where the battle's climactic charge, Pickett's Charge, took place on the afternoon of July 3, 1863. NPS photo.

Gettysburg National Military Park and Eisenhower National Historic Site Natural Resource Condition Assessment

Natural Resource Report NPS/NER/NRR—2017/1369

Mary-Jane James

Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882

January 2017

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

Please cite this publication as:

James, M. J. 2017. Gettysburg National Military Park and Eisenhower National Historic Site Natural resource condition assessment. Natural Resource Report NPS/NER/NRR—2017/1369. National Park Service, Fort Collins, Colorado.

NPS 305/135905, 446/135905, January 2017

Contents

Figures

Page

Figures (continued)

Page

Figures (continued)

Page

Tables

Tables (continued)

Page

Tables (continued)

Page

Tables (continued)

Page

Executive Summary

Gettysburg National Military Park (GETT) and Eisenhower National Historic Site (EISE) are located in the south central portion of Pennsylvania in Adams County. The parks are adjacent to each other and share a common boundary on the western side of GETT and are part of the Mid-Atlantic Network (MIDN). GETT preserves the site of the American Civil War battle of Gettysburg, the Soldiers' National Cemetery, and the commemoration of the great battle by Civil War veterans. The landscape is a mosaic of mature and maturing woodlands and woodlots, agricultural fields, pasturelands, grasslands, wetlands, and streams that provide habitat for flora and fauna. GETT’s enabling legislation mandated the protection of lands occupied by the military during the battle and the preservation of important topographical features of the battlefield. EISE preserves the presidential and retirement home and farm of General and President Dwight D. Eisenhower, 34th President of the United States. During his presidency the farm sported a putting green, a skeet range, and a show herd of Angus cattle. The farm was used as a weekend retreat, temporary White House, and meeting place for world leaders. EISE contains flat open fields and pastures dissected by rolling hills, forested areas, meadows, wetlands, riparian zones, and local stream valleys.

Natural resources presented in this Natural Resource Condition Assessment (NRCA) were divided into four general areas: physical resources, water-related resources, ecosystem integrity, and focal animal communities. Within each of these general areas, specific natural resources were assessed.

- Physical Resources
    - Air quality - ozone
    - Air quality - wet deposition
    - Air quality - visibility
    - Night sky resources
    - Acoustic environment
- Water-Related Resources
    - Stream water quality
    - Wetlands, vernal pools, and ponds
    - Aquatic macroinvertebrates
    - Fish community
- Ecosystem Integrity Resources
    - Forest communities, woodlots, and vegetation associations
    - Plant species of interest
    - Agricultural fields and grasslands
- Focal Terrestrial Animal Community Resources
    - Avian community
    - Herpetofaunal community

- Terrestrial Arthropod & Lepidoptera communities
- Mammal community
- White-tailed deer abundance

The approach of this NRCA was to use existing data to evaluate the condition of natural resources at GETT and EISE. Thresholds for condition (good, moderate concern, and significant concern) were obtained from a variety of resources such as federal and state regulations (e.g., water quality criteria), peer-reviewed literature, study reports, and in some cases when threshold values were not available, best professional judgment. If possible, trends in the condition (improving, deteriorating, or unchanging) were also evaluated. And finally, an estimate of the confidence in the assessment was provided based on the quality and quantity of available information (high, medium, low confidence). The assessment of condition used standardized symbology provided by NRCA guidelines are presented in Table 1a. A summary of assessment values for all resource categories evaluated in this effort can be seen in Table 1b.

Table 1a. Symbol key legend used to report natural resource condition, trend, and confidence in data used for the assessment.

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

Table 1b. Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Air Quality			
Ozone (human health standard)	moderate concern, trend unknown	moderate concern, trend unknown	Continued monitoring by local, state, and federal agencies (data interpolated by the NPS ARD from stations relatively close to the parks)
Ozone, SUM06 (ecological standard)	moderate concern, trend unknown	moderate concern, trend unknown	
Ozone, W126 (ecological standard)	moderate concern, trend unknown	moderate concern, trend unknown	
Wet N deposition	significant concern, improving trend	significant concern, improving trend	
Wet S deposition	significant concern, improving trend	significant concern, improving trend	
Mercury wet deposition	Condition threshold not established but trend was improving	Condition threshold not established but trend was improving	
Visibility	significant concern, trend unknown	significant concern, trend unknown	
Night sky resources	moderate concern, trend unknown	moderate concern, trend unknown	Based on modeled NSNSD data, field data for both parks would be beneficial
Acoustic resources	significant concern, trend unknown	significant concern, trend unknown	Based on modeled NSNSD data, field data for both parks would be beneficial
Water Resources			
Water quality- dissolved oxygen	good condition, trend unknown	good condition, trend unknown	Continue with MIDN water quality monitoring. Possibly expand continuous water quality monitoring to other locations and include other parameterxs.
Water quality- nutrients	moderate concern, trend unknown	condition and trend were unknown	
Water quality- pH	good condition, trend unknown	good condition, trend unknown	

Table 1b (continued). Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Water Resources (continued)			
Water quality- siltation	moderate concern, trend unknown	moderate concern, trend unknown	Continue with MIDN water quality monitoring. Possibly expand continuous water quality monitoring to other locations and include other parameterxs.
Water quality- specific conductance	good condition, trend unknown	good condition, trend unknown	
Water quality- temperature	good condition, trend unknown	good to moderate concern, trend unknown	
Water quality- toxic chemicals	moderate concern, trend unknown	condition and trend were unknown	
Wetland patch size	Significant concern, unknown trend	Significant concern, unknown trend	Conduct a wetlands inventory.
Wetlands (0-100m buffer)	moderate concern, trend unknown	moderate concern, trend unknown	
Wetlands (100-250m buffer)	moderate concern, trend unknown	Significant concern, unknown trend	
Wetlands (250-500m buffer)	moderate concern, trend unknown	Significant concern, unknown trend	
Aquatic macroinvertebrates: Crayfish community	Significant concern, unknown trend	Significant concern, unknown trend	Continue monitoring the aquatic macroinvertebrate community using the MIDN protocol. Conduct focal crayfish study
Aquatic macroinvertebrates	Significant concern, unchanging trend	Significant concern, unchanging trend	
Fish community	good condition, trend unknown	good to moderate condition, trend unknown	Conduct fish survey

Table 1b (continued). Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Terrestrial Resources			
Forest Communities - Forest structural stage	good condition, trend unchanging	Not sampled	Continue with MIDN forest monitoring. Data are currently being analyzed by the MIDN with respect to trends. Possibly, re-monitor plots after prescribed burns are conducted.
Forest Communities - Forest canopy tree cover	good condition, trend unknown	Not sampled	
Forest Communities - Forest snags	good condition, trend unknown	Not sampled	
Forest Communities - Forest course woody debris	good condition, trend unknown	Not sampled	
Forest Communities - Forest regeneration (stocking index)	moderate concern, growth rate invasive plants	Not sampled	
Forest Communities - Forest soil chemistry (Ca:Al)	good condition, trend unchanging	Not sampled	
Forest Communities - Forest soil chemistry (C:N)	significant concern, trend unchanging	Not sampled	
Plant Species of Interest – Species of Concern	condition and trend unknown	unknown condition and trend	Conduct surveys for density and areal coverage for plant species of interest.
Plant Species of Interest – Invasive plants	significant concern, trend unknown	condition and trend unknown	
Agricultural fields & grasslands - Field size	significant concern, trend unknown	moderate concern, trend unknown	Develop metadata for current landuse cover related to battlefield rehabilitation. Conduct a grassland vegetation study. Develop mow plans for all fields.
Agricultural fields & grasslands – P:A ratio	good condition concern, trend unknown	good condition concern, trend unknown	
Agricultural fields & grasslands – Mow plans	moderate concern, trend unknown	moderate concern, trend unknown	
Agricultural fields & grasslands – Floristic index	condition and trend unknown	condition and trend unknown	

Table 1b (continued). Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Focal Communities			
Avian community - songbird	good condition, trend unknown	moderate concern, trend unknown	Conduct avian monitoring.
Avian community - grassland	condition and trend unknown	condition and trend unknown	Conduct grassland bird study and focal loggerhead shrike study.
Herpetofauna - Amphibians community	moderate concern, trend unknown	significant concern, trend unknown	Conduct herpetofauna monitoring.
Herpetofauna- Reptiles	moderate concern, trend unknown	significant concern, trend unknown	
Terrestrial arthropod & Lepidoptera	condition and trend unknown	condition and trend unknown	Develop monitoring plan and conduct terrestrial arthropod & Lepidoptera monitoring
Mammal community (excluding bats)	moderate concern, trend unknown	significant concern, trend unknown	Conduct a mammal survey, including a focal bat study.
Mammal community (bats)	moderate concern, trend unknown	significant concern, trend unknown	
Deer abundance	moderate concern, improving trend	moderate concern, improving trend	Continue with deer management plan.

Physical Resources Summary

The National Park Service Air Resources Division (NPS ARD) oversees the national air resource management program for the National Park Service (NPS) and assesses the condition of air quality metrics for all NPS units. The NPS ARD uses data from local, state, and federal monitoring programs and interpolates and interprets these data over a 5-year period to estimate trends in air quality. The NPS ARD used three metrics to assess ozone conditions: the 4th-highest daily maximum 8-hour average ozone concentration, which is the human health standard, and W126 and SUM06 metrics (both ecological standards) that measure exposure to ozone sensitive vegetation. All three of these ozone metrics were rated as moderate concern for GETT and EISE. While trends in these metrics were not specifically evaluated, the NPS ARD regional interpolated trend maps showed an improving trend in the general regional area of the park. The confidence in the assessment was high since the condition was based on monitoring data collected relatively close (25 km) to the parks Table 1a-b).

Wet deposition was estimated by the NPS ARD as total nitrogen (N) wet deposition, total sulfur (S) wet deposition, and trends in mercury deposition based on interpolated data. Both total N and total S wet deposition were rated as significant concern for GETT and EISE. Trends in wet deposition were not estimated by the NPS ARD. Threshold standards for air quality related to mercury deposition have not yet been established; however, the trend in mercury deposition was evaluated as unchanging. The confidence in the current condition and trend was assessed as high since air quality monitoring is ongoing and the stations are relatively close to the parks (25 km) Table 1a-b).

The NPS ARD estimated visibility as a Haze Index that was based on haze levels on the clearest and haziest days. The visibility at GETT and EISE was evaluated as significant concern. Although the NPS ARD did not estimates trends in visibility for the parks, NPS ARD regional Haze maps indicated no change on the 20% clearest days and a possible improving trend in visibility on the 20% haziest days. The confidence in the current condition and trend was assessed as high since air quality monitoring is ongoing and the stations are relatively close (25 km) to the parks Table 1a-b).

NPS Natural Sounds and Night Skies Division (NPS NSNSD) monitors night sky resources and natural lightscape for park units. The NPS NSNSD modeled night sky resources at GETT and EISE and the Anthropogenic Light Ratio (ALR) a measure of sky brightness related to anthropogenic sources, was found to be of moderate concern for both parks. No trend was estimated as night sky resources have only recently (2013) been modeled for the parks. The data were of good quality and were recent; however, since the ALR was based on modeled data for the region the confidence in the assessment was medium Table 1a-b).

In the National Park setting the acoustic environment can be made up of natural, cultural, and historic sounds depending on the purpose and values of the park. The NPS Natural Sounds Team collects sound data and provides management objectives based on the needs of the park. The acoustic environment has not yet been measured in the field at GETT and EISE but noise impacts have been modeled for the parks. The modeled noise impacts were estimated as significant concern with an unknown trend, and the confidence in the assessment was medium since the estimate was based on modeled data as opposed to field data Table 1a-b).

Water and Water-Related Resources

The main water resources at GETT and EISE are small streams and runs. At GETT, the main stream system is Rock Creek and its tributaries including Plum Run west and Plum Run south. The stream habitat at EISE consists of Marsh Creek and Willoughby Run, a tributary of Marsh Creek. Streams and runs within GETT and EISE primarily have classified designated uses for warm water resident fishes and migratory fishes, although Marsh Creek (EISE) is designated for cold water resident fishes and migratory fishes. None of the surface waters in either GETT or EISE were designated as wild and scenic rivers, exceptional value, or high quality streams Table 1a-b).

Surface water quality was assessed for some streams within the parks by the state in 2002 and 2004. The MIDN has conducted water quality monitoring for selected parameters (dissolved oxygen, pH, specific conductance, and temperature) at GETT and EISE from 2010 to present. The MIDN data have not yet been formally analyzed; however, most parameters were within acceptable water quality ranges for warm water resident fishes during sampling events and were evaluated as good condition for these parameters. Marsh Creek (EISE), a cold water resident fish designated stream, had acceptable temperatures only 32% of the sampling events and was evaluated as moderate concern for temperature. Parameters not monitored by the MIDN, but assessed by state in 2002 and 2004 (nutrients, siltation, and toxics) were found to be sub-standard and some streams (Rock Creek, Stevens Run [GETT], and Willoughby Run [EISE]) were assessed as non-attaining for designated uses and were reported as needing Total Maximum Daily Load. As of 2016, Total Maximum Daily Load plans were not yet developed for these streams and these water quality parameters were assessed as moderate concern. Trends were not assessed for any of the water quality parameters as the MIDN has not completely analyzed data for dissolved oxygen, pH, specific conductance, and temperature; and, there were no recent data for nutrients, siltation, or toxics. The confidence in the MIDN data was medium (due to ongoing analyses) and low for the other parameters due to the length of time (over ten years) since the last assessment Table 1a-b).

Wetlands types present in the parks were palustrine emergent freshwaters and forests/shrub freshwater wetlands. There were also several ponds at GETT. Field surveys of the wetlands at GETT and EISE were conducted over 20 years ago and the ponds have never been surveyed. In the absence of fine scale field data, Geographic Information System (GIS) landscape level data (National Land Cover Database) and in-house park GIS data were used to evaluate the condition of the wetlands based on wetland patch size and surrounding land use (e.g., anthropogenic land use versus natural lands). The condition of the wetlands at GETT scored as significant concern for wetland patch size (patches were very small) and moderate concern based on the low percent of natural lands in three buffer zones (0-100m, 100-250m, and 250-500m buffer zones) around the wetlands. At EISE, wetland patch size also scored as significant concern (too small). The immediate buffer zone (0-100m) scored as moderate concern while the other two zones (100-250m and 250-500m) scored as significant concern due to the low percent of natural lands surrounding the wetlands. There were some obligate vernal pool species that have been recorded in both parks; however, there has never been a survey to document the existence of vernal pools. The confidence in the assessment was medium and trend was not evaluated as this was a first attempt to assess the wetlands using these metrics. Additionally, battlefield rehabilitation may have changed the land use adjacent to the parks wetlands since the 2011 National Land Cover Database was developed Table 1a-b).

A focal survey of crayfish was conducted at GETT and EISE in 2005. Invasive crayfish (rusty crayfish [*Orconectes rusticus*] and virile or northern crayfish [*O. virilis*]) comprised 98% of the relative abundance of all crayfish collected at the two sites within EISE, and may have extirpated native crayfish in Marsh Creek. Similarly at GETT, the virile crayfish comprised more than 75% of the crayfish community at five of the nine sites sampled and may have completely eliminated native crayfish from some streams within the park (sections of an unnamed tributary to Willoughby Run, Rock Creek, and Stevens Run). The crayfish community for both GETT and EISE was assessed as significant concern. No trend was estimated since there was only one focal survey conducted for crayfish. Confidence in the condition was medium as the data were over ten years old Table 1a-b).

Aquatic macroinvertebrate sampling was initiated by the MIDN at GETT and EISE in 2009 and continues to the present (data were only interpreted to 2014). The MIDN calculated an Index of Biotic Integrity (IBI) based on the PA Riffle-Run Index of Biotic Integrity and the PA Multihabitat Index of Biotic Integrity for low gradient Streams. The MIDN IBI is based on a multi-metric index that measures relevant aspects of benthic macroinvertebrate community composition. Sampling for macroinvertebrates was conducted at one station in EISE on lower Willoughby Run and four stations in GETT: upper Willoughby Run, Stevens Run, Rock Creek, and Plum Run. The macroinvertebrate community at EISE had an impaired community in all five sampling years, and was assessed as significant concern with an unchanging trend. Similarly, all fours stations at GETT had an impaired macroinvertebrate community in all five years and was also assessed as significant concern with an unchanging trend. Confidence in the condition was high as the data were recent and the MIDN plans to continue aquatic macroinvertebrate sampling Table 1a-b).

Fish were surveyed at both GETT and EISE in 2004 during the MIDN fish inventory. An IBI developed for New Jersey streams and based on the Environmental Protection Agency's Rapid Bioassessment Method was used to evaluate the fish community at GETT and EISE. The condition of the fish community at GETT was evaluated as good (Rock Creek). At EISE, the condition of the fish community was rated as good (Marsh Creek) to moderate concern (Willoughby Run). Suboptimal scores were attributable to low numbers of insectivorous cyprinids and piscivores, sunfish species, and high abundances of pollution tolerant and generalist species. Trends could not be evaluated because the fish community has only been surveyed once. Confidence in the condition was medium as the data were over ten years old Table 1a-b).

Ecosystem Integrity

The MIDN has monitored forest health at GETT as part of the Vital Signs Monitoring Program since 2007 (forest cover is low at EISE and thus is not monitored). Metrics used by the MIDN to evaluate forest health include forest community structure, density and composition of tree seedlings, monitoring selected herbaceous species as indicators of deer browsing, detection of forest pests and diseases, detection of invasive plants, status of coarse woody debris and snags, and measures of soil chemistry. Five of the metrics (forest community structure, coarse woody debris, snags, and Ca:Al soil chemistry) all ranked as good condition; forest regeneration ranked as moderate concern; and C:N soil chemistry ranked as significant concern. Overall, the most comprehensive monitoring at GETT (2007-2009) indicated that the condition of the forest health at GETT was good. The MIDN has yet to evaluate trends in forest condition. The confidence in the assessment was high as monitoring was ongoing by the MIDN Table 1a-b). The trend in structural stage was unchanging from 2007-2009 (census 1) to 2011-2013 (census 2). Forest regeneration from census 1 to census 2 for tree seedlings was improving but was deteriorating for invasive plants. The trend for soil chemistry was unchanging (based on 8 plots sampled in 2010 and 2013).Trends were not evaluated for canopy tree condition, snags, or coarse wood debris from census 1 to census 2.

GETT and EISE maintain a combined area of approximately 1,030 ha (2,545 ac) of grasslands, fields, and crops that are managed as a cultural resource to restore and perpetuate the battlefield as it appeared at the time of the Battle of Gettysburg. Although culturally important, these large expanses of open land (e.g., agricultural fields, successional old fields, active and inactive pastures, grasslands, wet meadows, and reed canary grass riverine grasslands) also provide critical habitat for a variety of flora and fauna, such as grassland obligate bird species, turtles and snakes, small mammals, and rare plant species. The grasslands at the parks have not been specifically monitored and have only been surveyed in the context of other studies (e.g., avian surveys). Agricultural fields and grasslands were mapped during the National Vegetation Classification mapping in 2003-2004; however, battlefield rehabilitation (e.g., tree removal, prescribed burns) has altered the vegetation since the mapping effort; and the vegetation map was significantly out of date even before it was published in 2006; however, the parks maintain draft in-house GIS files to track the battlefield rehabilitation effort. Metrics used to assess the condition of fields and grasslands were field patch size, perimeter to area (P:A) ratio of the fields, mow plans, and Floristic Quality Index. Using the draft in-house park GIS data, the grasslands at GETT and EISE were assessed as significant concern for field size (too small for grassland obligate birds), good condition for P:A ratio, moderate concern for mow plans, and unknown for Floristic Quality Index (there were no data on the vegetation communities of the grasslands). Trends were not evaluated. The confidence in the assessment for field size and P:A ratio was medium for both GETT and EISE as these assessments were based on draft in-house GIS data layers that have not been finalized. The confidence for mowing plans was medium as the parks' have established protocols for mowing but mow plans are not in place for all fields. The assessment for Floristic Quality Index was low as there were not data to evaluate the current vegetation community of the grasslands and fields Table 1a-b).

Both GETT and EISE are home to a variety of state-listed plants (no federally-listed plants have been observed in the parks). Approximately 4% and 1% of the plants recorded at GETT and EISE (in 2004-2005), respectively, were state listed. These species occur in a variety of habitats from forests to open grasslands. The condition for species of concern was assessed as unknown since the last survey was conducted over 10 years ago and may not be representative of current species within the parks. Invasive and exotic plants are common in both parks with species such as such as multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), tree of heaven (*Ailanthus altissima*), mile-a-minute (*Persicaria perfoliata*), Canada thistle (*Cirsium arvense*), Asiatic tearthumb (*Polygonum perfoliatum*), Japanese stilt grass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), Amur honeysuckle (*Lonicera maackii*), and Morrow's honeysuckle (*Lonicera morrowii*) being particularly troublesome and potentially negatively impacting the cultural and natural resources of the parks. Additionally, MIDN forest vegetation monitoring indicated that the frequency of exotic plants at GETT was the highest among all MIDN parks (forest vegetation monitoring is not conducted at EISE). Therefore, invasive vegetation was evaluated as significant concern for GETT based on best professional judgement. The condition of invasive plants at EISE was evaluated as unknown since invasives have not been monitored at EISE. Trends could not be assessed for either park. However, both parks are taking proactive management actions, such as mechanical removal, chemical control, and prescribed burns, to reduce the abundance and distribution of invasive and exotic plants Table 1a-b).

Focal Animal Communities

The avian community at GETT and EISE has been surveyed once in the past 15 years (in 1999-2001). Focal surveys on loggerhead shrikes (1999-2001) and grassland/shrubland birds (2005) have also been conducted. The condition of the breeding avian community was evaluated using a guild based index developed for the Mid-Atlantic Piedmont and Coastal Plain region. The index incorporated the percent of species in nine bird guilds in three biotic elements (structural, functional, and compositional, three guilds per biotic element) to rank the avian community during the breeding season. Using this system the avian community at GETT was assessed as good condition for the breeding bird community. At EISE, the community was evaluated as moderate concern due to a lower than desired species richness of specialist guilds (forest interior, pine associated, upper canopy foragers, bark probers, upper canopy foragers, and ground gleaners) and a higher than desired species richness for exotics and nest disrupters. However, this assessment should be interpreted with caution due to the scarce amount of forest habitat at EISE. Confidence in the assessment for both parks was medium due to the age of the data and trends could not be evaluated due to the lack of long term data Table 1a-b).

The Northeast Temperate Network Breeding Landbird protocol has guidelines for evaluating the integrity of grassland bird communities using a guild based index. Unfortunately, this assessment could not be applied to the grassland bird data collected in 2005 as several required metrics were not available from the data. Therefore, the condition and trend for grassland bird communities in both parks was rated as unknown Table 1a-b).

Herpetofauna (amphibians and reptiles) were surveyed in GETT and EISE in 1999-2000. The metric used to evaluate herpetofauna was the percent of species observed in GETT and EISE compared to the number of species present in Adams County as listed in the Pennsylvania Amphibian and Reptile Survey database (48 species: 21 amphibians and 27 reptiles). Seventy-one percent of amphibians (15 species) and 50% of reptiles (14 species) have been recorded at GETT. The condition of the GETT herpetofauna community was evaluated as moderate concern for both amphibians and reptiles. At EISE, 33% of amphibians (7 species) and 7% of reptiles (2 species) were observed, and both communities were evaluated as significant concern. Since there was only one monitoring effort (~15 years ago) the confidence in the assessment was medium and the trend was unknown for both GETT and EISE. No state or federally listed herpetofauna species were observed in either park Table 1a-b).

Terrestrial arthropods including Lepidoptera were inventoried once (in 1999-2000) at GETT and EISE. This inventory was a first attempt at trying to develop a monitoring plan for these species. Although, this study suggested potential taxa that could be used as sentinel groups to monitor, there was a lack of spatial and temporal population data and a need for greater taxonomic resolution. Therefore, more data were required before the condition of terrestrial arthropod communities at GETT and EISE could be evaluated and the condition of the community was assessed as unknown and the confidence in the assessment was low. Trends could not be evaluated because these communities have only been inventoried once Table 1a-b).

The mammal community (white-tailed deer are discussed separately below), including focal bat studies, was surveyed at GETT and EISE in the mid-1990s and again in the early 2000s. The metric used to evaluate the condition of the mammal community was the percent of observed species in Adams County in comparison to the percent of species recorded in the parks. Forty-one mammals and 12 bat species were known to be present in Adams County. Sixty-six percent of mammals (27 species) and 55% of bat species (six species) were observed at GETT, and both communities were evaluated as moderate concern. At EISE, 17% of the expected mammals (6 species) and 42% of expected bat species (five species) were observed, and both of these communities were evaluated as significant concern. Since the surveys used different methods, trends could not be evaluated. The confidence in the assessment was medium as the data were dated (~10 years ago) and may not be representative of the present mammal community within GETT and EISE. The northern long-eared bat (or northern myotis, *Myotis septentrionalis*), a state listed candidate rare species and federally listed threatened species has been recorded at both GETT and EISE. The least shrew (*Cryptotis parva*), a state endangered species, has been recorded at both GETT and EISE. Both parks are part of the Least Shrew Important Mammal Area. These areas allow for the conservation of important habitat that would allow least shrew dispersal within and among populations, thus promoting stability for shew populations in this part of PA Table 1a-b).

Currently, the NPS is managing the abundance of white-tailed deer at GETT and EISE through culling. The parks monitor the deer population each spring and also conduct long-term forest monitoring to help assess browsing impacts and set deer management goals. The parks’ desired management goal for deer is 10 deer km^{-2} of forest. The most recent estimate of deer density (in 2016) ranged from 33-93 deer km^{-2} of forest. This density was higher than the desired goal; however, since the initiation of culling deer density has decreased approximately 50%. Additionally, there has been a decrease in deer browse damage to forest and crops, thus objectives in regards to deer impacts appear to be being met. Based on best professional judgement the condition of deer abundance, as it pertains to management goals, was assessed as moderate concern (since the density goal has not yet been met), with an improving trend (since management actions are succeeding in reducing deer density towards the management goal). The confidence in the assessment was high Table 1a-b).

Acknowledgments

I would like to thank the staff of Gettysburg National Military Park and Eisenhower National Historic Site: Z. Bolitho, D. Reiner, C. Musselman, R. Krichten, W. Peterson, E. Clarke, for thoughtful discussions, help in obtaining data and reports, and comments on early versions of this NRCA; the staff of the Northeast Region (NER) and Mid-Atlantic Network (MIDN) NPS staff: C. Chapin (NER), C. Roman (NER), P. Sharpe (NER), C. Arnott (NER), S. Cowell (NER), A. Weed (MIDN), N. Dammeyer (MIDN), M. Johnson (MIDN), H. Salazer (NER), M. Taylor (NER) for assistance with GIS data and other data, MIDN reports, and helpful comments on section of this NRCA. Many thanks go to R. Bannon, R. Duhaime, and C. LaBash of the NPS Field Technical Support Center at the University of Rhode Island for assistance with geospatial data collection, spatial analyses, and GIS map production. Several reviewers provided helpful suggestions that improved this Natural Resource Condition Assessment.

List of Acronyms

ACCD: Adams County Conservation District & Adams County Office of Planning and Development

ALR: Anthropogenic Light Ratio

BCI: Bird Community Index

CWF: Cold water resident fishes

DBH: Diameter at Breast Height

EISE: Eisenhower National Historic Site

GETT: Gettysburg National Military Park

GIS: Geographic Information System

GMP: General Management Plan

IBI: Index of Biological Integrity

IMA: Important Mammal Areas

MF: Migratory fishes

MIDN: Mid-Atlantic Network

NCBN: Northeast Coastal and Barrier Network

NETN: Northeast Temperate Network

NLCD: National Land Cover Database

NPS: National Park Service

NPS ARD: National Park Service Air Resources Division

NSNSD: Natural Sounds and Night Skies Division

NWI: National Wetlands Inventory

PIF: Partners in Flight

PA DCNR: Pennsylvania Department of Conservation and Natural Resources

PA DEP: Pennsylvania Department of Environmental Protection

PA-HIBI: Pennsylvania Multihabitat Index of Biotic Integrity

List of Acronyms (continued)

PA-RRIBI: Pennsylvania Riffle-Run Index of Biotic Integrity

PASDA: Pennsylvania Spatial Data Access

PARS: The Pennsylvania Amphibian and Reptile Survey

PNHP: Pennsylvania Natural Heritage Program

TMDL: Total Maximum Daily Load

USDA: U.S. Department of Agriculture

US EPA: U.S. Environmental Protection Agency

USFWS: U.S. Fish and Wildlife Service

WNS: White-nose Syndrome

WWF: Warm water resident fishes

Chapter 1. NRCA Background Information

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

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

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

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

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

---

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

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

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

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

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

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

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

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

Important NRCA Success Factors

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

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park’s desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

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

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

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

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

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

Chapter 2. Introduction and Resource Setting

2.1 Introduction

2.1.1. History and Enabling Legislation

2.1.1.1 Gettysburg National Military Park

Gettysburg National Military Park is the site of the American Civil War of battle Gettysburg, the Soldiers' National Cemetery, and the commemoration of the great battle by Civil War veterans. The Battle of Gettysburg, fought on July 1–3, 1863, was the bloodiest single battle of the American Civil War. Victory for the Union Army at Gettysburg has been considered a major turning point in the war, ending the northward invasion by General Robert E. Lee's Confederate Army. Over 51,000 soldiers were killed, wounded, captured, or missing after the three-day battle. Significant sites on the battlefield began to be preserved almost immediately after the 1863 battle, and as a memorial for the armies that fought in the battle, Gettysburg National Military Park was established by congress on February 11, 1895. The park's enabling legislation mandated the protection of lands occupied by the military during the battle and the preservation of important topographical features of the battlefield. The park contains historic and designed landscapes that are nationally significant and contribute to the story of the battle and its consequences. These landscapes, when combined with the historic structures, archeological resources, and museum objects and archives of the park, reflect the history of the battle and its significance to the Civil War and to U.S. history. Together, they provide one of the most complete physical records of a pivotal Civil War battle, its aftermath, and its legacy (NPS 2014). GETT has been administered by the NPS since 1933, the park now incorporates 2,443 ha (6,034 ac) of land across which the battle, its aftermath, and commemoration occurred (Perles et al. 2006, NPS 2015b). The park land consists of a Main Unit (2,171 ha [5,362 ac]) that borders the town of Gettysburg to the north and south, several small disjunct parcels within and nearby the town, and East Cavalry Field (272 ha [672 ac]) that lies approximately 5.5 m (3.5 mi) east of the town center. The majority of land parcels within the park boundary are owned by the federal government, the Friends of National Parks group, or are protected by easement. Only 17% of the park land, approximately 460 ha (1,136 ac), is in private ownership. Approximately 1.8 million people visit the park each year to enjoy hiking trails, scenic car tours, over 1,400 monuments and 400 cannons, and beautiful vistas overlooking the battlefield and the surrounding landscape (NPS 2015b).

The enabling legislation of Gettysburg National Military Park in 1864 stated the purpose of the park as:

> *…to hold and preserve the battlegrounds of Gettysburg, on which were fought the actions of the first, second and third days of July, Anno Domini one thousand eight hundred and sixty-three, with the natural and artificial defenses, as they were at the time of said battle, and by such perpetuation, and such memorial structures as a generous and patriotic people may aid to erect, to commemorate the heroic deeds, the struggles, and the triumphs of their brave defenders.*

On February 11, 1895, the U. S. Congress made Gettysburg the third national Military Park in the United States, among the purposes of the Park was the instruction to:

…acquire…such lands in the vicinity of Gettysburg, Pennsylvania…which were occupied by the infantry, cavalry and artillery on the first, second and third days of July, eighteen hundred and sixty-three, and other such adjacent lands…necessary to preserve the important topographical features of the battlefield.

2.1.1.2 Eisenhower National Historic Site

Located adjacent to Gettysburg National Military Park is Eisenhower National Historic Site. Eisenhower National Historic Site preserves the presidential and retirement home, and farm of General and President Dwight D. Eisenhower, 34th President of the United States. The 76 ha (189 ac) farm was purchased by the President and Mrs. Eisenhower in 1950. During his presidency he used the farm as a weekend retreat, temporary White House, and meeting place for world leaders, including Soviet Premier Nikita Khrushchev, President Charles De Gaulle, Prime Minister Winston Churchill, and Governor Ronald Reagan. During this time, the farm sported a putting green, a skeet range, and a show herd of Angus cattle. The Eisenhower properties illustrate the nation's political history through their association with important national and international events and developments that affected or were affected by Dwight Eisenhower in the 1950s and 1960s (NPS 1999a)

The site was designated as a National Historic Landmark in April 1966 and Eisenhower National Historic Site was created on November 27, 1967 (NPS 2015a). The designation order states:

…the farm of General Dwight D. Eisenhower, thirty-fourth President of the Unites States, at Gettysburg, Pennsylvania, is of outstanding historical significance to the people of the United States because of its close association with the life and work of General Eisenhower and because of its relation to the historic battle of Gettysburg during the Civil War…the establishment…as a national historic site would constitute a fitting and enduring memorial to General Dwight D. Eisenhower and to the events of far-reaching importance which have occurred on the property…

Currently, EISE encompasses 280 ha (690 ac) as adjoining farms (Redding's and Brandon farms) were later acquired and are now part of the park. The majority of the site is agricultural land with only about 7.6 ha (19 ac) being classified as woodland. EISE is managed to restore and maintain the cultural and natural resources in their historic period appearances and is maintained as a working farm (NPS 2014).

2.1.2 Geographic Setting

GETT and EISE are located in the south central portion of Pennsylvania in Adams County (Figures 1 to 3). The parks are adjacent to each other and share a common boundary on the western side of GETT. The parks are situated in the Piedmont Province east of the Appalachian Mountains in south central Pennsylvania (Thornberry-Ehrlich 2009). The parks are 24 km (15 mi) east of South Mountain, which rises to 609 m (2,000 ft) above sea level.

GETT has gently rolling hills and valleys with elevations averaging between 150 to 175 m (500-580 ft) above sea level (Figure 2). The landscape is a mosaic of mature and maturing woodlands and woodlots, agricultural fields, pasturelands, and streams which provide habitat for flora and fauna (NPS 2015b). Since 1863, natural succession and human development has changed the natural appearance of GETT's landscape and historic battlefields. While some vegetation features (thickets, woodlots, woodlands, and wetlands) were altered or removed by man over the years, others were overgrown by nature, becoming dense and containing many non-native species. In addition, some historic fields, pastures, and other open areas were covered by non-historic vegetation. In the early 1990s, 50% (756 ha) of GETT was agricultural land (cropland and pasture), and 36% (547 ha) was forestland. The remaining 14% was comprised of maintained areas, residential areas, or other types of human-dominated developed land (Yahner et al. 1992). In 1999, the Gettysburg National Military Park General Management Plan (GMP) was approved, outlining goals for rehabilitating the1863 cultural and natural features that impacted the battle. The plan included such projects as the replanting of historic woodlots and orchards, removal of invasive vegetation, cutting of shrubs and trees, and prescribed burns. Additionally, the GMP called to re-establish original fencelines, lanes and trails, recreate historic viewsheds, as well as maintain the integrity of the historic farmsteads (NPS 1999a).

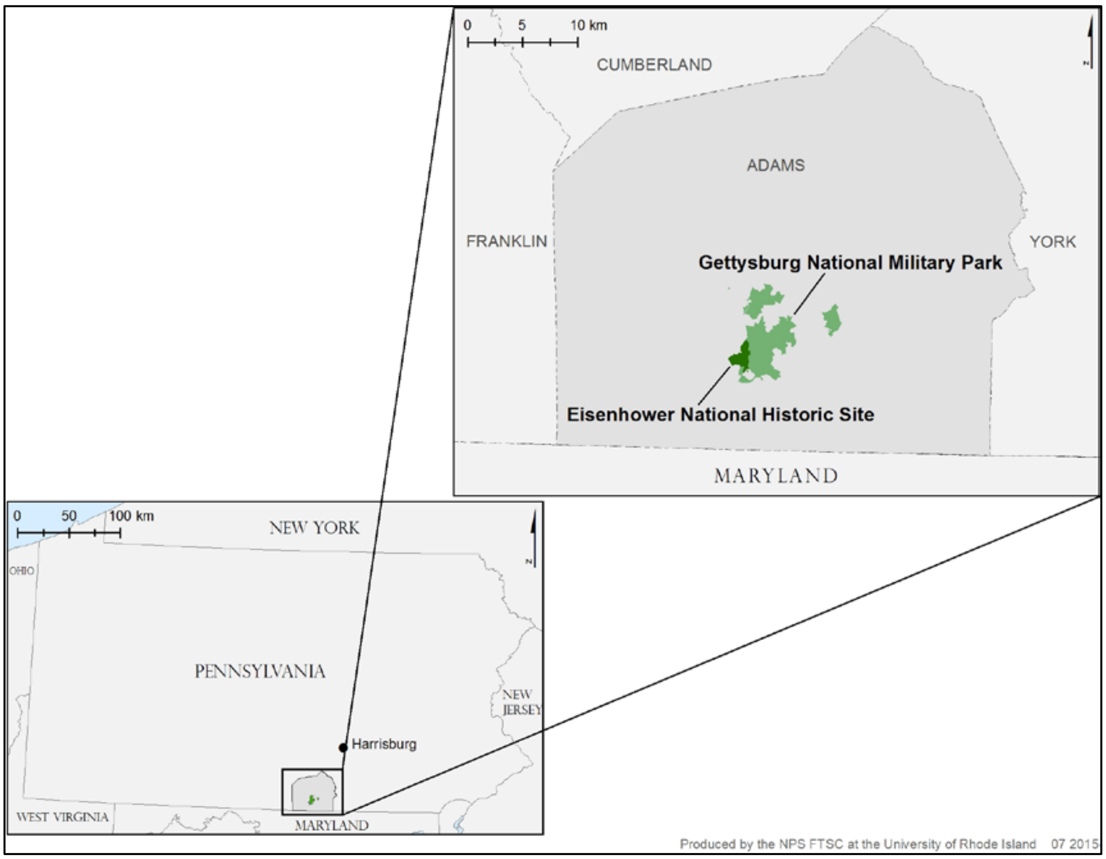


Figure 1. Location of Gettysburg National Military Park and Eisenhower National Historic Site.

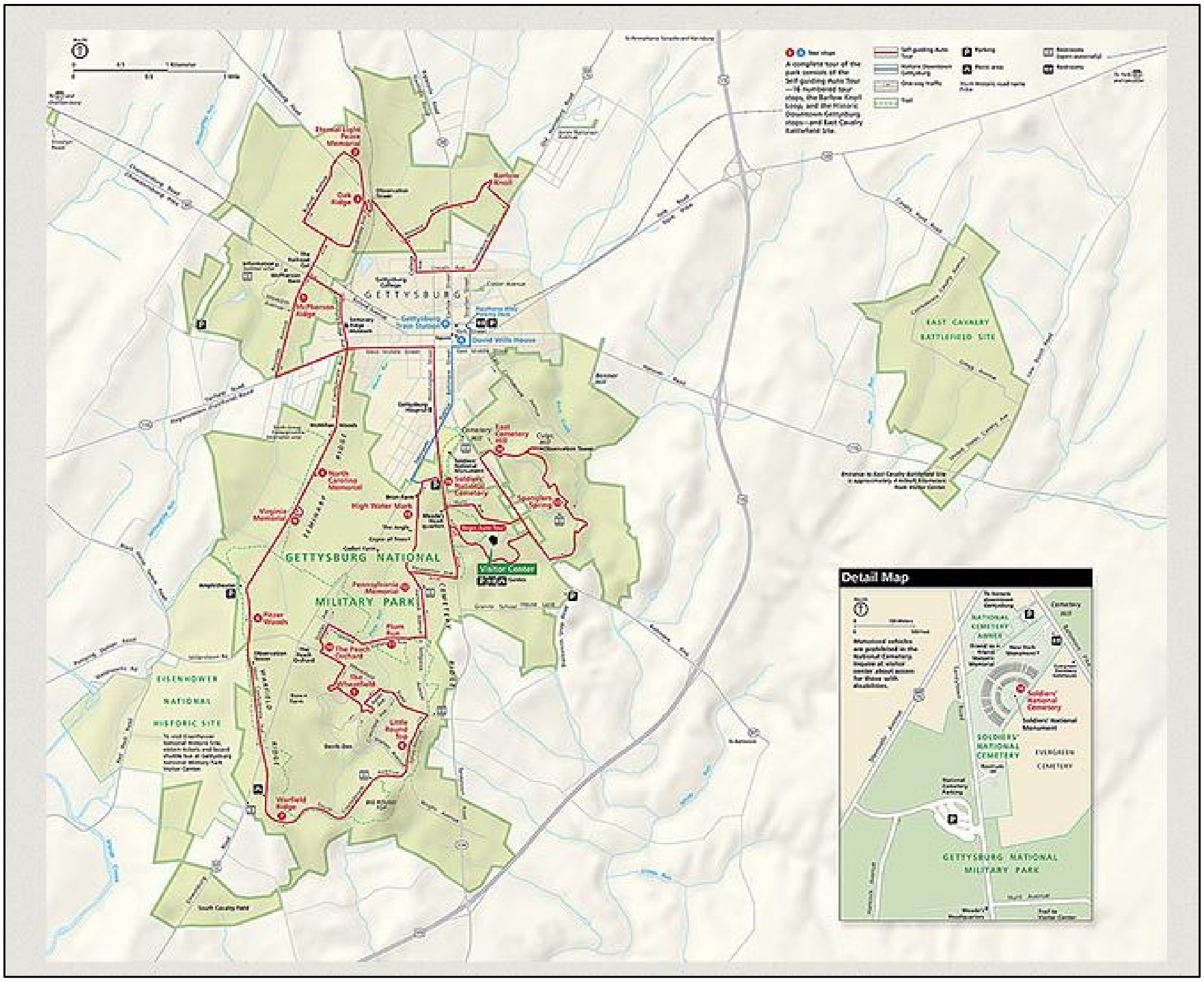


Figure 2. Map of Gettysburg National Military Park, National Park Service map.

EISE contains flat open fields and pastures dissected by rolling hills, forested areas, meadows, wetlands, riparian zones, and stream valleys (NPS 2015a) (Figure 3). In the early 1990s, 83% (232 ha) of ElSE was agricultural land, 3% was forestland, and 14% maintained areas, residential areas, and other developed land (Yahner et al. 1992). Crop species at EISE include barley, corn, hay (timothy, clover, alfalfa, and fescue), sorghum, oats, rye, soybeans, and winter wheat (Yahner et. al. 1991). Forestland contains mature tree species that typify Appalachian forest types and are principally oak *(Quercus* spp.), hickory *(Carya* spp.), and tulip poplar *(Liriodendron tulipifera)* (Yahner et al. 1992).

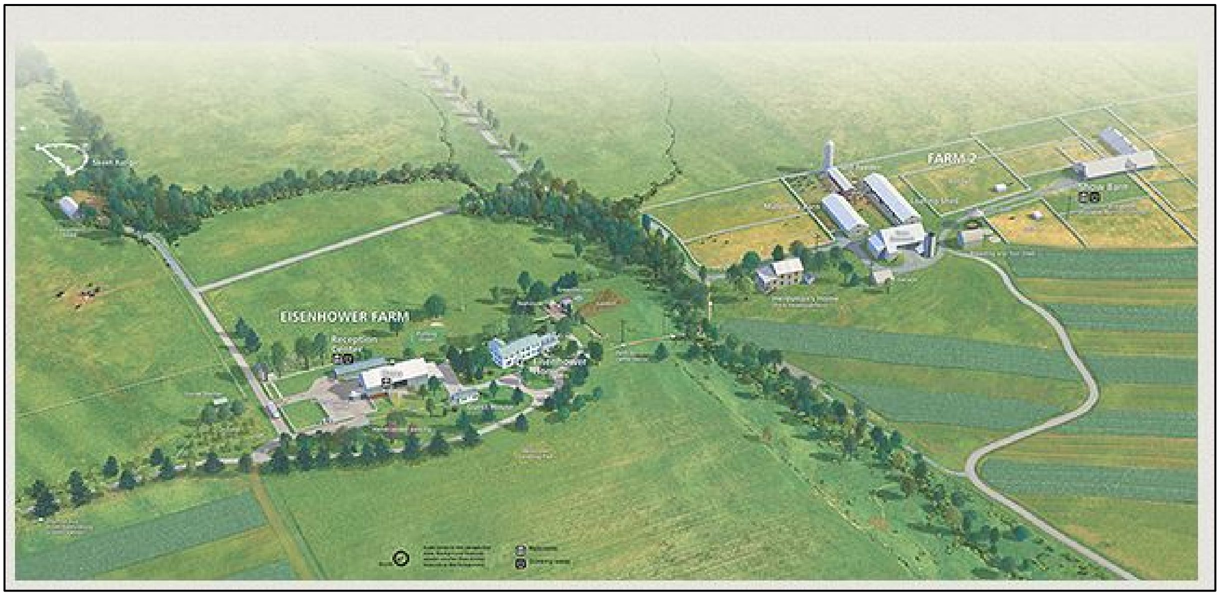


Figure 3. Map of Eisenhower National Historic Site, National Park Service map.

2.1.3 Watershed

GETT and EISE are located within the Rock Creek (163 km^2) and Marsh Creek (199 km^2) watersheds (Figure 4). Both watersheds were designated as Critical Water Planning Areas by the Pennsylvania Department of Environmental Protection (PA DEP) in 2011 (Moltz and Palmer 2012). This action was taken as a result of an assessment that found demand exceeded water supply under certain conditions in these watersheds. For example, the amount of water withdrawn from the watersheds on a daily basis in each season was greater than low-flow conditions, and the quantified water deficits represented a potential shortfall of water under stressed conditions, which would be exacerbated by future population growth (Moltz and Palmer 2012).

GETT and EISE utilize groundwater and surface water resources as the public drinking water supply. The Gettysburg Municipal Authority pumping station is located on Marsh Creek, just north of the EISE boundary. This particular system has seven wells and a surface water intake on Marsh Creek (Thornberry-Ehrlich 2009). Recharge to the area's aquifers is through precipitation; however, only a portion of precipitation eventually percolates into the groundwater supply (Low et al. 2000). Wastewater from the public supply service area is routed to treatment plants which discharge into both creeks (Moltz and Palmer 2012). In 2010, the population in the watershed was ~29,000, a 7.5% increase between 2000 and 2010 (Moltz and Palmer 2012). The majority of the population (68%) resides in the Rock Creek watershed. It is anticipated that the population within the watershed will increase 22% from the 2000 population level by 2020 and a 29% increase from the 2000 level to 2030 (Moltz and Palmer 2012).

The majority (67%) of landuse in the watersheds are parcels on ten or more acres of land with buildings of various types (residential, commercial, and agricultural). The second most common (10.2%) type of landuse is residential on less than ten acres of land. Vacant land occupies 15.3%, commercial use occupies 6.4%, while industrial parcels only occupy 0.8% (Moltz and Palmer 2012).

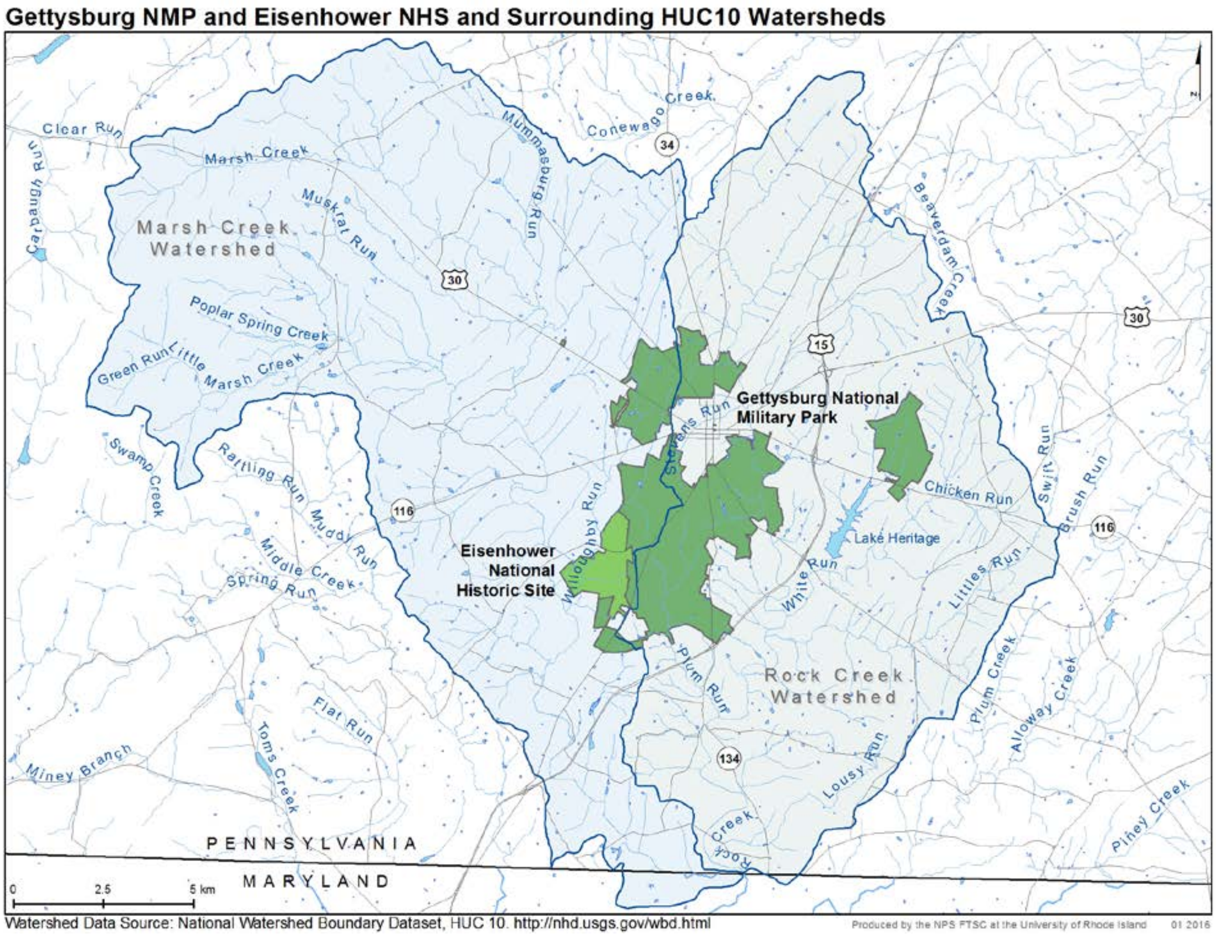


Figure 4. Marsh Creek (HUC-10: 0207000902) and Rock Creek watersheds (HUC-10: 0207000901).

2.1.4 Geologic Setting

GETT and EISE are within the Gettysburg basin between the Piedmont Plateau and Blue Ridge physiographic provinces. The Gettysburg basin is one of a series of northeast-southwest trending Mesozoic-age extensional basins that fringe the length of the eastern side of the Appalachian Mountains. The geologic units in this province are relatively young, gently dipping, and un-deformed in contrast to the rocks to the east and west. The rocks in the basin include sedimentary sandstones, siltstones, and shales intruded by igneous sills, dikes, and irregular igneous bodies. Geologic formations within the two units contain fossil resources. Seismicity, arsenic contamination, and radon gas are a few of the geologic hazards in the parks area. Earthquakes are also associated with local faults as well as the Lancaster Transverse seismic zone (Thornberry-Ehrlich 2009).

In addition to their influence on the physical landscape, geologic features and processes dictated the history of the Gettysburg area. The military campaigns leading up to the battle used topographic features such as the Blue Ridge, Cashtown Gap, Turners Gap, and the Great Valley to transport troops and conceal strategic movements. During the battle, ridges and low hills underlain by resistant igneous diabase and sandstone, respectively, played pivotal roles in the outcome of the three-day struggle (Thornberry-Ehrlich 2009).

At EISE, the geologic units at the site are generally flat lying and un-deformed red shales, sandstones, and thin limestone beds with surface variations due to erosion and incising of rivers through these nearly horizontal layers. The westerly view from Eisenhower's farm includes Culp Ridge, Green Ridge, South Mountain, Jacks Mountain, and Piney Mountain (Thornberry-Ehrlich 2009).

A paleontological resource inventory, compiled from literature, was conducted by Kenworthy et al. (2006) for GETT and EISE. Paleontological resources were present within the building stones of historic structures and monuments at both parks and merit resource-management attention. For example, two capstones, quarried locally (outside park boundaries), on the bridge over Plum Run show casts of reptile footprints from a *Coelophysis*-like dinosaur and at least 10 of the battlefield monuments contain limestone or marble and as such may be fossiliferous (Kenworthy et al. 2006).

2.1.5 Climate

GETT and EISE are located in the Pennsylvania Climate Division 4, known as the Lower Susquehanna. The Lower Susquehanna is generally considered to have a humid continental climate, but the varied physiographic features have a marked effect on the weather and climate of the various part of the valley (Knight et al. 2014). This region is a transition zone between the humid continental climate of northern and central Pennsylvania to the north and the humid subtropical climate of central Maryland to the south, with hot, humid summers and cool winters. The prevailing winds are westerly and carry most of the weather disturbances that affect the region from the interior of the continent. The Atlantic Ocean only has occasional influence on the climate of the area, although coastal storms can affect the day-to-day weather, especially in the winter months (Davey et al. 2006). The direct effects of an Atlantic hurricane are uncommon, though remnant rains from tropical storms have contributed to the region's worst floods (Knight et al. 2014).

Temperatures are moderately continental. On average, January is the coldest month, with an average temperature of −1 °C (30 °F). Winters range from cool to moderately cold, with relatively frequent snowfalls. July is the warmest month with an average temperature of 23.6 °C (74.5 °F) (Moltz and Palmer 2012, Davey et al. 2006). Precipitation is fairly evenly distributed throughout the year, with amounts generally ranging from 864-1,321 mm (34-52 in) (Knight et al. 2014). Thunderstorms follow a frequency that matches the solar cycle, occurring between the equinoxes and reaching a peak near the solstice. On average, tornadoes pass through the area about once every three years. Ice storms, which can cause significant disruption, occur at irregular intervals, but are primarily confined to the months between December and March (Kocin and Uccellini 2004).

2.1.6 Visitation Statistics

GETT attracts 1.8 million visitors each year and is open year-round. It offers visitors hiking trails, scenic car tours on over 64 km (40 mi) of roads, and beautiful vistas overlooking the battlefield and nearby town (NPS 2015d). There are also over 1,400 monuments and 400 cannons, which dot the landscape. The highest visitation occurred in 1970, with over 6.8 million visitors (Figure 5). The highest monthly visitation occurs during the summer months (May through August, Figure 5) (NPS 2015d).

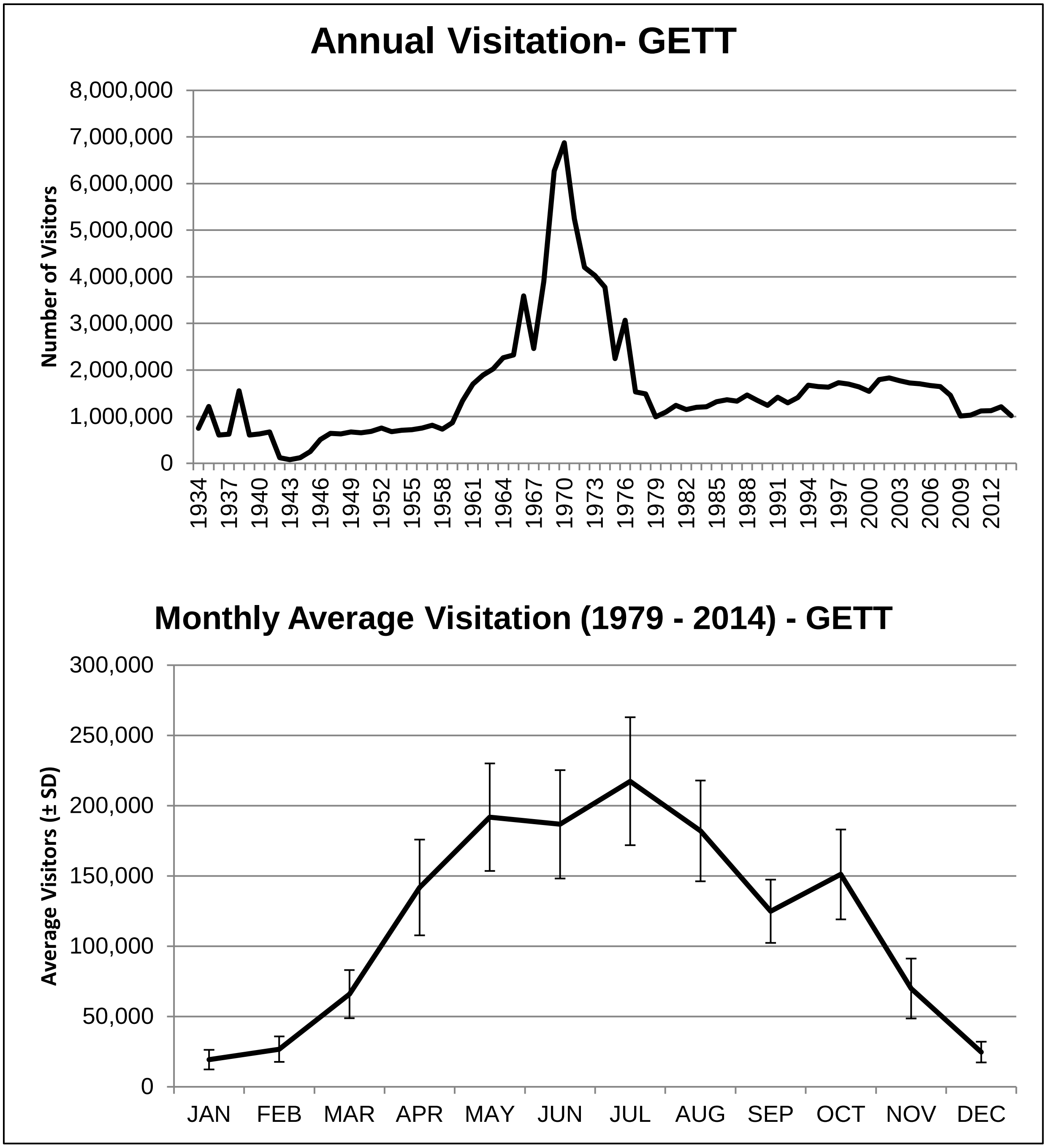


Figure 5. Annual (top graph) and monthly average (bottom graph) visitation statistics for GETT.

Visitation at EISE is considerably lower than at GETT (Figure 6), peaking at 180,000 visitors in the early 1980s and declining to approximately 60,000 visitors in recent years. Similar to GETT, the highest monthly visitation occurs during the summer months (May through August, Figure 6) (NPS 2015d).

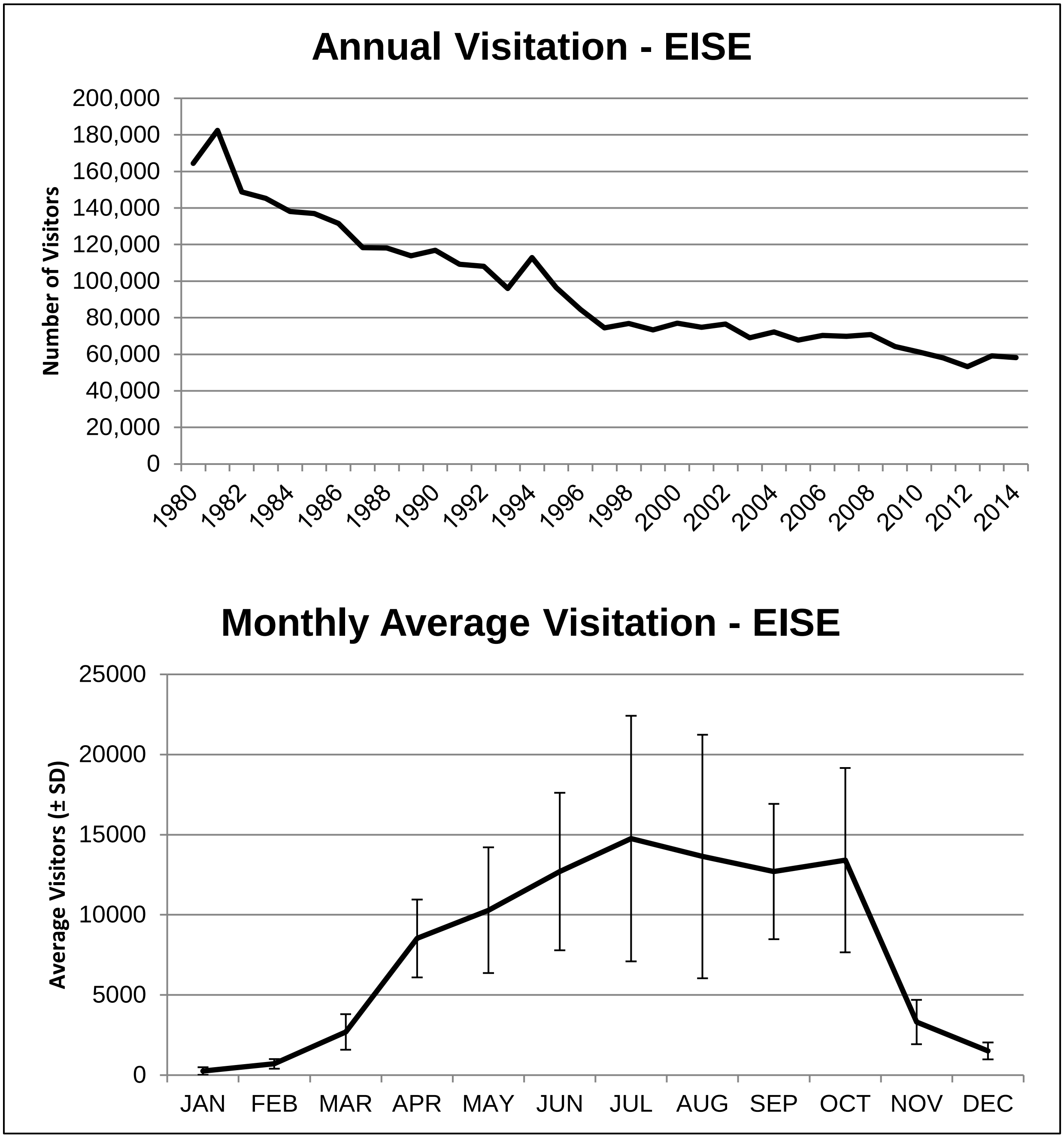


Figure 6. Annual (top graph) and monthly average (bottom graph) visitation statistics for EISE.

2.2 Natural Resources Descriptions and Ecological Units

2.2.1 Physical Resources

Air quality metrics monitored by the NPS ARD for GETT and EISE are: ozone (both human health and ecological standards), total nitrogen (N) and total sulfur (S) wet deposition, and visibility. The NPS ARD uses data from a variety of federal, state, tribal and local resources to assess air quality at all NPS units nationwide.

Other physical resources at GETT and EISE include night sky resources and the acoustic environment. Night sky resources are easily altered and, in many places, are becoming lost in the glow of artificial lights, and can negatively impact the ability to experience dark night skies. Recently the NPS NSNSD has recognized the importance of protecting and conserving the night sky as cultural and significant natural resource and has developed methodologies for assessing the condition of the night sky resources in urban and non-urban parks (NPS NSNSD 2013). The NPS NSNSD also collects sound data and provides management objectives based on the needs of the park (NPS NSNSD 2013). In the National Park setting, both natural, cultural, historic sounds may be desirable and appropriate depending on the purpose and values of the park. The acoustic environment, like water, scenery, or wildlife, is a valuable resource that can easily be degraded by inappropriate sounds or sound levels and as a result, the acoustic environment requires careful management just as any other park resource. Both of these resources have been modeled by the NSNSD for GETT and EISE (NPS NSNSD 2013).

2.2.2 Water Resources

Several streams dissect the parks and larger creeks and smaller drainages locally called “runs” are common throughout both GETT and EISE. The main water resources at GETT include a ~3.2 km section of Rock Creek and two tributaries of Rock Creek named Plum Run. Within GETT, Rock Creek flows through an area dominated by large, unconsolidated diabase boulders, many of which line the stream bed. Stream substrates include cobble and gravel beds composed of shale, sandstone and limestone, all covered with silt. The substrates of Plum Run also include cobble and gravel composed of mudstone, shale, sandstone, limestone, and an outcrop of diabase boulder in the Devil’s Den area (Atkinson 2008). There are also several small ponds located throughout GETT. Both parks contain small areas of wetlands, generally less than 2 ha in size, that are situated within the stream floodplains. A review of the available inventory data for the park suggests that the majority of the wetland habitats fell within the palustrine wetland system with specific classes represented by emergent and forested/scrub/shrub types (NPS 1999a).

The water resources at EISE include a 0.48 km section of Marsh Creek and a 1.13 km section of Willoughby Run, a tributary of Marsh Creek. The confluence of Rock Creek and Marsh Creek form the Monocacy River (Watershed Alliance of Adams County 2015a, 2015b). Both Marsh Creek and Willoughby Run, flow through a variety of landscapes including orchards, farmland, villages, commercial and industrial centers, and woodlands. Marsh Creek is a large stream that varies from 5 m to nearly 15 m wide. The upstream boundary of the park crosses Marsh Creek in the vicinity of a municipal dam and an associate impounded section. Downstream of the dam there are there are several stream channels around various islands. The channels reform into a single channel several hundred meters prior to exiting the park (Atkinson 2008). Willoughby Run flows nearly parallel to Marsh Creek approximately 0.3 km to its east end, and is much smaller with a main channel width of 3 m to 8 m. The dominant substrates of both streams include cobble, gravel, and areas of exposed bedrock, all extensively covered with silt (Atkinson 2008).

None of the surface waters in either GETT or EISE were designated as wild and scenic rivers, exceptional value, or high quality streams (Adams County Conservation District & Adams County

Office of Planning and Development [ACCD] 2011, NPS 2014). Streams and runs within GETT and EISE primarily have classified designated uses for warm water resident fishes (WWF) and migratory fishes (MF), although Marsh Creek (EISE) is designated for cold water resident fishes (CWF) and MF (Pennsylvania Code §93.7 2016a). Threats to water quality in both parks include agricultural activities such as grazing and farming that may contribute to siltation, low dissolved oxygen, and channelization. Urban runoff from storm sewers and small residential runoff could contribute to elevated nutrient levels and low dissolved oxygen. Industrial point sources could contribute to toxic chemicals in waterbodies (Pennsylvania Spatial Data Access [PASDA] 2016, ACCD 2011).

2.2.3 Ecosystem Integrity and Focal Communities

Since the historic battle of Gettysburg, human development and natural succession have changed the appearance and composition of the landscape and ecosystems at GETT and EISE. Vegetation has changed over time as thickets, woodlots, wetlands, pastures, and agricultural farmland have been removed or altered over time. The parks' 1999 GMP called for the rehabilitation of the1863 cultural and natural features that impacted the Battle of Gettysburg. Battlefield rehabilitation projects started in July 2000 and have included non-historic tree removal, the planting of trees, maintaining historic woodlots, planting orchards, removing non-historic vegetation, prescribed burns, and building fences. The parks' landscape includes planted crops, pastures, and meadows providing the visitor with a glimpse of the local agrarian lifestyle. Woodlots and forested habitat comprise several successional communities, from mature oak/hickory to early scrub-shrub. Open fields and field edges boast a diverse mixture of vegetation for both the visitor to observe and for wildlife to utilize as either cover or feed. Currently the parks are transitioning portions of agricultural lands into warm season grasses to encourage a more diverse plant community for open-upland bird species (NPS 2014).

Over 900 species of plants have been recorded at GETT and over 250 species at EISE (refer to Appendix Table 55). The Pennsylvania Department of Conservation and Natural Resources (PA DCNR) lists plants of special concern as well as invasive and non-native species. At GETT, 35 species were state-listed and at EISE three plants were state-listed, none were federally listed (Table 2). Non-native and invasive plant species were common with 17% and 20%, respectively, of the plants at GETT and EISE were noted as being non-native or invasive (Appendix Table 55, Table 3).

A variety of wildlife has been recorded at GETT and EISE. Species identified as existing or potentially present in the park include 33 fish species, various aquatic macroinvertebrates including both native and invasive crayfish, 177 species of birds, 35 mammals, 15 amphibians, and 14 reptiles. These include nine state special status bird species, one state-listed and one federally listed mammal species (Table 2).

Table 2. State and Federally listed species observed at GETT (G) and EISE (E) during monitoring or survey efforts. Scientific names, as listed in Integrated Taxonomic Information System (http://www.itis.gov/), and common names are listed. Non-accepted scientific synonyms (in parentheses) are also given.

Scientific Name	Common Name	Status
Plants		
Aplectrum hyemale (G)	Putty root	State Rare
Asclepias variegate (G)[1]	Redring milkweed	State Endangered
Bromus kalmia (G)	Artic brome	State Threatened
Carex buxbaumii (G)	Buxbaum's sedge	State Rare
Carex shortiana (G)	Short's sedge	State Rare (under review)
Carex tetanica (G)	Rigid sedge	State Threatened
Carya laciniosa (G, E)	Shellbark hickory	State Special Concern
Cypripedium parviflorum var. pubescens (G)	Large yellow lady's-slipper	State Vulnerable
Dichanthelium dichotomum var dichotomum (G)	Cypress panicgrass	State Endangered
Dichanthelium oligosanthes (D. oligosanthes var. scribnerianum) (G)	Heller's rosette grass	State Threatened (under review)
Eleocharis elliptica (G)	Elliptic spikerush	State Endangered
Eleocharis obtusa (E, G)	Blunt spikerush	State Endangered
Helianthemum bicknellii (G)	Bicknell's hoary rockrose	State Endangered
Ilex opaca (G)	American holly	State Threatened
Juncus biflorus (G)	Grass-leaved rush	State Threatened
Juncus brachycarpus (G)	Short-fruited rush	State Threatened
Lithospermum canescens (G)	Hoary puccoon	State Threatened (under review)
Luzula bulbosa (G)[1]	Bulbose wood-rush	State Endangered
Lysimachia hybrida (G)[1]	Lowland yellow loosestrife	State Threatened
Orontium aquaticum	Goldenclob	State Rare
Packera anonyma (Senecio anonymus) (G)[1]	Small's ragwort	State Rare
Panicum (gettingeri) philadelphicum (P. tuckermanii) (G, E)	Philadelphia panicgrass	State Threatened
Penstemon laevigatus (G, E)	Eastern smooth beardtongue	Tentatively undetermined
Phlox pilosa (G)	Downy phlox	State Endangered
Prenanthes serpentaria (G)	Lion's foot	State Threatened (under review)

[1] Species was listed as an "unconfirmed" record in NPSpecies (2015).

Table 2 (continued). State and Federally listed species observed at GETT (G) and EISE (E) during monitoring or survey efforts. Scientific names, as listed in Integrated Taxonomic Information System (http://www.itis.gov/), and common names are listed. Non-accepted scientific synonyms (in parentheses) are also given.

Scientific Name	Common Name	Status
Plants (continued)		
Quercus shumardii (G)	Shumard's oak	State Endangered
Ranunculus fascicularis (G)[1]	Early (tufted) buttercup	State Endangered
Ranunculus pusillus (G)	Low spearwort	State Endangered (under review)
Ribes missouriense (G)	Missouri gooseberry	State Endangered
Rudbeckia fulgida (G)	Orange coneflower	State Threatened (under review)
Stylosanthes biflora (G)	Sidebeak pencilflower	State Endangered (under review)
Symphyotrichum puniceum var. puniceum (Aster firmus) (G)	Purplestem aster	State Threatened
Tipularia discolor (G)	Crippled cranefly orchid	State Rare
Triosteum angustifolium (G)	Yellowfruit horse-gentian	State Endangered (Tentatively undetermined)
Veratrum virginicum (G)[1]	Virginia bunchflower	State Endangered (under review)
Birds		
Ammodramus henslowii (G)	Henslow's sparrow	State Candidate Rare
Ardea alba (G) [1]	Great egret	State Endangered
Asio flammeus (G, E)	Short-eared owl	State Endangered
Bartramia longicauda (G)	Upland sandpiper	State Endangered
Dendroica striata (G)	Blackpoll warbler	State Endangered
Haliaeetus leucocephalus (G) [1]	Bald eagle	State Threatened
Lanius ludovicianus (E)	Loggerhead shrike	State Endangered
Nyctanassa violacea (G)	Yellow-crowned night heron	State Endangered
Tyto alba (G)	Barn owl	State Candidate at Risk
Mammals		
Cryptotis parva (G, E)	Least shrew	State Endangered
Myotis septentrionalis (G, E)	Northern long-eared bat	Federally Threatened, State Candidate Rare

[1] Species was listed as an "unconfirmed" record in NPSpecies (2015).

Table 3. Pennsylvania state listed invasive species observed at GETT and or EISE (PA DCNR 2016, NPS 2015d).

Scientific Name	Common Name
PA DCNR listed Invasive Plants	
Acer platanoides (G, E)	Norway maple
Ailanthus altissima (G, E)	Tree of heaven
Alliaria petiolata (G, E)	Garlic mustard
Berberis thunbergii (G, E)	Japanese barberry
Celastrus orbiculatus (G)	Asian Bittersweet
Cirsium arvense (G, E)	Canada thistle
Cirsium vulgare (G, E)	Bull thistle
Elaeagnus umbellata (G)	Autumn olive
Euonymus alatus (G)	Winged euonymus
Hedera helix (G)	English ivy
Lespedeza cuneata (G)	Chinese lespedeza
Ligustrum obtusifolium (G)	Border privet
Lonicera japonica (G, E)	Japanese Honeysuckle
Lonicera morrowii (G, E)	Marrow's honeysuckle
Lonicera maackii (G, E)	Amur honeysuckle
Lonicera tatarica (G)	Tartarian honeysuckle
Microstegium vimineum (G, E)	Japanese stilitgrass
Ornithogalum umbellatum (G, E)	Star of Bethlehem
Persicaria perfoliata (G, E)	Mile-a-minute
Perilla frutescens (G)	Beefsteakplant
Rosa multiflora (G, E)	Multiflora rose
Rubus phoenicolasius (G)	Wine raspberry
PA DCNR Watch Listed Invasive Plants	
Hemerocallis fulva (G, E)	Orange daylily
Holcus lanatus (G)	Common velvetgrass
Morus alba (G, E)	White mulberry
Poa trivialis (G)	Rough bluegrass
Schedonorus arundinaceus (G)	Tall fescue
Vinca minor (G)	Common periwinkle
Invasive animals	
Orconectes virilis (G, E)	Virile crayfish
Orconectes rusticus (E)	Rusty crayfish

2.2.4 Resources Issues Overview

The major natural resource goals for GETT are those related to preserving the landscape as it appeared at the at the time of the Battle of Gettysburg and maintaining important topographical features of the battlefield such as pastures, fields, thickets, and woodlots. Threats to the battlefield landscape include natural succession, invasive plants, deer browsing, agricultural use, and past human alteration (e.g., draining of wetlands) that has changed the landscape and vistas of the historic battlefield. Similarly, the natural resource goals at EISE are related to preserving the historic farmlands of the Eisenhower estate.

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

The management directives at GETT are to:

- Conserve the important features of the Gettysburg Battlefield Historic District which are necessary for maintaining the rural, agricultural, and memorial character of Gettysburg and conveying to visitors why, where, and how the battle occurred;
- use the battlefield setting as the primary interpretive resource; and,
- managing the park as a memorial landscape which not only reflects the pre-battle 1863 rural agricultural environment but includes superimposed post-battle elements necessary for commemoration and visitor understanding of the battle.

The management directives at EISE are to:

- Restore and maintain the cultural and natural resources in their historic period appearances and is maintained as a working farm.

2.3.2 Status of Supporting Science

The MIDN monitors, along with assistance from park staff, several natural resource vital signs at GETT and EISE (e.g., forest health, water quality, aquatic macroinvertebrates) (Table 4). Monitoring and/or modeling of local and regional air quality, night sky resources, and the acoustic environment are conducted by other state and/or federal agencies. Several baseline inventories and/or surveys have also been conducted at GETT and EISE, but these were generally conducted in the late 1990s or early 2000s, and therefore may not be reflective of the current status of some of the natural resources (e.g., avian community, herpetofauna inventory, fish communities) (Table 4). Data and reports are accessible through the MIDN website and the NPS Integrated Resource Management Applications website. The parks also maintain in house, draft GIS data related to the battlefield rehabilitation.

Table 4. Status of natural resource supporting science at GETT and EISE as of 2016.

Natural Resource	Period of available data	Data type	Source
Acoustic resources	2014	Modeled data	NPS NSNSD modeled data
Agricultural Fields and grasslands	2003-2004, 2015	National Vegetation Classification mapping	Perles et al. 2006, in-house GIS data
Air Quality – Ozone, wet deposition, visibility	2008-2012	Inventory and Monitoring	Kohut 2007, NPS ARD, Sullivan et al. 2011
Aquatic Macroinvertebrate Community	2007, 2009 to present	Inventory and Monitoring	Lieb et al. 2007, MIDN (no comprehensive report as of the writing of this NRCA)
Avian Community	1999-2001, 2005	Inventory, focal study	Yahner et al. 2001b, Peterjohn 2007
Forest Communities, Woodlots, and Vegetation Associations	1986-1987, 1990-1996, 1991, 2003-2004, 2007 to present	Focal studies of woodlots, Inventory and Monitoring, National Vegetation Classification mapping	Bowersox et al. 2002, 2004, MIDN Reports and Resource Briefs (e.g., Comiskey and Wakamiya 2011, Comiskey and Wheeler 2015), Perles et al. 2006, Yahner et al. 1992
Fish Community	2004	Inventory	Atkinson 2008
Herpetofauna	1999-2001	Inventory	Yahner et al. 1999a, 2001a, Derge et al. 2001
Plants of Special Interest (state-listed and invasive)	1986-1987, 2003-2005, 2007 to present	State-listed plant inventory. Additional data recorded in the context of other monitoring.	Kunsman 2006, Comiskey and Wakamiya 2011, Perles et al. 2006, Yahner et al. 1992
Mammal Community (excluding white-tailed deer)	1994-1995, 2000-2001, 2005	Inventory	Yahner et al. 1997,1999b, Hart 2001, 2006a, 2006b
Night Sky Resources	2013	Modeled data based on regional values	NPS NSNSD modeled data
Stream Water Quality	1999, 2002-2004, 2010 to present	Baseline, US EPA Assessment, Inventory and Monitoring	US EPA Water Quality Assessment, MIDN water quality monitoring
Terrestrial Arthropod/Invertebrate community	1999-2000	Inventory	Kim and Piechnik 2009

Table 4 (continued). Status of natural resource supporting science at GETT and EISE as of 2016.

Natural Resource	Period of available data	Data type	Source
Wetlands	1986-1987	Inventory, Mapped wetlands GIS data, NLDC 2011 GIS data	In-house draft GIS data, Homer et al. 2015, National Wetlands Inventory data, , Yahner et al. 1992
White-Tailed Deer Abundance	1992, 2010, yearly estimates by park staff	Deer abundance estimates	Frost 1997, Stainbrook and Diefenbach 2012. Park staff (2016)

Chapter 3. Study Scoping and Design

3.1 Preliminary Scoping

3.1.1 Park Involvement

An initial kick-off meeting for the NRCA was conducted on 14 July 2015 at GETT. Meeting attendees included staff from GETT: Z. Bolitho, D. Reiner, C. Musselman, R. Krichten, W. Peterson, E. Clarke, the Northeast Region: C. Chapin (NER), C. Roman (NER), S. Colwell (NER), A. Weed (NER), and M.J. James of the University of Rhode Island. At this meeting, the general approach and framework for the Natural Resource Condition Assessment was presented and attendees toured the park. Park and NER staff kindly supplied the author with digital copies of GIS data and other documents. Throughout the compilation of this document the author communicated with GETT/EISE park staff (D. Reiner, C. Musselman), and Regional staff: C. Arnott (NRCA coordinator), P. Sharpe, and C. Roman, for additional information and data for park resources. This NRCA will include information for GETT and EISE separately, in each section, when possible.

3.2 Study Design

3.2.1 Assessment Framework and General Approach and Methods

This Natural Resource Condition Assessment report was organized by Natural Resource Ecosystems. Within each ecosystem, the reporting areas such as specific habitats and/or communities were summarized. Each of the reporting areas was subdivided into the sections listed below:

- *Relevance and Context*: A brief overview of the importance of the natural resource to the park(s).
- *Data and Methods*: Description of available information (e.g., research studies, surveys, inventory and monitoring) for the resource and the methodology used to obtain data, including the period of data collection.
- *Reference Condition*: Metrics and benchmarks that were used to compare the current condition of the resource, including the justification for the metric and benchmark. Depending on the available data, there may be one or several metrics for the resource. Whenever possible established NPS metrics and benchmarks (e.g., NPS vital sign parameters, MIDN forest condition, NPS air quality assessment) or metrics from established monitoring programs (e.g., US Environmental Protection Agency [US EPA] water quality monitoring) were used to estimate the condition of the park's natural resources. In cases where metrics and/or benchmarks were not available, condition was based on the most recent, quantitative, and reliable data for the park or on best professional judgment.
- *Status of the Resource, Condition and Trends*: A summary of the status of the resource (good, moderate concern, significant concern, refer to Table 5) based on historic, recent research, and/or monitoring efforts and a statement of current condition status and trend. In some chapters this may be combined with Reference Condition in tabular format, if appropriate.
- *Confidence in Assessment*: A statement of the confidence and/or data used to evaluate the condition (refer to Tables 5 and 6) for each metric previously described in the Reference Condition section. A brief justification for the statement of condition is presented if appropriate.

- *Data Gaps*: A description of data gaps, if any, in the assessment of resource condition.
- *Threats*: A brief synopsis of known threats to the resource.
- *Sources* of Expertise: A list of people that provided unpublished data or personal anecdotes regarding the resource, if appropriate.
- *Literature Cited*: A list of information sources cited in the text.

Table 5. Symbol key legend used to report natural resource condition, trend, and confidence in data used for the assessment.

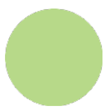
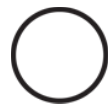
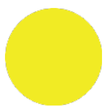
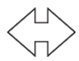
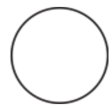
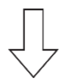
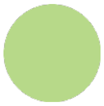
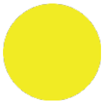
Condition Status		**Trend in Condition**		**Confidence in Assessment**	
	Good Condition		Condition is Improving		High
	Moderate Concern		Condition is Unchanging		Medium
	Significant Concern		Condition is Deteriorating		Low
	Condition Status Unknown; Consequently, Trend is also Unknown and Confidence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

Table 6. Example of interpretation of condition symbols.

Symbol	**Interpretation of condition or trend**
	Resource is in good condition, its condition is improving, high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.

Since natural resource conditions are typically evaluated for each indicator or metric, the NPS has recently developed guidelines for combining the conditions for different metrics for resources that were represented by one or more metrics. (NPS NRCA 2013). To determine the combined condition, each red symbol (significant concern) was assigned 0 points, each yellow symbol (moderate concern) is assigned 50 points, and each green symbol (good condition) 100 points. The average condition was calculated and the scale in Table 7 was used to determine the resulting condition (NPS NRCA 2013). To determine the overall trend the total number of down arrows was subtracted from the total number of up arrows. If the result was -3 or lower, the overall trend was down. If the result is between 2 and -2, the overall trend was unchanging (NPS NRCA 2013).

Table 7. Range of values from NRCA guidelines when averaging multiple metrics to estimate condition.

Condition		Point value	Average for multiple metrics
	Good	100	67 to 100 points (good)
	Moderate Concern	50	34 to 66 points (moderate concern)
	Significant Concern	0	Score 0 to 33 points (significant concern)

3.2.2 Reporting Areas

The MIDN selected a suite of physical, chemical, and biological elements and processes as key Vital Signs to monitor within their Network's parks. These 15 Vital Signs collectively represent the overall health or condition of the park (Comiskey and Callahan 2008). The Vital Signs were grouped into four general categories: air and climate, geology and soils, water, and biological integrity (Table 8). This NRCA follows these same general groupings.

Table 8. MIDN Vital Signs categories and vital signs selected for monitoring at GETT and EISE (after Comiskey and Callahan 2008). Blanks indicate that Vital Sign is not a priority and is not monitored.

Level 1 Category	**Level 2 Category**	**MIDN Vital Sign**	**GETT**	**EISE**
Air and Climate	Air Quality	Ozone	+	+
		Wet and dry deposition	+	+
		Visibility	+	+
		Air contaminants (mercury)	+	+
	Weather and Climate	Weather and climate	+	+
Geology and Soils	Geomorphology	Stream/river channel characteristics	●	●
	Soil Quality	Soil structure and composition	●	●
Water	Hydrology	Stream/river water dynamics	●	●
		Wetland water dynamics	◊	◊
	Water Quality	Water chemistry	●	●
		Aquatic macroinvertebrates	●	●
Biological Integrity	Invasive Species	Invasive exotic plants	●	●
	Infestations and Disease	Native forest pests	●	●
		Exotic diseases/pathogens – plants	●	●
	Focal Species or Communities	Riparian wetland communities	◊	◊
		Forest plant communities	●	●
		Fish communities		
		Amphibian communities	◊	◊
		Breeding birds	◊	◊
		Mammals		
		White tailed deer (herbivory)	●	●
		Vegetation communities		
		Threatened and endangered species and communities		
Human Use	Visitor usage			
Ecosystem Pattern and Processes	Fire	Fire and Fuel Dynamics		
	Landscape	Landcover and landuse change		◊

● Inventory and monitoring funded vital signs that are being monitored or for which protocols will be developed.

+ Vital signs monitored by the park or an outside partner, where network does not have the lead.

◊ High priority vital sign with no current or planned monitoring due to limitations in staff time or funding.

Chapter 4. Natural Resource Conditions

4.1 Physical Resources

4.1.1 Air Quality - Ozone

4.1.1.1 Relevance and Context

Ozone is not directly emitted into the air, but is produced at ground level by a chemical reaction with certain air pollutants (e.g., nitrogen oxides and volatile organic compounds from industrial and automobile emissions) in the presence of intense, high-energy sunlight during hot summer months (US EPA 2014a). Ground-level ozone is a health and environmental hazard. It is a respiratory irritant, can reduce lung function, cause asthma attacks, and reduce resistance to infection (US EPA 2014a). Ozone can also cause damage to ozone sensitive vegetation (Kohut 2005). Foliar damage can lead to reduced growth and increased susceptibility to disease and insect damage (Kohut 2005, Porter 2003).

The NPS ARD oversees the national air resource management program for the NPS. To assess ozone air quality condition, the NPS ARD uses all available monitoring data (e.g., NPS, US EPA, state, tribal, and local monitors) over a 5-year period to generate interpolations for all NPS units within the continental US, including those without on-site monitoring. With the exception of Shenandoah NP and Valley Forge NHP, the MIDN Network parks have no on-site ambient air quality monitoring; however in most cases there are nearby monitors. Ozone is a regional pollutant and the values from these monitoring stations are likely representative of the ozone concentrations at MIDN parks including GETT and EISE (Maniero 2004).

4.1.1.2 Data and Methods

The US EPA has established National Ambient Air Quality Standards (NAAQS) for human health standards for ozone levels. These standards are intended to protect public health and welfare. The NPS ARD (2013, 2015) has developed NPS park-specific estimates based on 5-year (2008-2012) interpolations for ozone. The interpolations were used by the NPS ARD to determine an estimate for ozone-related air quality, and each estimate was assigned one of three condition categories: *Good Condition, Moderate Condition*, or *Significant Concern* (NPS ARD 2013). At GETT and EISE, ambient concentrations of ozone were not monitored on-site, but were estimated by kriging, a statistical interpolation process. The closest ozone monitoring stations to GETT and EISE (25 km from the parks) are in Arendtsville (Adams County) and in Franklin County, PA (NPS 2015) (Figure 7). The estimated hourly concentrations of ozone were then used to generate annual exposure values for GETT and EISE (Kohut 2007).

Vegetation sensitivity is also considered, and the NPS ARD conducted a risk assessment for ozone sensitive vegetation using the W126 and SUM06 metrics. W126 measures cumulative ozone exposure during daylight hours over the growing season and is expressed in parts per million-hours (ppm-hrs). The SUM06 metric sums hourly daylight ozone concentrations $\geq$ 0.060 ppm over the growing season, and is also expressed in ppm-hrs. Both metrics are better predictors of plant response to ozone condition than the 8-hour US EPA human health standard metric (NPS ARD 2013). The GETT and EISE ozone exposure values for the Sum06 and W126 indices were also calculated by kriging (Kohut 2007). The NPS ARD rated parks at low, moderate, or high risk for ozone injury to vegetation, based on presence of sensitive plant species, ozone exposures, and environmental conditions (e.g., soil moisture). For ozone condition assessments, parks that were at risk were adjusted to the next condition category for vegetation injury (e.g., a park with an average ozone concentration of 72 ppb, but judged to be at high risk for vegetation injury, would move from the *Moderate* to *Significant Concern* for ozone) (NPS ARD 2015). The NPS ARD uses the W126 and SUM06 metrics, in addition to the human health standard, as ecological benchmarks for ozone.

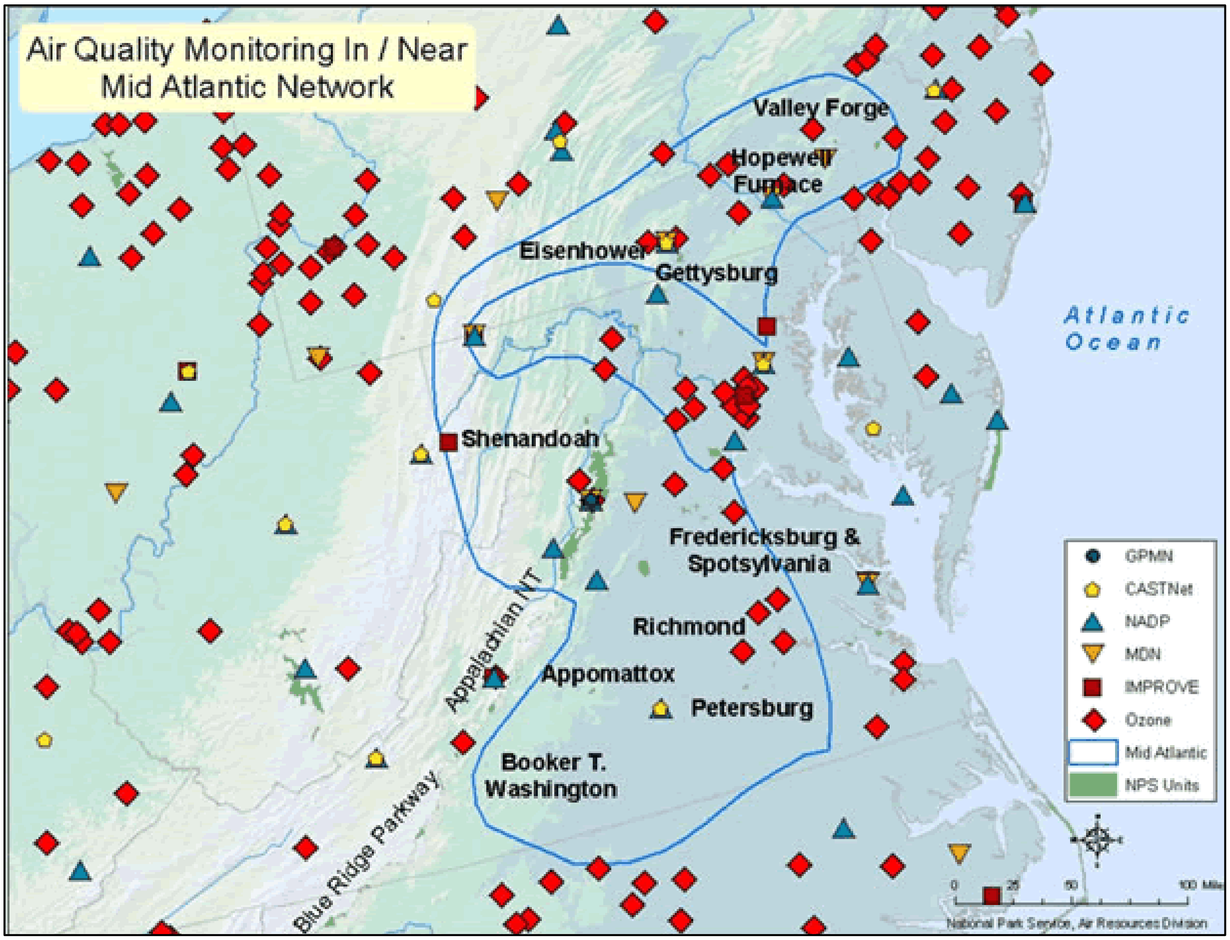


Figure 7. Air quality monitoring sites in the vicinity of GETT and EISE (NPS ARD 2015).

In 2004 and 2008, the NPS ARD completed a risk assessment for ozone related vegetation injury using an ecologically based rating system that focused on ozone plant sensitivity and the presence of ozone sensitive vegetation within park units (MIDN 2004, Kohut 2005, NPS ARD 2006). There were 19 and 29 species of ozone sensitive plants present at GETT and EISE, respectively (MIDN 2004, NPS ARD 2006, Kohut 2007) (Table 9).

Table 9. Plant species present at GETT (G) and EISE (E) that are sensitive to ozone damage based on data from MIDN 2004, NPS ARD 2006, and Kohut 2007. Non-accepted scientific synonyms are given in parentheses as listed in Integrated Taxonomic Information System (http://www.itis.gov/).

Scientific Name	Common Name
Aesculus octandra (Aesculus flava) (G)	Yellow buckeye
Ailanthus altissima (E, G)	Tree of heaven
Apocynum androsaemifolium (G)	Spreading dogbane
Apocynum cannabinum (G, E)	Indian hemp
Asclepias incarnata (G, E)	Swamp milkweed
Asclepias syriaca (G, E)	Common milkweed
Cercis canadensis (G, E[1])	Eastern redbud
Clematis virginiana (G, E[1])	Devil's darning needles
Corylus americana (G, E)	American hazelnut
Eupatorium rugosum (Ageratina altissima var. altissima) (G)	White snakeroot
Fraxinus americana (G, E)	White ash
Fraxinus pennsylvanica (G, E)	Green ash
Liquidambar styraciflua (G[1])	Sweetgum
Liriodendron tulipifera (G, E[1])	Tulip poplar
Parthenocissus quinquefolia (G, E)	Virginia creeper
Pinus rigida (G)	Pitch pine
Pinus virginiana (G)	Virginia pine
Platanus occidentalis (G, E)	American sycamore
Populus tremuloides (G)	Quaking aspen
Prunus serotina (G, E)	Black Cherry
Prunus virginiana (G)	Chokecherry
Rhus copallinum (G[1])	Winged sumac
Robinia pseudoacacia (G, E[1])	Black locust
Rubus allegheniensis (G[1], E)	Allegheny blackberry
Rudbeckia laciniata (G, E)	Cutleaf coneflower
Sambucus canadensis (Sambucus nigra ssp. canadensis) (G, E)	American black elderberry
Sassafras albidum (G, E[1])	Sassafras
Solidago altissima (G, E[1])	Canada goldenrod
Vitis labrusca (G)	Fox grape

[1] Indicates species was listed in Kohut 2007, MIDN 2004, or NPS ARD 2006, but was not listed in NPSpecies 2015 for the park.

4.1.1.3 Reference Condition and Status of the Resource (current condition and trends)

The ozone injury risk assessment indicated the risk of injury was moderate to high in MIDN parks (NPS 2006). In 2004, similar risk assessment of foliar ozone injury to plants at GETT and EISE was also determined to be high (MIDN 2004). Separate from the ozone injury risk assessments, the NPS ARD analyzed the SUM06 and W126 ozone metrics for 2008-2012. These metrics had values in the as moderate concern range (NPS ARD 2015) (Table 10, Figures 9 to 11).

Table 10. Reference thresholds and condition estimate for ozone at GETT and EISE.

Metric	Good Condition	Moderate Concern	Significant Concern	GETT and EISE Condition and Trend[1]	
Ozone concentration (ppb) (human health standard)	≤60 ppb	61-75 ppb	≥76 ppb		2008-2012[2]: 73.4 ppb-hrs
SUM06, Ozone ecological standard (ppm-hrs)	< 8 ppm-hrs	8-15 ppm-hrs	> 15 ppm-hrs		2008-2012[2]: 14.9 ppm-hrs
W126, Ozone ecological standard (ppm-hrs)	<7 ppm-hrs	7-13 ppm-hrs	> 13 ppm-hrs		2008-2012[2]: 11.8 ppm-hrs

[1] Trends for ozone metrics were not estimated for EISE or GETT by the NPS ARD (2013): however, NPS ARD trend maps show significant and possible improving trends in the general area of the parks.

[2] Data source NPS ARD 2015.

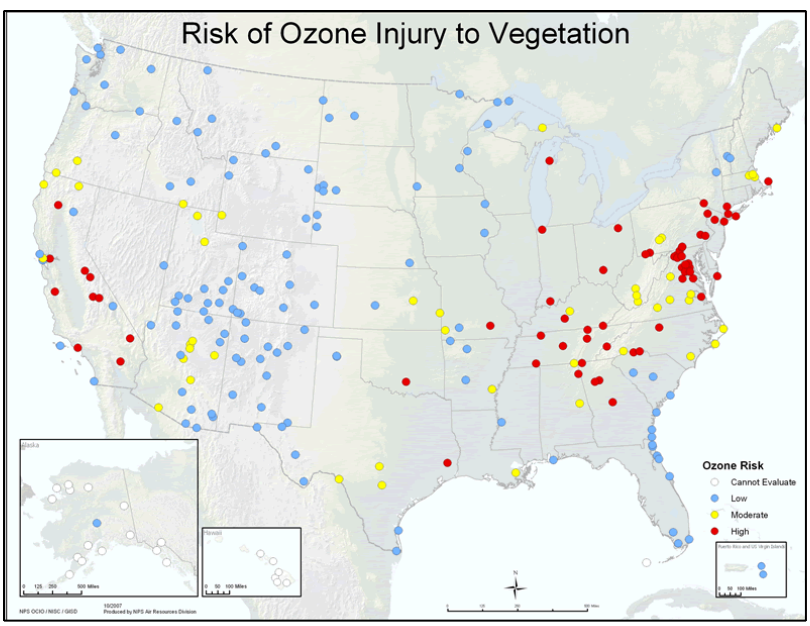


Figure 8. Ozone risk assessment for sensitive vegetation (NPS ARD 2015).

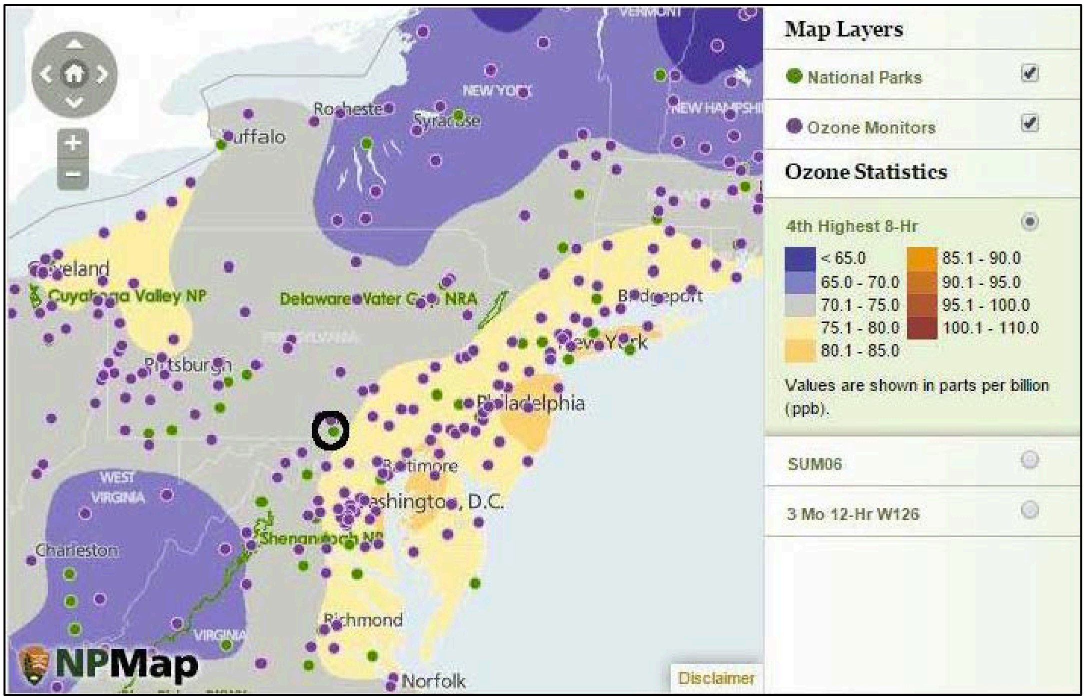


Figure 9. Ozone concentration statistics (annual 4th highest daily maximum average ozone concentration (ppb yr^{-1}), for 2008-2012 (NPS ARD 2015). GETT and EISE are indicated by black circle.

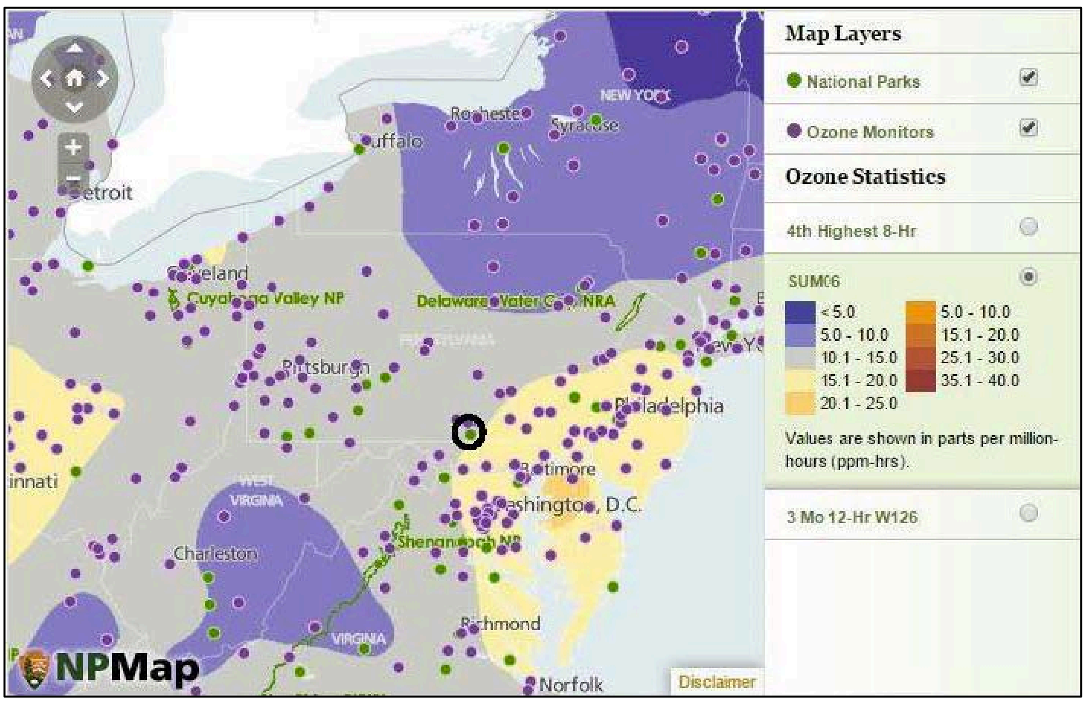


Figure 10. SUM06 ozone concentration statistics for 2008-2012 (NPS ARD 2015). GETT and EISE are indicated by black circle.

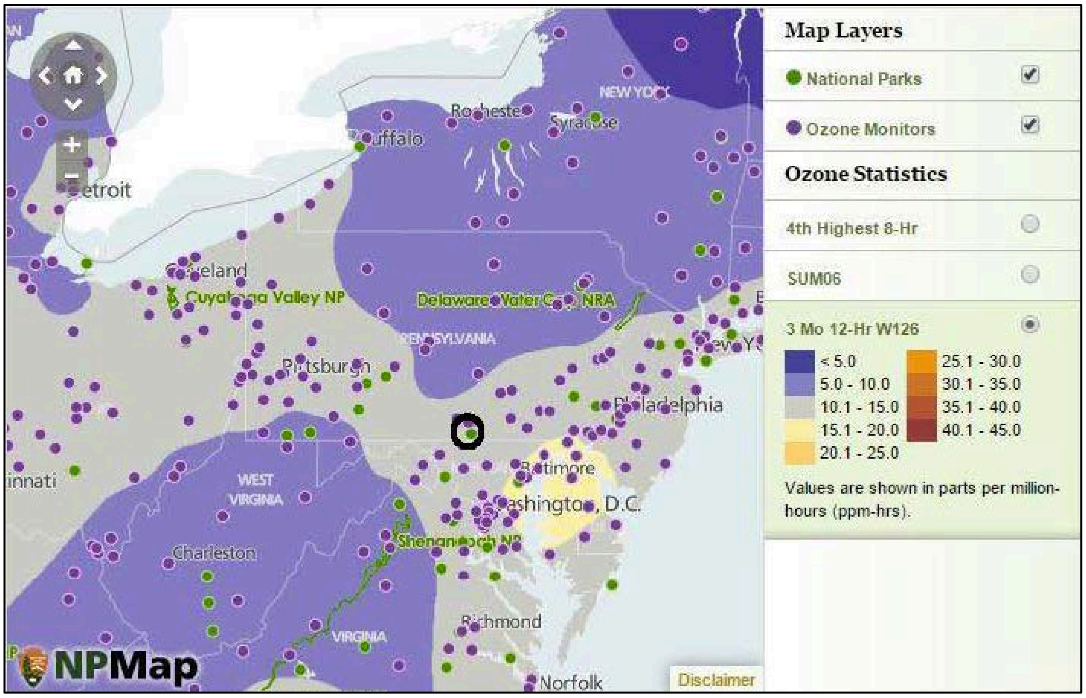


Figure 11. W126 ozone concentration statistics for 2008-2012 (NPS ARD 2015). GETT and EISE are indicated by black circle.

Although trends for ozone concentration, SUM06, and W126 metrics were not specifically estimated for GETT and EISE, trend maps from the NPS ARD (2013) show significant and possible improving trends in the general area of the parks (Figures 12 and 13).

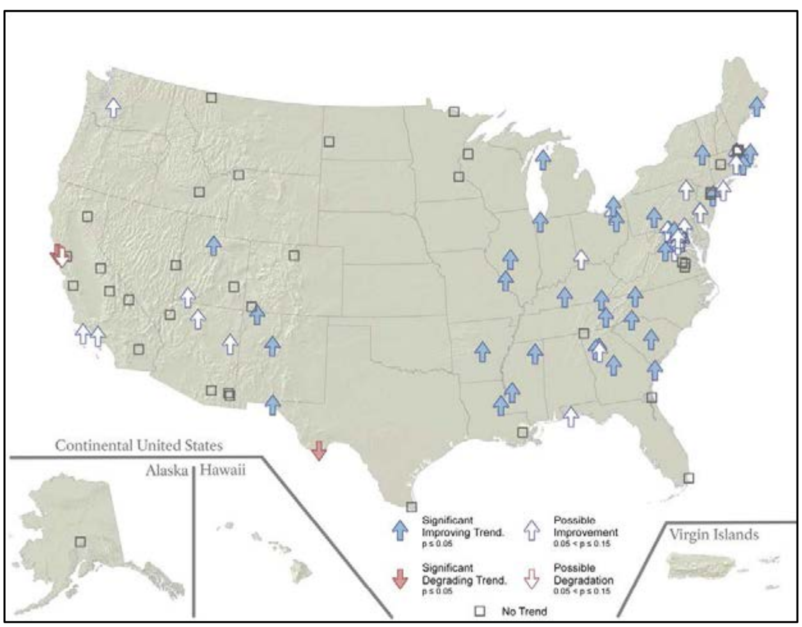


Figure 12. Map of trends in annual 4th highest daily maximum average ozone concentration (ppb yr^{-1}), 2000-2009. Map excerpted from NPS ARD 2013.

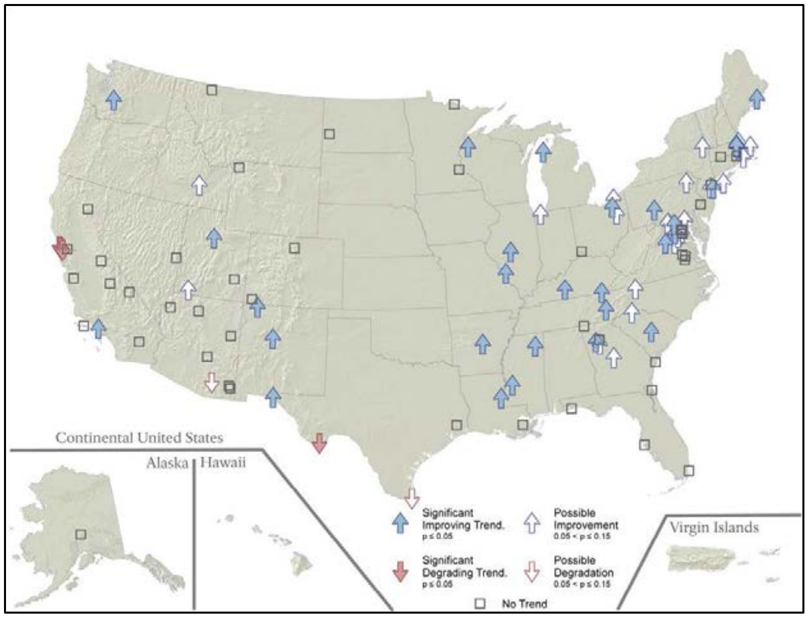


Figure 13. Map of trends in W126 metric (ppm-hrs yr^{-1}), 2000-2009. Map excerpted from NPS ARD 2013.

4.1.1.4 Confidence in Assessment

The data used to assess ozone were recent and of good quality. The confidence in the current condition and trend was assessed as high because air quality monitoring is ongoing and the stations are relatively close to the parks.

4.1.1.5 Data Gaps

There were no data gaps for ozone as air quality is regularly monitored and interpreted by both federal and state agencies (NPS, US EPA).

4.1.1.6 Threats

While GETT and EISE contain very little emission sources that contribute to air pollution, air quality at the park is highly influenced by local and regional air pollution including both local (adjacent urban areas such as Baltimore, MD) and regional (Northeast) emissions from automobile traffic and industry.

4.1.2 Air Quality - Wet Deposition

4.1.2.1 Relevance and Context

Deposition of nitrogen (N) and sulfur (S) compounds can acidify sensitive resources such as streams, lakes, soils, disrupt soil nutrient cycling, and affect biodiversity. Ammonium, nitrate, and sulfate ions in precipitation (rain and snow) are used as indicators of atmospheric deposition because they can be directly linked to these ecological effects. Mercury is primarily emitted by the burning of coal in power plants and most often deposited in the inorganic form; it is converted to an organic form, methylmercury, in the environment. Methylmercury is a toxic form of mercury that affects human and wildlife health through bioaccumulation to toxic levels in food webs. Animals and people who eat organisms (e.g., fish) contaminated with mercury are at greatest risk for mercury exposure (NPS ARD 2013). The NPS ARD used the amount of total N wet deposition, total S wet deposition, and mercury wet deposition (dry deposition data were not available for most areas) as a measure of condition for atmospheric deposition (NPS ARD 2013).

The National Atmospheric Deposition Network/National Trends Program (NADP/NTN) is a nationwide network of precipitation monitoring sites. NADP/NTN collects data on the chemistry of precipitation to monitor geographical and long-term temporal changes. The NADP/NTN has expanded its sampling to include the Mercury Deposition Network (MDN), which currently has over 35 sites. The MDN was formed in 1995 to collect weekly samples of precipitation, which are analyzed for total mercury. The NPS ARD used data from a variety of sources including the NADP/NTN to assess wet deposition in national park units. Wet deposition conditions were evaluated by the NPS ARD as total N wet deposition, total S wet deposition, and trends in mercury deposition (NPS ARD 2013). The NPS ARD used data from 5-year periods to generate interpolations for all NPS units within the continental US, including those without on-site monitoring. The data used to estimate wet deposition for GETT and EISE were from monitors outside of the park. The nearest NADP/NTN and MDN air quality monitoring stations to the parks are located at Arendtsville, PA (25 km from the parks) (NADP 2015, NPS ARD 2015) (Figure 7). These wet deposition monitoring stations likely provide adequate coverage for GETT and EISE (Maniero 2004).

4.1.2.2 Data and Methods

The NPS ARD (2013) has developed park-specific estimates based on 5-year interpolations (2008-2012) for wet deposition. The interpolations were used by the NPS ARD to determine an index for wet deposition-related air quality, and each index was assigned one of three condition categories: good condition, moderate condition, or significant concern (NPS ARD 2013). The NPS ARD estimated wet deposition for park units within the continental US by multiplying N or S concentrations in precipitation by a normalized precipitation amount. Several factors were considered in rating deposition condition, including natural background deposition estimates (deposition that ecosystems may have experienced prior anthropogenic influences, U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service 2011) and deposition effects on ecosystems. Estimates of natural background deposition for total N or S deposition were approximately 0.50 kg ha^{-1} yr^{-1} in the East, which was roughly equivalent to a wet deposition only rate of 0.25 kg ha^{-1} yr^{-1}. Certain sensitive ecosystems respond to levels of deposition on the order of 1.5 kg ha^{-1} yr^{-1} wet deposition and evidence is not currently available that indicates that wet deposition amounts less than 1 kg ha^{-1} yr^{-1} cause ecosystem harm (NPS 2015).

Sullivan et al. (2011) evaluated the sensitivity of all Inventory and Monitoring National Park units to potential acidification effects caused by atmospheric deposition. The assessment considered three factors that influenced acidification risk to park resources: pollutant exposure, inherent ecosystem sensitivity, and park protection mandates (Sullivan et al. 2011). Pollutant exposure was evaluated using N and S atmospheric deposition rates. Ecosystem sensitivity was evaluated by the make-up of terrestrial plant, aquatic algae, and higher life form communities. Acidification can cause sensitive species to decline and therefore the composition of species present and biodiversity in the ecosystem can be indicative of acidification stress. Sullivan et al. (2011) ranked each park according to these factors and calculated a summary risk ranking for each park based on the averages of the three theme rankings. Parks with ecosystems potentially sensitive to N or S, the assigned condition category for wet deposition was adjusted up one category (e.g., a park with a moderate N deposition of 1-3 kg ha^{-1} yr^{-1} that contains N-sensitive ecosystems would be assigned the deposition condition of significant concern).

Thresholds for mercury deposition have not yet been established; however, a trend in mercury deposition (2000 to 2009) was estimated for GETT and EISE by the NPS ARD (2013).

<u>4.1.2.3 Reference Condition and Status of the Resource (current condition and trends)</u>

The NPS ARD (2015) evaluated both total N and S wet deposition as significant concern (Table 11, Figures 14 and 15). Isopleth maps of nitrate (NO_3), ammonium (NH_4), and total nitrogen (N) wet deposition indicated that annual average rates for all three deposition measures were towards the higher end (significant concern) of the spectrum of concentrations. Similarly, isopleth maps of average annual sulfate (SO_4) deposition were also towards the higher end of the spectrum (Figures 16 to 20) (NPS 2015). The NPS ARD (2013) estimated significant improving trends for total N and S wet deposition for GETT and EISE (Table 11).

Table 11. Condition thresholds and estimated annual average atmospheric wet deposition for GETT and EISE.

Metric	**Good Condition**	**Moderate Concern**	**Significant Concern**	**GETT and EISE Condition and Trend**
Total N wet deposition (kg ha^{-1} yr^{-1})	<1 kg ha^{-1} yr^{-1}	1-3 kg ha^{-1} yr^{-1}	>3 kg ha^{-1} yr^{-1}	2008-2012 [(1)]: 4.8 kg ha^{-1} yr^{-1} 2000-2009[2]: Improving trend
Total S wet deposition (kg ha^{-1} yr^{-1})	<1 kg ha^{-1} yr^{-1}	1-3 kg ha^{-1} yr^{-1}	>3 kg ha^{-1} yr^{-1}	2008-2012[(1)]: 3.8 kg ha^{-1} yr^{-1} 2000-2009[2]: Improving trend
Mercury wet deposition (ng m^{-2})	Thresholds not yet developed			182.9 ng m^{-2} [(3)] Improving trend (but not statistically significant) (2000-2009)[2]

[1] Data source NPS ARD 2015.

[2] Data source NPS ARD 2013

[3] Data source NADP 2015, average mercury deposition from Jan 2015 to present based on MDN data.

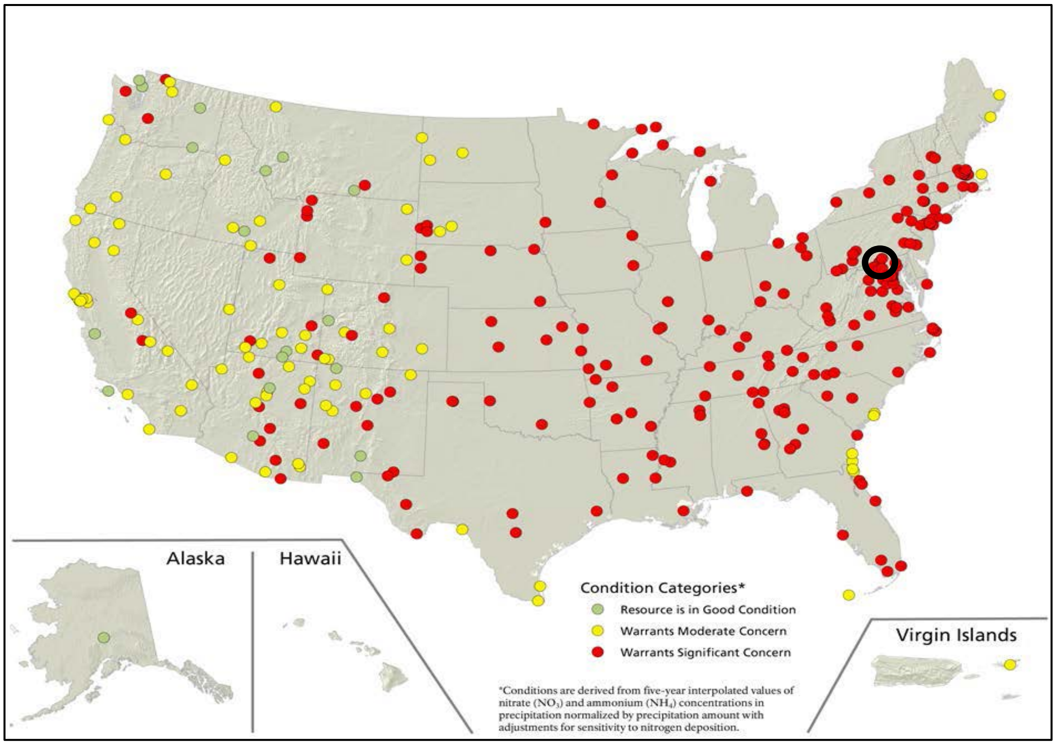


Figure 14. NPS ARD (2013) air quality condition assessments for nitrogen wet deposition, 2005–2009. EISE and GETT are indicated by the black circle.

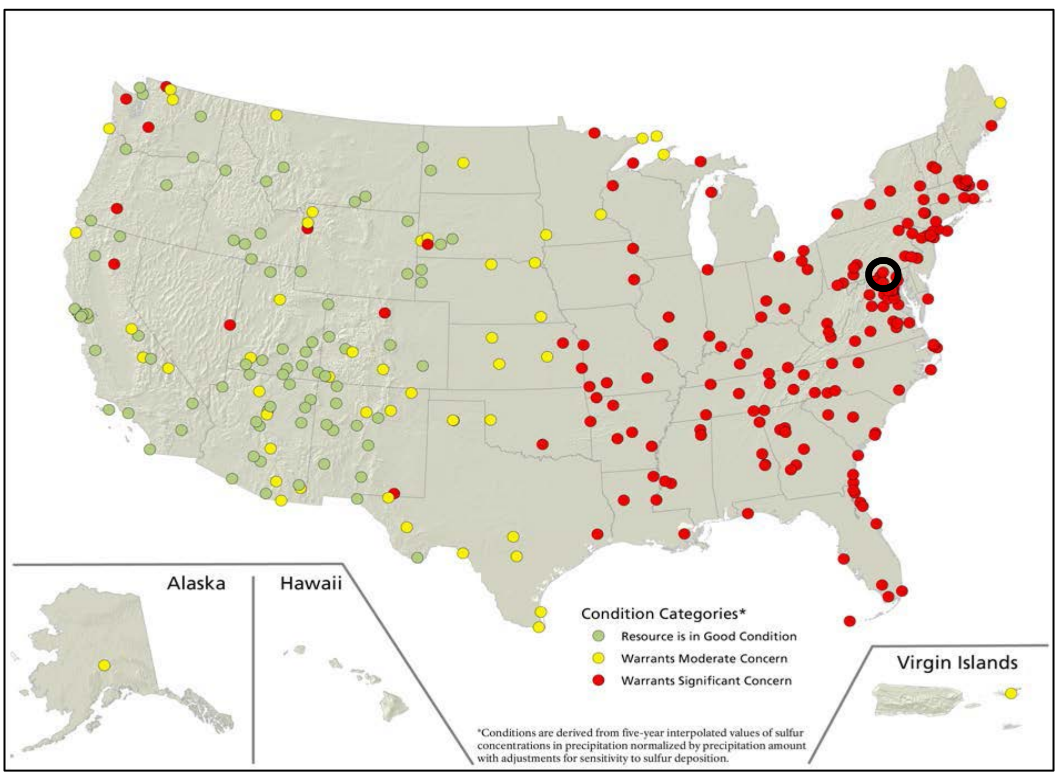


Figure 15. NPS ARD (2013) of air quality condition assessments for sulfur wet deposition, 2005–2009. EISE and GETT are indicated by the black circle.

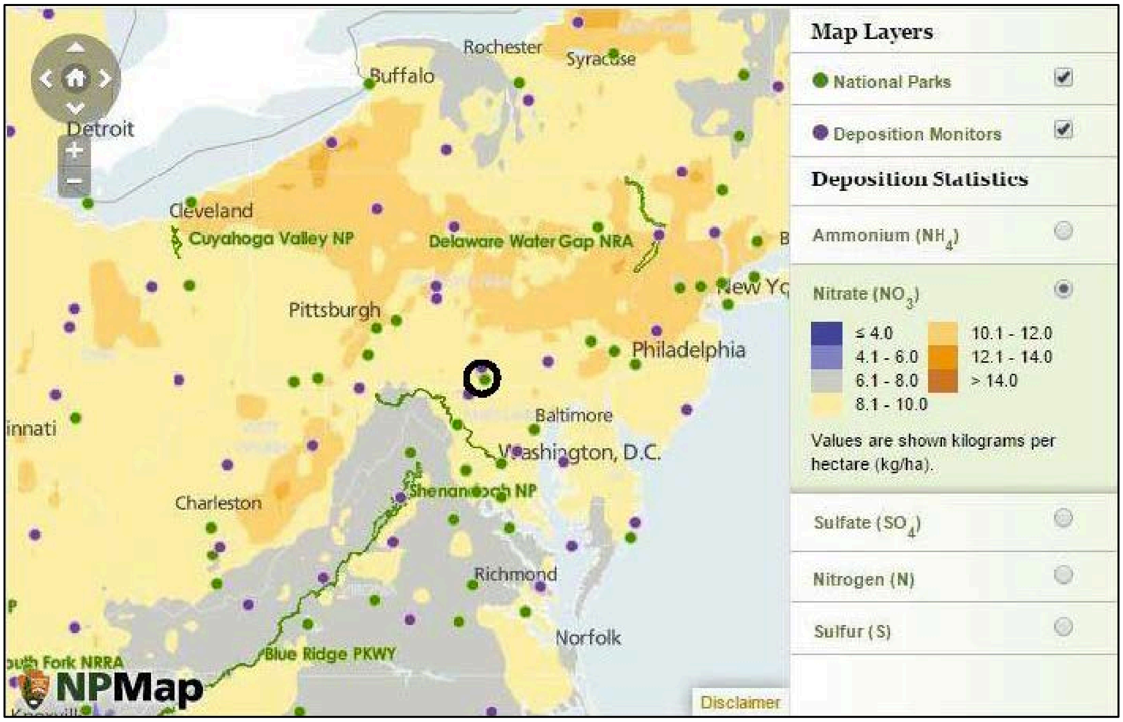


Figure 16. Annual nitrate (NO_3) deposition statistics for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

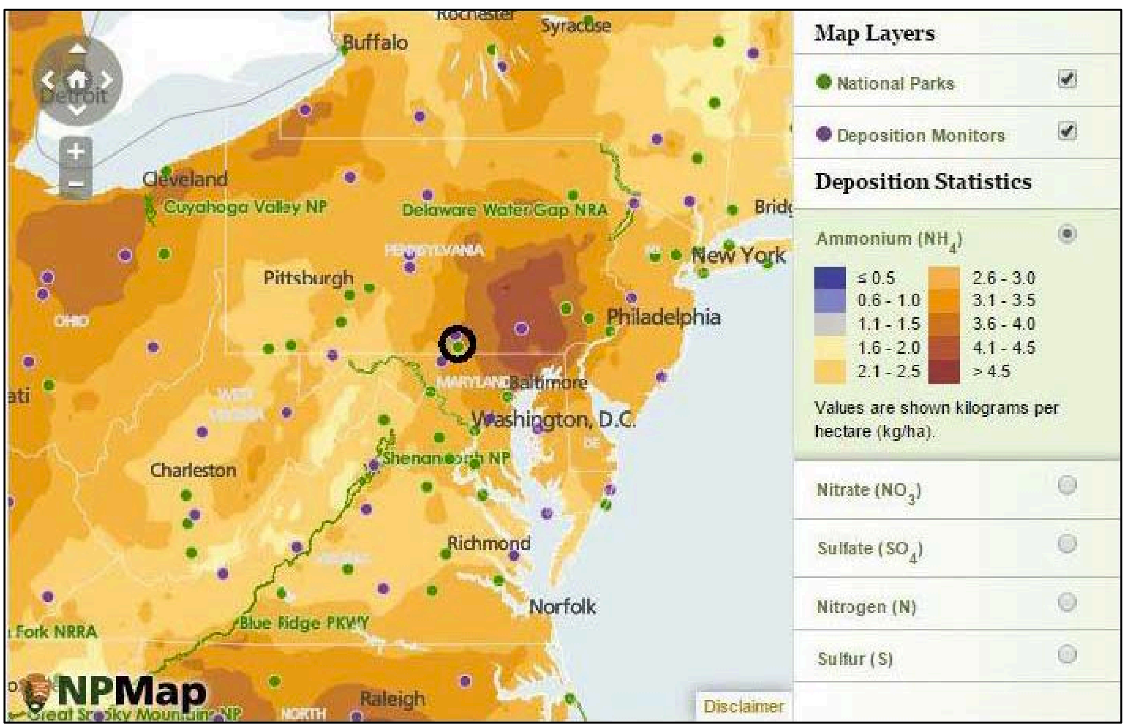


Figure 17. Annual average ammonium (NH_4) deposition statistics for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

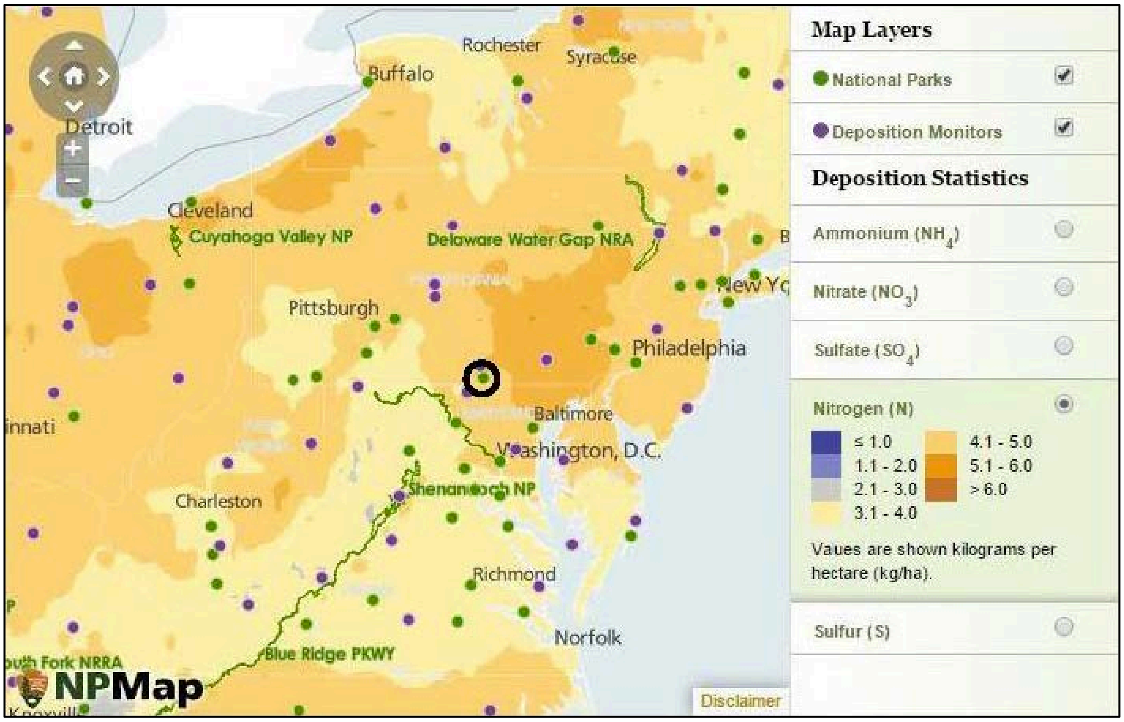


Figure 18. Annual average nitrogen (N) deposition statistics for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

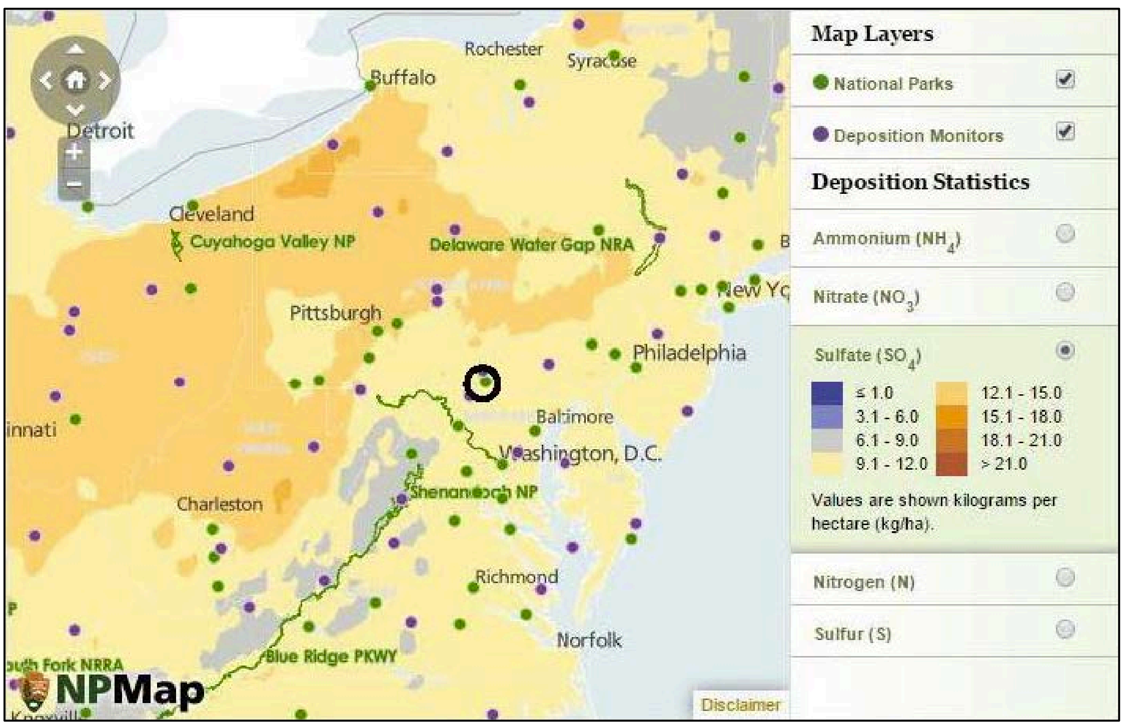


Figure 19. Annual average sulfate (SO_4) deposition statistics for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

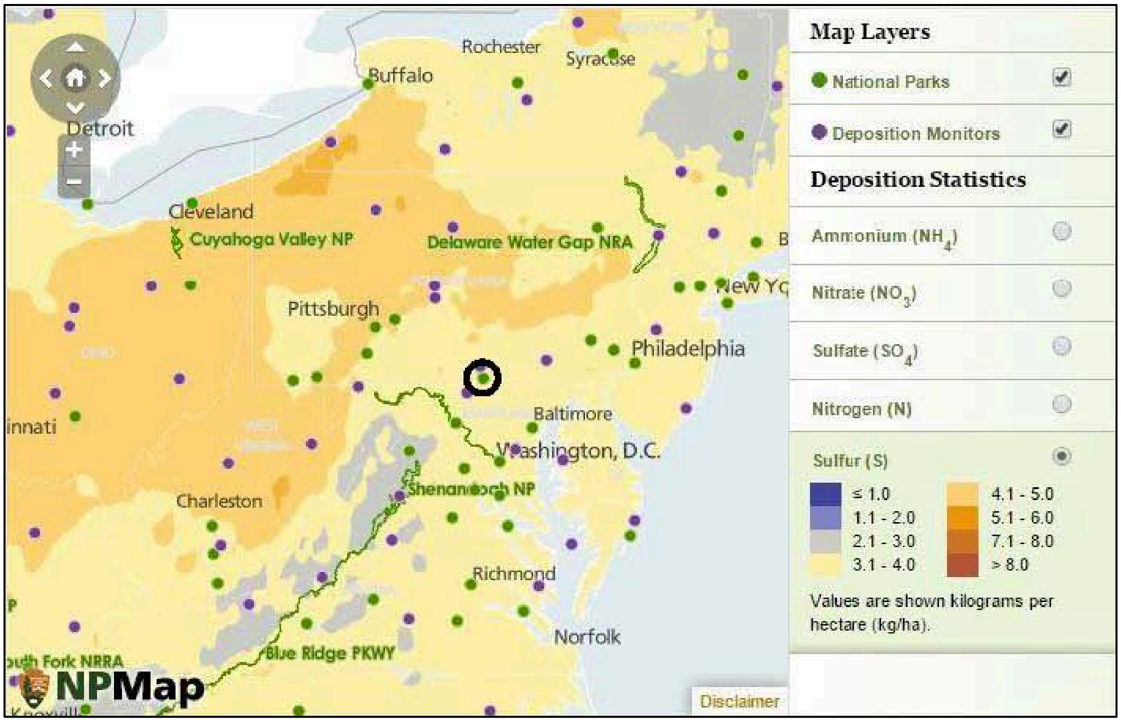


Figure 20. Annual average sulfur (S) deposition statistics for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

Condition thresholds for mercury wet deposition have not yet been established; however, the trend in mercury deposition at GETT and EISE was evaluated as improving (but not statistically significant) from 2000 to 2009 (Table 11, Figure 21) (NPS 2013).

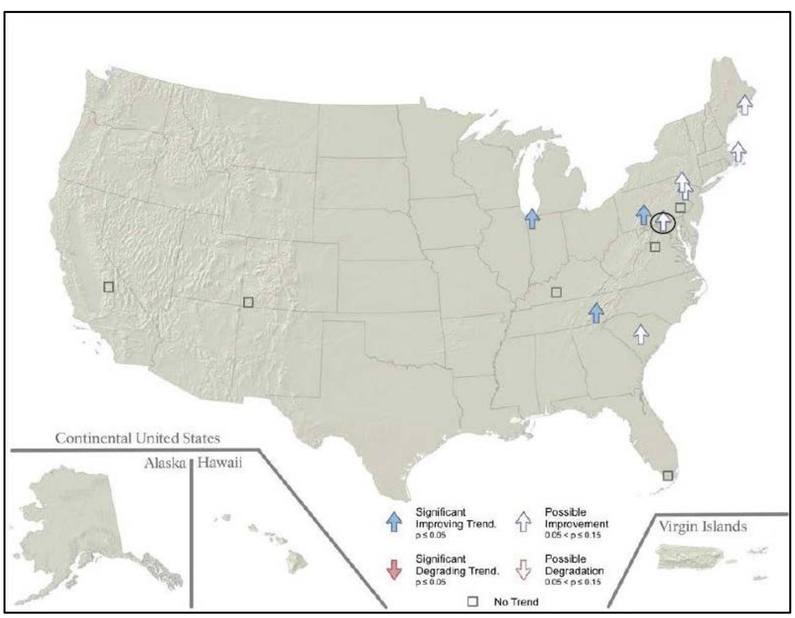


Figure 21. Trends in mercury concentrations in precipitation (ng liter^{-1} yr^{-1}), 2000–2009. Circle indicates location of GETT and EISE figure excerpted from NPS ARD 2013).

Sullivan et al. (2011) estimated the potential effects caused by acidifying atmospheric deposition and ranked GETT as very high for pollutant exposure, and moderate for ecosystem sensitivity and park protection. The overall summary risk for potential acidification effects caused by atmospheric deposition was assessed as significant concern for GETT (Sullivan et al. 2011). Since GETT and EISE are adjacent to each other and share many of the same ozone sensitive resources (e.g., plants, streams), this assessment is likely the same for EISE.

4.1.2.4 Confidence in Assessment
The data used to assess wet deposition were recent and of good quality. The confidence in the current condition and trend was assessed as high because air quality monitoring is ongoing and the stations are relatively close to the parks.

4.1.2.5 Data Gaps
There were no data gaps for wet deposition as air quality is regularly monitored and interpreted by both federal and state agencies (e.g., PA Department of Environmental Protection, NADP/NTN, NPS).

4.1.2.6 Threats
While GETT and EISE contain very little emission sources that contribute to air pollution, air quality at the parks are highly influenced by local and regional air pollution transport as it is influenced by both local (adjacent urban areas such as Baltimore, MD) and regional (Northeast) emissions from automobile traffic and industry. Wet deposition can alter the environment where they fall from the atmosphere, which can be long distances from the pollution source. The Susquehanna River Basin, to the east of GETT and EISE, is one of the areas most impacted by atmospheric deposition (refer to Figure 17, for example) in the United States (Buda 2010).

4.1.3 Air Quality-Visibility

4.1.3.1 Relevance and Context
Air pollution causes haze and reduces visibility. The NPS ARD examined the haze levels on the clearest and haziest days to characterize visibility conditions at National Park units (NPS ARD 2013a, b). Visibility was estimated using a Haze Index, as the Haze Index increases, visibility worsens.

The US EPA’s Regional Haze Program protects visibility in Class I areas. Class I areas include national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres that were in existence when the Clean Air Act was amended in 1977. Class I areas receive the highest degree of air quality protection under the Clean Air Act and have specific national regional haze goals (NPS ARD 2013a, US EPA 2014b). Generally, all other parks that do not meet the criteria for Class I are considered Class II areas. GETT and EISE are considered Class II areas. The nearest Interagency Monitoring of Protected Visual Environments (IMPROVE) station to GETT and EISE, is located 25 km from the parks at Arendtsville, PA (Figure 7) (NPS 2015). Although GETT and EISE were not specifically mentioned, Maniero (2004) suggested that if visibility is of particular concern for a Network park the MIDN may want to consider installing a digital camera to record and interpret visibility conditions on site. While digital camera monitoring would not be adequate for regulatory purposes, it would be useful for documenting visibility trends and provides an excellent means of sharing information with the public (Maniero 2004).

4.1.3.2 Data and Methods

The NPS ARD obtained visibility data from the IMPROVE network. The NPS ARD examined visibility in 10-year trends and computed Haze Index values in deciviews (dv) on the 20% haziest days and the 20% clearest days, consistent with Regional Haze Rule visibility goals (NPS ARD 2013a, US EPA 2014b). For an overall visibility trend, trends for clearest and haziest days were both considered. If the Haze Index trend on the 20% clearest days was deteriorating, the overall visibility trend was reported as deteriorating. Otherwise, the Haze Index trend on the 20% haziest days was reported as the overall visibility trend (NPS ARD 2013a). The NPS ARD also used the Group 50 (G50) metric to assess visibility. The G50 metric is the current visibility minus the visibility under natural conditions. The natural visibility value for GETT and EISE is 7.5 dv (NPS ARD 2015, 2013b).

4.1.3.3 Reference Condition and Status of the Resource (current condition and trends)

The visibility metrics for GETT and EISE for were evaluated as significant concern by the NPS ARD (2015) (Table 12, Figures 22 to 24). No trend was calculated by the NPS ARD for the 2008-2012 data. Previously, condition (2005-2009) and trend (2000-2009) in visibility were estimated by the NPS ARD (2013a) and the overall visibility at GETT and EISE was evaluated as significant concern, with an improving trend.

Table 12. Estimated annual average visibility (NPS ARD 2015) and G50 values (NPS ARD 2013b) for 2008-2012.

Metric	Good Condition	Moderate Concern	Significant Concern	GETT and EISE Condition and Trend
Average Visibility – on 20% Clearest days (dv)	<2 dv	2-8 dv	>8 dv	12.4 dv
Average Visibility – on 20% Haziest days (dv)	<2 dv	2-8 dv	>8 dv	25.5 dv
G50 Visibility minus natural conditions	<2 dv	2-8 dv	>8 dv	11.2 dv

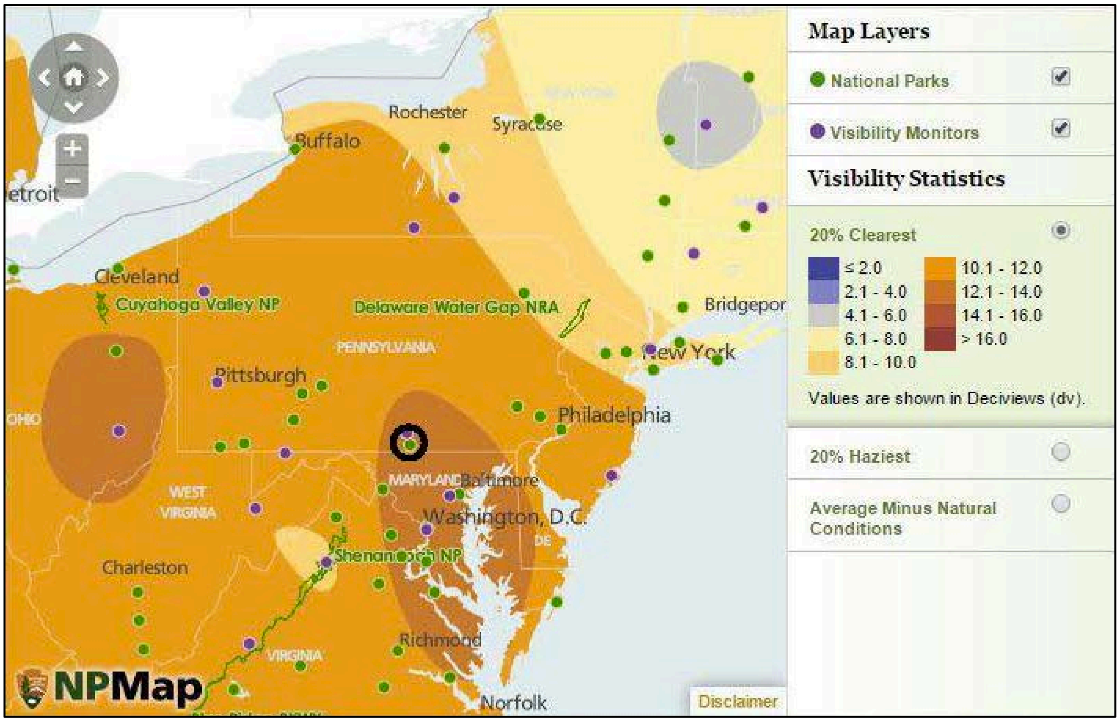


Figure 22. Visibility shown on 20% clearest days for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

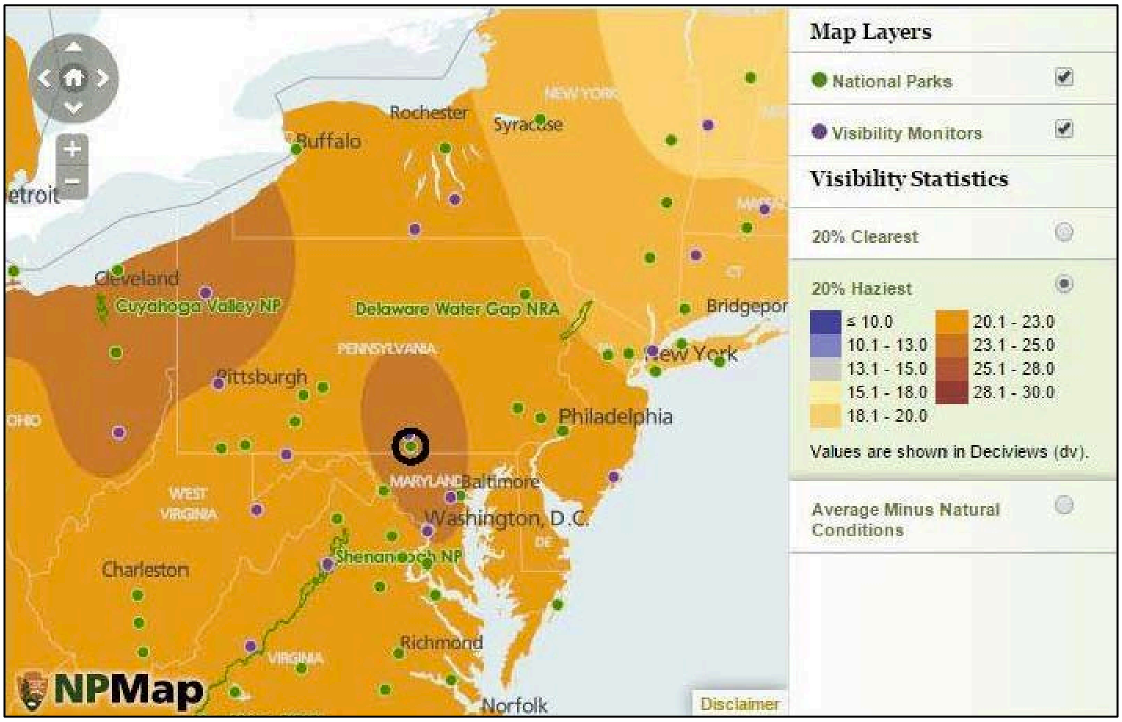


Figure 23. Visibility shown on 20% haziest days for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

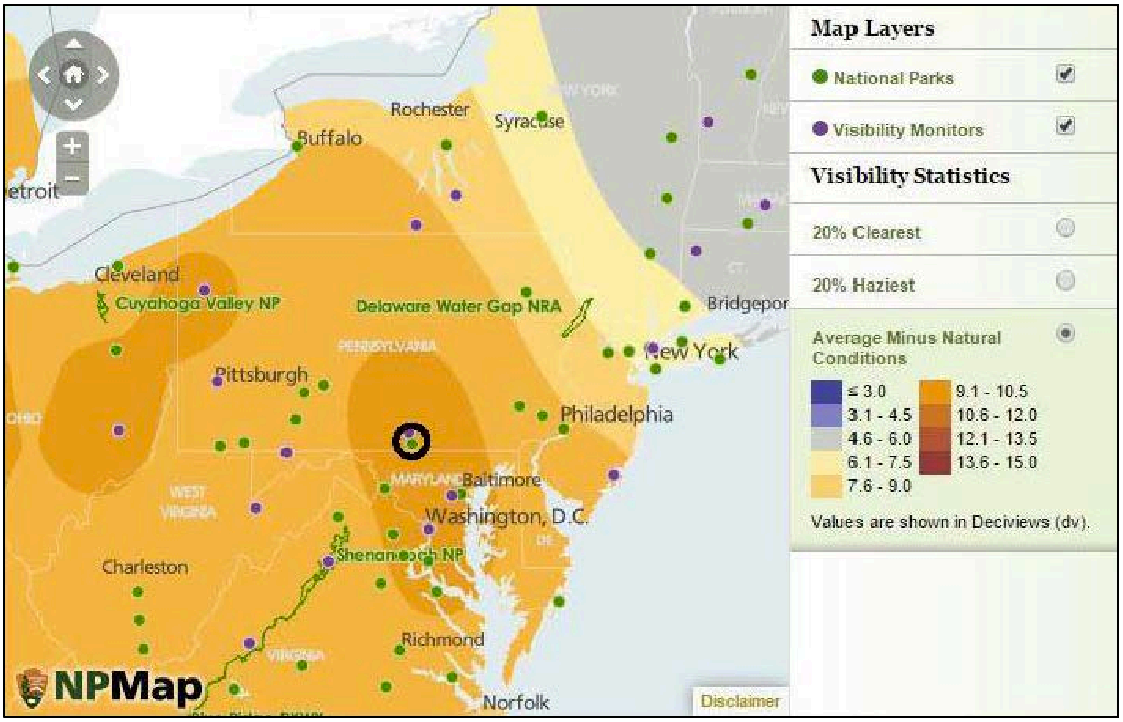


Figure 24. Average visibility minus natural conditions (the difference between current visibility and unimpaired visibility) for 2008-2012. GETT and EISE are indicated by black circle (NPS ARD 2015).

4.1.3.4 Confidence in Assessment

The data used to assess visibility were recent and of good quality. The confidence in the current condition and trend was assessed as high because air quality monitoring is ongoing and the stations are relatively close to the parks.

4.1.3.5 Data Gaps

There were no data gaps for visibility it is regularly monitored and interpreted by both federal and state agencies (IMPROVE, NPS, US EPA).

4.1.3.6 Threats

While GETT and EISE contain very little emission sources that contribute to the Haze Index, air quality and thus visibility, at the parks are highly influenced by local and regional air pollution transport as it is influenced by both local (adjacent urban areas such as Baltimore, MD) and regional (Northeast) emissions from automobile traffic and industry.

4.1.4 Night Sky Resources

4.1.4.1 Relevance and Context

The quality of the nighttime environment is relevant to nearly every unit in the NPS System. The 2006 NPS Management Policies (section 4.10) speak of the importance of a natural photic environment to ecosystem function and the importance of the natural lightscape for aesthetics. A lightscape can be important as a natural feature, a cultural feature, or both. Natural lightscapes are also important to wilderness character and have been identified under the Clean Air Act Amendments as an air quality related value.

The night sky as we see it is a combination of both natural and human-caused sources of light. Natural light sources include moonlight, starlight from individual stars and planets, and other celestial bodies. The NPS uses the term "natural lightscape" to describe resources and values that exist in the absence of human-caused light at night. Natural lightscapes are critical for nighttime scenery, such as viewing a starry sky, but are also critical for maintaining nocturnal habitat for a variety of species. The NPS NSNSD draws a distinction between the *lightscape* – the human perception of the nighttime scene, including both the night sky and the faintly illuminated terrain, and the *photic environment* – the totality of the pattern of light at night at all wavelengths. *Lightscapes* include aesthetic and experiential qualities that are integral to natural resources and cultural resources. The *photic environment* affects a broad range of species, is integral to ecosystems, and is a natural physical entity (NPS NSNSD 2013). In the highest quality skies, human-caused sources of light are less luminous than natural sources, and natural features of the night sky predominate. In a degraded natural lightscape, human-caused light is greater than that produced by natural sources, in some cases, many tens of times brighter (NPS NSNSD 2015c).

Alteration of night sky resources can be in the form of astronomical light pollution, where stars and other celestial bodies are obscured from view, or in the form of ecological light pollution where lighting (e.g., glare, illumination, fluctuations in lighting) can disrupt natural ecosystem processes and wildlife behavior (Longcore and Rich 2004). The largest human-caused source of ecological light pollution is outdoor electrical lighting, but other sources include skyglow (human-caused light scattered through the atmosphere), aircraft, fishing boats, vehicle lights, and satellites (Longcore and Rich 2004). Ecological light pollution can alter behavior and affect the population ecology of organisms in the natural world. Such effects include, but are not limited to, changes in orientation or disorientation, and attraction or repulsion from altered lightscape, changes in the timing of diurnal or crepuscular behaviors that may in turn influence foraging, reproduction, migration, communication, and survivorship (Longcore and Rich 2004).

Lightscapes can be cultural as well, and may be integral to the historical fabric of a park. The grandeur of a memorial or the magnitude of a historical event can be enhanced by nighttime lighting. NPS NSNSD acknowledges that nighttime lighting may be significant to the visitor experience of certain parks or required to effectively manage cultural resources. Careful consideration of such lighting should include how it affects resources and values in the park and whether the timing, amount and direction of the lighting are appropriate, both to protect the surrounding natural environment and to retain the suitable cultural lightscape (NPS NSNSD 2015c).

Artificial light can impact visitors through two primary processes: direct glare from light fixtures can affect vision and nighttime recreation experiences; and sky glow from collective sources of artificial light scattered in the atmosphere can reduce the ability to view the night sky. Both aspects of artificial light can unnaturally illuminate the ground and diminish visitors' ability to dark adapt their vision (NPS NSNSD 2015c). Kulesza et al. (2013) conducted an assessment of the importance of dark skies to visitors in Parks Service-wide. Although, dark skies were not specifically addressed for

GETT or EISE in that report, a few parks in the Northeast Region (NER) were included in the study (e.g., Minute Man NHS, Delaware Water Gap NRA). This study found that dark night skies were found to be extremely or very important to visitors in some NER parks.

The quality of natural lightscapes and starry night skies are dependent on the weather, the clarity of the air, and the amount of light pollution present (NPS NSNSD 2015d). The brightness and appearance of skyglow depends on atmospheric factors such as moisture, air pollution, and dust particles. Clean, dry air scatters light pollution less, resulting in darker skies for observers close to the light source. Poor air quality has the opposite effect, increasing light pollution close to the source and decreasing it at longer distance (NPS NSNSD 2015d).

At GETT and EISE, protecting photic resources, lightscapes, and naturally occurring night skies are related to: the ability to enhance the visitor experience; peaceful, historic, and cultural setting; and nocturnal wildlife (NPS NSNSD 2015c, 2015d). Although the night sky quality at GETT and EISE is partially degraded due to the proximity of the multiple population centers, both parks provide important habitat for nocturnal wildlife and a peaceful rural setting. National parks are tasked with preserving night sky quality and can serve as an example to surrounding communities and agencies by taking steps to mitigate anthropogenic light internally (NPS NSNSD 2015c, 2015d).

4.1.4.2 Data and Methods

The NPS NSNSD measures the quality of the photic environment by measuring total sky brightness averaged across the entire sky and comparing that value to natural nighttime light levels. This measure, called the ALR, can be directly measured or modeled when observational data is unavailable. The ALR is calculated by taking the total observed sky brightness and comparing it to the natural night sky component, yielding the anthropogenic quanta. A natural night sky has an average brightness across the entire sky of 78 nL (nanolamberts, a measure of luminance), and includes components such as the Milky Way, Zodiacal light, airglow, and other starlight. For example, a ratio of 0.0 would indicate pristine natural conditions where the anthropogenic component was 0 nL and natural component was 78 nL. A ratio of 1.0 would indicate that anthropogenic light was 100% brighter than the natural light from the night sky, equating to an anthropogenic component of 78 nL and natural component of 78 nL (NPS NSNSD 2013). Therefore, lower ALR levels reflect higher quality night sky conditions (NPS NSNSD 2015c, 2015d). The ALR is a robust and descriptive metric that can be modeled relatively easily.

However, the utility of a single metric to describe the quality of a complex resource such as the photic environment metric is limited and as such the NPS NSNSD also suggests using additional parameters, if possible, to determine the condition of night sky resources (NPS NSNSD 2013). The NPS NSNSD has determined threshold values for good, moderate concern and significant concern for non-urban parks, such as GETT and EISE for these parameters (Table 13):

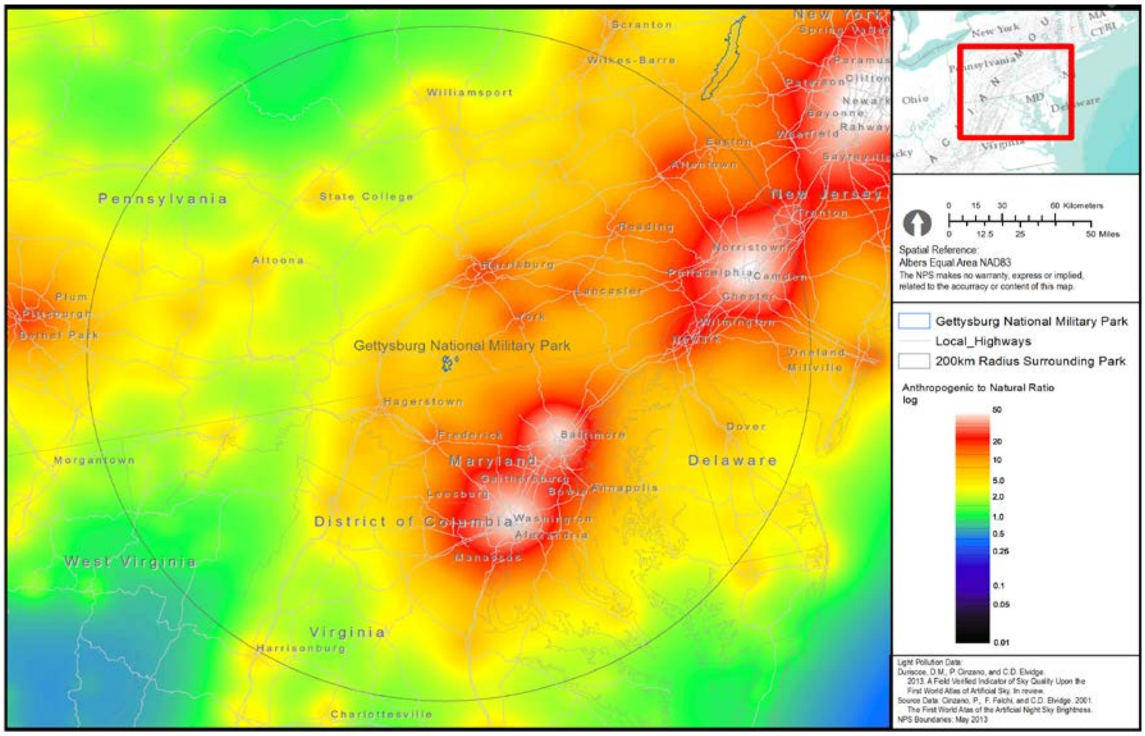
- The Bortle Dark-Sky Scale (Bortle 2001) – The Bortle Dark-Sky Scale is a nine-step scale, based on the visibility of certain celestial features (e.g., Milky Way, Zodiacal features), that can be used to estimate night sky quality. This is a simple way to make qualitative appraisals of night sky resources that can be done quickly by a dark-adapted individual, but can be biased from one person to another (Bortle 2006; see: http://www.skyandtelescope.com/resources/darksky/3304011.html).

- Typical Limiting Magnitude (Moore 2001): Limiting magnitude is semi--quantitative visual estimate of sky brightness determined by the dimmest star one can see. It works on the principle that brighter skies mask out faint stars, but varies with the training and visual acuity of the observer and with air quality (NPS 2013).
- Sky Quality Meter (SQM): Measures the amount of light in the night sky using a broad spectrum brightness band that roughly corresponds to the entire human visual range. The SQM measure the aggregate average brightness for the entire sky.
- Celestial Feature Appearance: The ability to see celestial features such as the Milky Way.
- Lightscape Appearance: The appearance of the lightscape to visitors in the park.
- Human Vision: The influence of the natural lightscape on dark adaptation to human vision.
- Sky Quality Index: The Sky Quality Index is an experimental 1-100 index being developed by the NPS that features units of equal aesthetic value.

Table 13. Threshold condition indicators for field measurement of night sky resources that could be used at non-urban parks such as GETT and EISE. Table modified from NPS NSNSD 2013.

Qualitative Description	Good Condition	Moderate Concern	Significant Concern
Bortle Class	Bortle Class 1-3	Bortle Class 4	Bortle Class 5-9
Typical Limiting Magnitude	6.8–7.6	6.3–6.7	<6.2
Sky Quality Meter	≥21.60	21.20-21.59	<21.20
Celestial Feature Appearance	Zodiacal light can be seen under favorable conditions, Milky Way shows detail and stretches from horizon to horizon	Milky Way has lost most of its detail and is not visible near horizon, Zodiacal light is rarely seen	Milky Way may be visible when it is directly overhead, otherwise not apparent, Andromeda Galaxy may be barely visible
Lightscape Appearance	Most observers feel they are in a natural environment, with natural features of the night sky readily visible	Anthropogenic light dominates natural celestial features, some shadows from distant lights may be seen	Little sense of naturalness remains in the night sky, landscape is clearly shadowed or illuminated, horizon aglow
Human Vision	Negligible impact to dark adaptation looking in any direction	Dark adaption possible in at least some directions, though visible shadows are likely present	Full dark adaptation not possible, substantial glare may be present, circadian rhythms may be disrupted
Sky Quality Index	>75	50–74	<50

<u>4.1.4.3 Reference Condition and Status of the Resource (current condition and trends)</u>
The NPS NSNSD modeled the night sky quality for the local area surrounding GETT and EISE (Figure 25). These images provide an important landscape scale context for considering night sky quality at the parks.



Created by NPS Natural Sounds & Night Skies Division and NPS Inventory and Monitoring Program MAS Group on 20150226

Figure 25. Regional view of anthropogenic light near GETT and EISE. White and red represents more environmental influence from artificial lights while blues and black represent less artificial light. The scale is small in order to show regional context and to show how far reaching the impacts of artificial lighting can be. While GETT and EISE may be influenced by artificial light it still maintains more naturalness than surrounding areas and serves as a harbor of dark skies (map excerpted from NPS NSNSD 2015e, 2015f).

The modeled median ALR value at GETT was 7.15 and at EISE was 7.06 (Figure 25) (NPS NSNSD 2015e, 2015f). At these light levels the Milky Way may be visible when it is directly overhead, otherwise it is not apparent. Little sense of naturalness remains in the night sky, and the landscape is clearly shadowed or illuminated. The horizon may appear aglow with anthropogenic light. Full dark adaptation or eyesight may not be possible, and substantial glare may be present. Circadian rhythms may be disrupted. However, the condition here is less impacted than the more urban areas around Washington, D.C. and Baltimore, MD. Based on these ALR values, the condition of the natural lightscape and night sky at GETT and EISE was evaluated as moderate concern (Table 14). Trend was not estimated as the condition was based on modeled data.

<u>4.1.4.4 Confidence in Assessment</u>
The quality of the data used to assess night sky resources was good; however, since it was based on modeled data the confidence was assessed as medium.

Table 14. Threshold conditions for anthropogenic light ratio (ALR) for night sky resources at Level 2 parks. Table modified from NPS NSNSD 2013.

Metric	Good Condition	Moderate Concern	Significant Concern	GETT Condition	EISE Condition
ALR Average Anthropogenic All-Sky Luminance : Average Natural All-Sky Luminance Light flux is totaled above the horizon (the terrain is omitted) and the anthropogenic and natural components are expressed as a unit less ratio The average natural sky luminance is 78 nL	Condition ALR < 2.00 (<156 nL average anthropogenic light in sky) At least half of park area should meet these criteria.	ALR 2.00–18.00 (156–1404 nL average anthropogenic light in sky) At least half of park area should meet this criteria.	ALR > 18.00 (>1404 nL average anthropogenic light in sky) At least half of park area should meet these criteria.	Modeled ALR: 7.15 (no trend estimated)	Modeled ALR: 7.06 (no trend estimated)

4.1.4.5 Threats

The naturally and culturally appropriate lightscape and night sky at GETT and EISE could be threatened by artificial light from park facilities and operations; and artificial light from nearby development, light domes from bright town/cities (NPS NSNSD 2015e, 2015f). There are wildlife species at both parks that have specific nocturnal behaviors that may be negatively impacted by ecological light pollution (e.g., bats). The dark sky and natural lightscape resources are influenced by the proximity of GETT and EISE to large urban centers (e.g., skyglow from Gettysburg). The parks could reduce the impact of artificial lighting by developing park lighting plans and retrofit of light sources in order to reduce glare, reduce overall light output, direct lights downward and install warmer color lamps.

4.1.5 Acoustic Environment

4.1.5.1 Relevance and Context

Our ability to see is a powerful tool for experiencing our world, but sound adds a richness that sight alone cannot provide. In many cases, hearing is the only option for experiencing certain aspects of our environment. An unimpaired acoustic environment is an important part of overall visitor experience and enjoyment as well as vitally important to overall ecosystem health.

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet that parks can offer. In a 1998 survey of the American public, 72% of respondents identified opportunities to experience natural quiet and the sounds of nature as an important reason for having national parks (Haas and Wakefield 1998). Additionally, 91% of NPS visitors “consider enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks” (McDonald et al. 1995). Despite this desire for quiet environments, anthropogenic noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

Sound also plays a critical role in intraspecies communication, courtship and mating, predation and predator avoidance, and effective use of habitat. Studies have shown that wildlife can be adversely affected by sounds that intrude on their habitats. While the severity of the impacts varies depending on the species being studied and other conditions, research strongly supports the fact that wildlife can suffer adverse behavioral and physiological changes from intrusive sounds (noise) and other human disturbances. Documented responses of wildlife to noise include increased heart rate, startle responses, flight, disruption of behavior, and separation of mothers and young (Selye 1956, Clough 1982, U.S. Department of Agriculture [USDA 1992], Anderssen et al. 1993, NPS 1994).

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

In 2011, the Night Skies Program and the Natural Sounds merged to form the NPS Natural Sounds and Night Skies Division. This program has pioneered techniques for measuring sound and light levels in remote locations, has advanced research into noise and light pollution, and is noted for their application of science to sensory resources. The NPS NSNSD assists park managers with specialized resource management and policy expertise as well as technical expertise in the form of acoustical monitoring, data collections and analysis, and all aspects of park planning and compliance (NPS NSNSD 2013).

At GETT and EISE, acoustic noise resources protection and noise reduction are related to: the ability to enhance the visitor experience, the rural, historical, and commemorative settings throughout the park, interpretative programs, living history exhibitions, and preserving quality wildlife habitat (NPS NSNSD 2015a, 2015b).

4.1.5.2 Data and Methods

Humans and wildlife perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air. Sound is measured in terms of frequency and amplitude (Templeton and Sacre 1997, Harris 1998). Noise, essentially the negative evaluation of sound, is defined as extraneous or undesired sound (Morfey 2001).

Frequency, measured in Hertz (Hz), describes the cycles per second of a sound wave, and is perceived by the ear as pitch. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz, and are most sensitive to frequencies between 1,000 Hz and 6,000 Hz. High frequency sounds are more readily absorbed by the atmosphere or scattered by obstructions than low frequency sounds. Low frequency sounds diffract more effectively around obstructions. Therefore, low frequency sounds travel farther.

Besides the pitch of a sound, we also perceive the amplitude (or level) of a sound. This metric is described in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in sound pressure level can have significant effects on the acoustic environment. For instance, a 6 dB increase in a noise source will double the distance at which it can be heard, increasing the affected area by a factor of four. Sound pressure level is commonly summarized in terms of dBA (A-weighted sound pressure level). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate human hearing sensitivity. Table 15 provides examples of A-weighted sound levels measured in national parks.

Table 15. Examples of sound levels measured in national parks.

Decibel level (dBA)	Sound Source
10	Volcano crater (Haleakala NP)
20	Leaves rustling (Canyonlands NP)
40	Crickets at 5 m (Zion NP)
60	Conversational speech at 5 m (Whitman Mission NHS)
80	Snowcoach at 30 m (Yellowstone NP)
100	Thunder (Arches NP)
120	Military jet, 100m above ground level (Yukon-Charley Rivers NP)
126	Cannon fire at 150m (Vicksburg NMP)

The natural acoustic environment is vital to the function and character of a national park. Natural sounds include those sounds upon which ecological processes and interactions depend. Examples of natural sounds in parks include:

- sounds produced by birds, frogs or insects to define territories or attract mates;
- sounds produced by bats to navigate or locate prey; and
- sounds produced by physical processes such as wind in trees, flowing water, or thunder.

Although natural sounds often dominate the acoustic environment of a park, human-caused noise has the potential to mask these sounds. Noise impacts the acoustic environment much like smog impacts the visual environment; obscuring the listening horizon for both wildlife and visitors. Examples of human-caused sounds heard in parks include:

- Aircraft (i.e., high-altitude and military jets, fixed-wing, helicopters)
- Vehicles
- Generators
- Watercraft
- Grounds care (lawn mowers, leaf blowers)
- Human voices

4.1.5.3 Characterizing the acoustic environment

Oftentimes, managers characterize ambient conditions over the full extent of the park by dividing total area into "acoustic zones" on the basis of different vegetation zones, management zones, visitor use zones, elevations, or climate conditions. Then, the intensity, duration, and distribution of sound sources in each zone can be assessed by collecting sound pressure level (SPL) measurements, digital audio recordings, and meteorological data. Indicators typically summarized in resource assessments include natural and existing ambient sound levels and types of sound sources. *Natural ambient* sound level refers to the acoustical conditions that exist in the absence of human-caused noise and represents the level from which the NPS measures impacts to the acoustic environment. *Existing* *ambient* sound level refers to the current sound intensity of an area, including both natural and human-caused sounds.

The influence of anthropogenic noise on the acoustic environment is generally reported in terms of SPL across the full range of human hearing (12.5-20,000 Hz), but it is also useful to report results in a much narrower band (20-1250 Hz) because most human-caused sound is confined to these lower frequencies.

4.1.5.4 Reference Condition and Status of the Resource (current condition and trends)

Reference criteria should address the effects of noise on human health and physiology, the effects of noise on wildlife, the effects of noise on the quality of the visitor experience, and finally, how noise impacts the inherent value of the acoustic environment.

Various characteristics of sound can contribute to how noise may affect the acoustic environment. These characteristics may include rate of occurrence, duration, pitch, and whether the sound occurs consistently or sporadically. In order to capture these aspects, the quality of the acoustic environment is assessed using a number of different metrics including existing ambient and natural ambient sound level (measured in decibels), percent time human-caused noise is audible, and noise free interval. In summary, if we are to develop a complete understanding of a park's acoustic environment, we must consider a variety of sound metrics. This can make selecting one reference condition difficult. For example, if we chose to use just the natural ambient sound level for our reference condition, we would focus only on sound pressure level and overlook the other aspects of sound mentioned above.

Ideally, reference conditions would be based on measurements collected in the park, but this is not always logistically feasible. In cases where on-site measurements have not been gathered, one can reference meta-analyses of national park monitoring efforts such as those detailed in Lynch et al. (2011) and Mennitt et al. (2013). The former aggregated data from 189 sites in 43 national parks, and reported that the median L_{90} across all sites and hours of the day was 21.8 dBA (between 20 and 800 Hz). L_{90} is the sound level that is heard 90% of the time; an estimate of the background against which individual sounds are heard. The latter, a similarly comprehensive geospatial modeling effort (which assimilated data from 291 park monitoring sites across the nation), revealed that the median daytime existing sound level in national parks rests around 31 dBA. In addition, among 89 acoustic monitoring deployments analyzed for audibility, the median percent time audible of anthropogenic noise during daytime hours was found to be 35%.

In cases where acoustic data have been collected on site, a balanced assessment of acoustical conditions in a park will report natural and existing sound levels (for either daytime, nighttime, or 24 hour time periods), percent time audible for natural sounds and noise sources of interest, and noise free intervals. Human responses can actually serve as a proxy for potential impacts to other vertebrates because humans have more sensitive hearing at low frequencies than most species (Dooling and Popper 2007), so a resource assessment might also consider the time that SPL levels exceeded those mentioned in Table 16. The first value (35 dBA) is designed to address the health effects of sleep interruption. Recent studies suggest that sound events as low as 35 dB can have adverse effects on blood pressure while sleeping (Haralabidis et al. 2008). The second threshold addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (Berglund et al. 1999). Park visitors camping in or near the park could experience either of these two effects. The third level (52 dBA) is based on the US EPA's speech interference threshold for speaking in a raised voice to an audience at 10 meters. This threshold addresses the effects of noise on interpretive programs in parks. The final threshold (60 dBA) provides a basis for estimating impacts on normal voice communications at 1 meter. Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations.

Table 16. Effects of sound pressure levels (SPL) on humans.

SPL (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans (Haralabidis et al. 2008)
45	World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund et al. 1999)
52	Speech interference for interpretive programs (US EPA 1971)
60	Speech interruption for normal conversation (US EPA 1971)

In cases where ability to collect acoustic data on site is limited, alternatives for assessing condition and trend are also available. Using acoustic data collected at 244 sites and 109 spatial explanatory layers (such as location, landcover, hydrology, wind speed, and proximity to noise sources such as roads, railroads, and airports), NPS NSNSD has developed a geospatial sound model which predicts natural and existing sound levels with 270 meter resolution (Mennitt et al. 2013). For the model, sound pressure levels for the continental United States were predicted using actual acoustical measurements combined with a multitude of explanatory variables such as location, climate, landcover, hydrology, wind speed, and proximity to noise sources (roads, railroads, and airports). The model predicts daytime sound levels during midsummer. The maps are generated using 270 meter resolution, meaning that each pixel represents 270 square meters. It should be noted that while the model excels at predicting acoustic conditions over large landscapes, it may not reflect recent localized changes such as new access roads or development. The park-specific maps are a subset of the national model and show predicted sound pressure levels for the park unit. An inset map is included in each park-specific map to provide a better sense of context, and major roads and highways are labeled for reference.

To gain insight into the condition of the acoustic environment in parks where acoustic data have not been collected, it is also useful to have an inventory of audible sounds. The important variables to track are what sounds are audible, how often they are audible, and how many times they are audible. These data are best collected by a single, focused listener in calm weather conditions during a series of listening sessions. It is advisable to conduct the sound inventory in a number of different locations and across different times of day to capture spatial and temporal variation in acoustic conditions. A listening session of this nature can be conducted with tools as simple as a pen, paper, and stopwatch, or with custom software produced by the NPS NSNSD which runs on most Apple iOS products. The ultimate goal of the inventory is to gather information about what sounds presently contribute to the acoustic environment, which are the most common, and which could possibly threaten the quality of the acoustic environment.

To assess the condition of the acoustic environment, it is also useful to consider the functional effects that increases in sound level might produce. For instance, the *listening area*, the area in which a sound can be perceived by an organism, will be reduced when background sound levels increase. The failure to perceive a sound because other sounds are present is called *masking*. Masking interferes with wildlife communication, reproductive and territorial advertisement, and acoustic location of prey or predators (Barber et al. 2010). However, the effects of masking are not limited to wildlife. Masking also inhibits human communication and visitor detection of wildlife sounds. In urban settings, masking can prevent people from hearing important sounds like approaching people or vehicles, and interfere with the way visitors experience cultural sounds or interpretive programs. Keep in mind that seemingly small increases in sound level can have substantial effects, particularly when quantified in terms of loss of listening area (Payne and Webb 1971, Barber et al. 2010). Each 3 dB increase in the background sound level will reduce a given listening area by half. See Table 17 for additional information.

Table 17. Increases in background sound level (dB) with resulting decreases in listening area.

Increase in background sound level (dB)	Decrease in listening area
1	21%
2	37%
3	50%
4	60%
5	68%
6	75%
7	80%
8	84%
9	87%
10	90%

Evaluating trends in condition is straightforward for parks where repeated measurements have been conducted because measurements can be compared. But inferences can also be made for parks where fewer data points exist. Nationwide trends indicate that prominent sources of noise in parks (namely vehicular traffic and aircraft) are increasing. However, it is possible that conditions in specific parks differ from national trends. The following events might contribute to a declining trend in the quality of the acoustic environment: expansion of traffic corridors nearby, increases in traffic due to industry, changes in zoning or leases on adjacent lands, changes in land use, planned construction in or near the park, increases in population, and changes to airspace (particularly those which bring more aircraft closer to the park). Most states post data on traffic counts on department of transportation websites, and these can be a good resource for assessing trends in vehicular traffic. Changes to airport operations, air space, and land use will generally be publicized and evaluated through the National Environmental Policy Act (NEPA) process.

Conversely, the following events may signal improvements in trend: installation of quiet pavement in or near parks, use of quiet technology for recreation in parks, decrease in vehicle traffic, use of quiet shuttle system instead of passenger cars, building utility retrofits (e.g. replacing a generator with solar array), or installation of "quiet zone" signage.

There is an ongoing effort to assess condition and trend of acoustic resources for the state of the parks (SOP) project, and although SOPs generally report one metric per resource (while NRCAs often incorporate multiple metrics), it may serve as a useful template (see this link for more information: https://irma.nps.gov/App/Reference/Profile/2206094). Table 18 reports suggested thresholds for the mean L_{50} impact, which is a measure of the impact of anthropogenic sources on the acoustic environment.

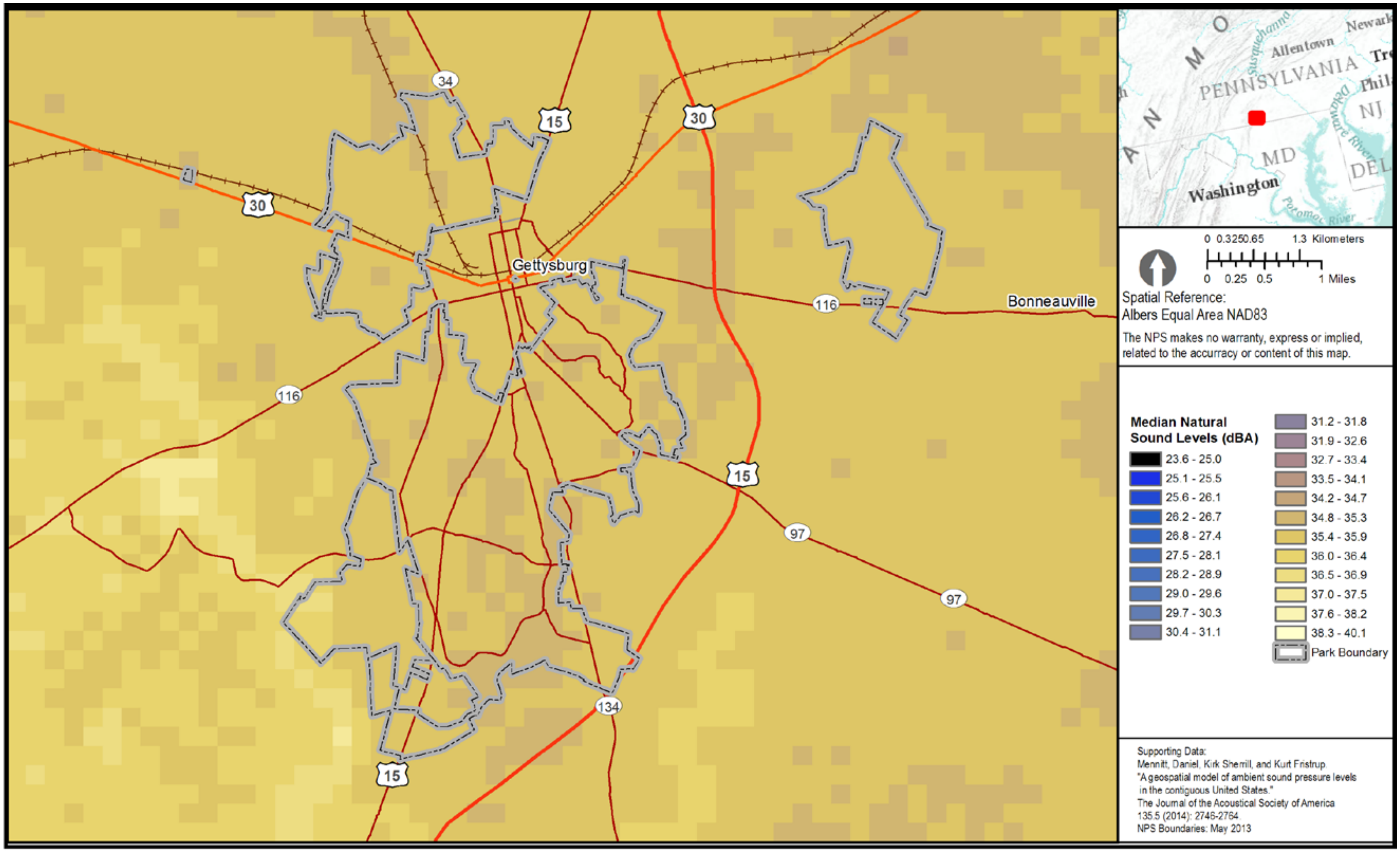
Table 18. Condition thresholds for non-urban parks (NPS NSNSD personal communication).

Metric	**Good Condition**	**Moderate Concern**	**Significant Concern**	**GETT Condition**	**EISE Condition**
Mean L_{50} impact (dBA) Calculated as difference between existing ambient and natural ambient models	Threshold ≤ 1.5 Listening area reduced by ≤ 30%	1.5 < Threshold ≤ 3.0 Listening area reduced by 30 - 50%	3.0 < Threshold Listening area reduced by > 50%	Mean impact: 9.5 dBA (range 4.7 to 13.46 dBA) (No trend estimated)	Mean impact: 6.6 dBA (range 4.8 to 10.13 dBA) (No trend estimated)

Because the National Park System is comprised of a wide variety of park units, two threshold categories are considered (urban and non-urban), based on proximity to urban areas (U.S. Census Bureau 2010). The urban criteria are applied to park units that have at least 90% of the park property *within* an urban area. The non-urban criteria were applied to units that have at least 90% of the park property *outside* an Urban Area. Parks that are distant from urban areas possess lower sound levels, and they exhibit less divergence between existing sound levels and predicted natural sound levels. These quiet areas are more susceptible to subtle noise intrusions than urban areas. Visitors and wildlife have a greater expectation for noise-free environments. Accordingly, the thresholds for the moderate concern and significant concern condition ratings are lower for these park units than for units near urban areas. Urban areas tend to have higher ambient sound levels than non-urban areas (US EPA 1971, Schomer et al. 2011). Higher thresholds are used for parks in urban areas. However, acoustic environments are important in all parks: units in urban areas may seek to preserve or restore low ambient sound levels to offer respite for visitors.

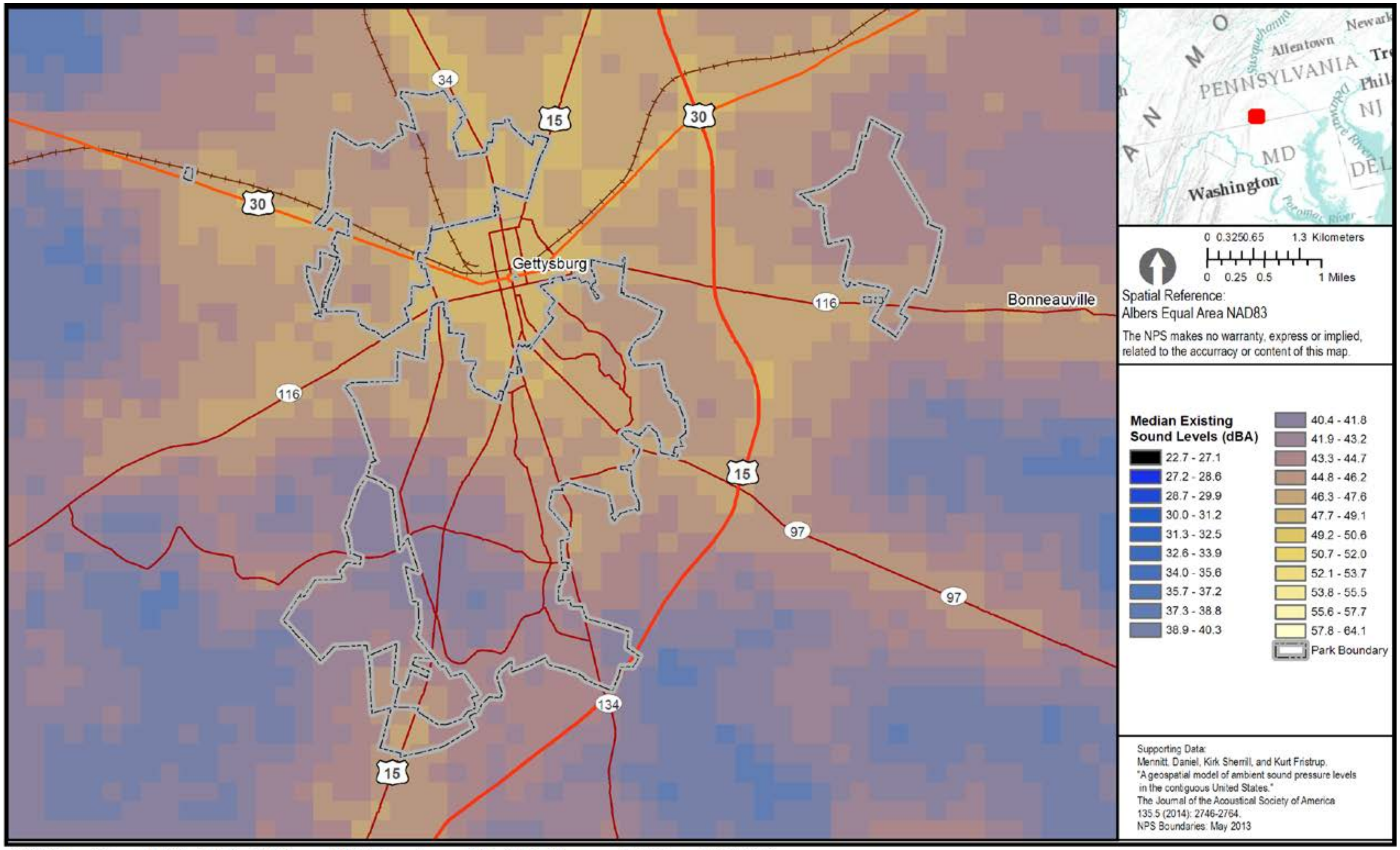
A common source of noise in national parks is transportation (i.e., airplanes, vehicles). Growth in transportation is increasing faster than is the human population (Barber et al. 2010). Between 1970 and 2007, traffic on US roads nearly tripled to almost 5 trillion vehicle km/yr (http://www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm). Aircraft traffic grew by a factor of three or more between 1981 and 2007 (http://www.bts.gov/programs/airline_information/ air_carrier_traffic_statistics/airtraffic/annual/1981_present.html). As these noise sources increase throughout the United States, the ability to protect pristine and quiet natural areas becomes more difficult (Mace et al. 2004).

The NPS NSNSD (2015a, 2015b) modeled the natural sound levels (Figure 26) and the existing sound pressure levels (Figure 27) for GETT and EISE. In addition to predicting these two ambient sound levels, the model also calculates the difference between the two metrics, providing a measure of impact to the natural acoustic environment from anthropogenic sources. The resulting metric (L_{50} dBA impact) indicates how much anthropogenic noise raises the existing sound pressure levels in a given location (Figure 28, NPS NSNSD 2015a, 2015b). For example, a one decibel change is not readily perceivable by the human hear, but any addition to this difference could begin to impact listening ability. For example, if a predator can hear a potential prey animal in an area of 100 square feet in a setting with natural ambient sounds, that animal's ability to hear would be reduced to 11 square feet if the sound levels were increased by 9.5 dBA. Similar reduction would occur for visitors and their ability to hear natural sounds or interpretive programs. An increase of 4.7 dBA would reduce listening area by 65% (NPS NSNSD 2015a, 2015b).



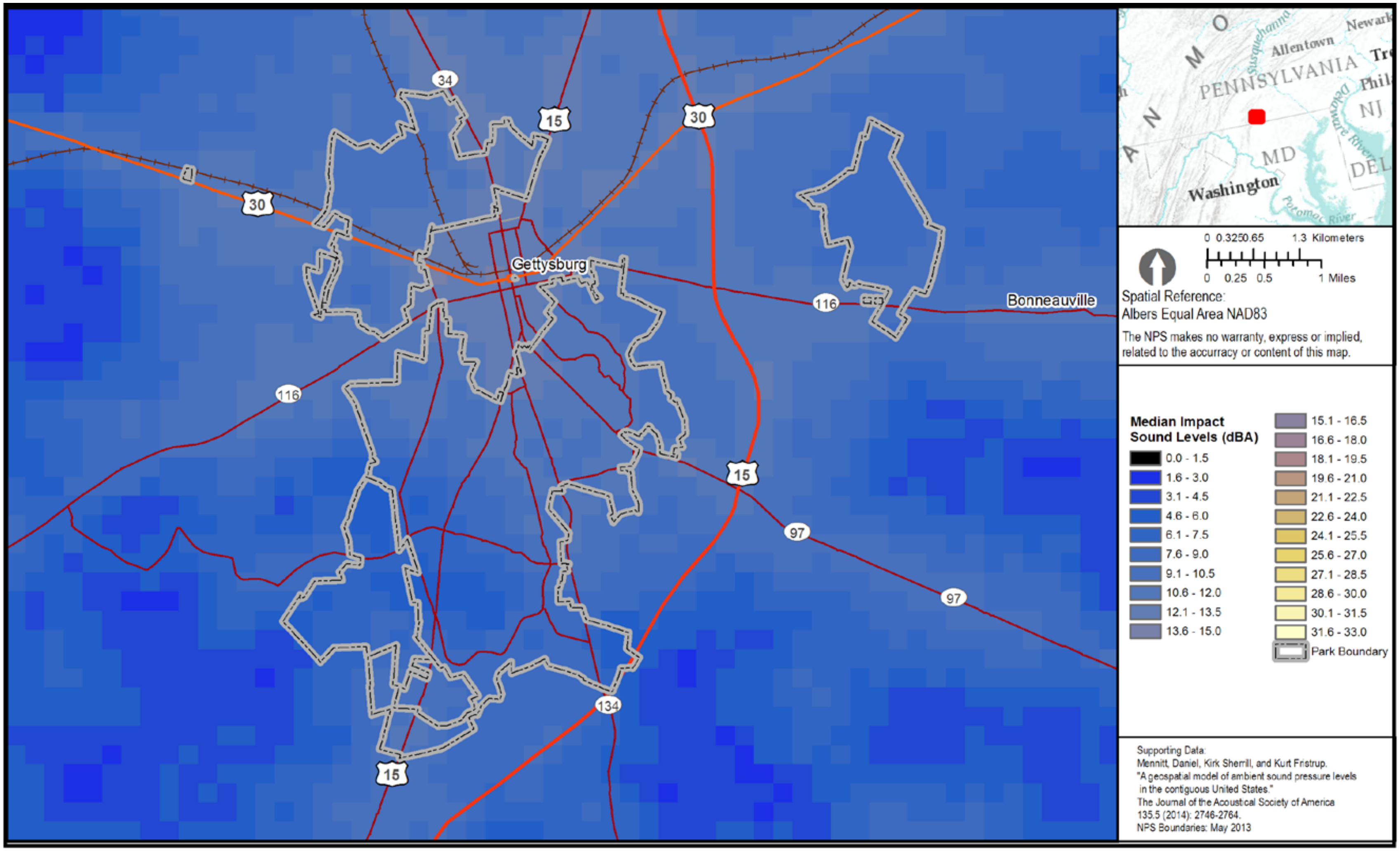
NPS Natural Sounds & Night Skies Division and NPS Inventory and Monitoring Program MAS Group 20150223

Figure 26. Median natural sound pressure levels for GETT and EISE. This park-specific natural sound level map is generated by version 3 of the geospatial model. The color scale indicates the decibel level that is predicted in the park based only on natural sound sources. Sound level is measured in A-weighted decibels, or dBA, with 270 meter resolution. Black and dark blue colors indicate low decibel levels while yellow or white colors indicate higher decibel levels (note: each figure has different legend values, Figure excerpted from NPS NSNSD 2015a, 2015b).



NPS Natural Sounds & Night Skies Division and NPS Inventory and Monitoring Program MAS Group 20150223

Figure 27. Median existing sound pressure levels for GETT and EISE. This park-specific existing sound level map is generated by version 3 of the geospatial model. The color scale indicates the decibel level that is predicted in the park based only on both human-caused and natural sound sources. Sound level is measured in A-weighted decibels, or dBA, with 270 meter resolution. Black and dark blue colors indicate low decibel levels while yellow or white colors indicate higher decibel levels. Sound levels in national parks can vary greatly, depending on location, topography, vegetation, biological activity, weather conditions and other factors. For example, the din of a typical suburban area fluctuates between 50 and 60 decibels (dBA), while the crater of Haleakala National Park is intensely quiet, with levels around 10 dBA. (Note: each figure has different legend values, figure excerpted from NPS NSNSD 2015a, 2015b).



NPS Natural Sounds & Night Skies Division and NPS Inventory and Monitoring Program MAS Group 20150223

Figure 28. Median sound level impact map for GETT and EISE. This park-specific L50 dBA impact map is generated by version 3 of the geospatial model. The color scale indicates how much anthropogenic noise raises the existing sound pressure levels in a given location (measured in A-weighted decibels, or dBA), with 270 meter resolution. Black and dark blue colors indicate low impacts while yellow or white colors indicate greater impacts (note: each figure has different legend values, Figure excerpted from NPS NSNSD 2015a, 2015b).

Gettysburg National Military Park

The NPS NSNDS (2015b) estimated the mean impact (L_{50} dBA impact) between natural and existing acoustic conditions to be 9.5 dBA, with a range from 4.7 to 13.46 dBA depending on the location within GETT (Figure 28). That is, the average existing sound level (with the influence of man-made sounds) is predicted to be 9.5 dBA above the natural ambient sound level. An increase of 9.5 dBA would reduce listening area for wildlife and visitors by 89%. This falls into the significant concern range for a non-urban park (Table 18). Trend was not estimated since this was based on modeled data.

Eisenhower National Historic Park

The NPS NSNDS (2015a) estimated the mean impact (L_{50} dBA impact) between natural and existing acoustic conditions to be 6.6 dBA, with a range from 4.8 to 10.13 dBA depending on the location within EISE (Figure 28). That is, the average existing sound level (with the influence of man-made sounds) is predicted to be 6.6 dBA above the natural ambient sound level. An increase of 6.6 dBA would reduce listening area for wildlife and visitors by 78%. This falls into the significant concern range for a non-urban park (Table 18). Trend was not estimated since this was based on modeled data.

4.1.5.5 Confidence in Assessment

The condition of significant concern for the acoustic environment was based on modeled data that predicts mean sound level impacts using measurements made in hundreds of national park sites as well as 109 explanatory variables such as location, climate, land cover, hydrology, wind speed, and proximity to noise sources such as roads, railroads, and airports (NPS NSNSD personal communication). The confidence in the assessment was based as medium simply for the reason that the condition was based on modeled data and not field data for GETT and EISE.

4.1.5.6 Data Gaps

Baseline acoustic ambient data collection within both GETT and EISE will clarify existing conditions and provide greater confidence in resource condition trends. The development of park-specific goals, indicators, and standards would be beneficial. Wherever possible, baseline ambient data collection should be conducted. In addition to providing site specific information, this information can also strengthen the national noise model.

With respect to the effects of noise, there is compelling evidence that wildlife can suffer adverse behavioral and physiological changes from noise and other human disturbances, but the ability to translate that evidence into quantitative estimates of impacts is presently limited. Several recommendations have been made for human exposure to noise, but no guidelines exist for wildlife and the habitats we share. The majority of research on wildlife has focused on acute noise events, so further research needs to be dedicated to chronic noise exposure (Barber et al. 2011). In addition to wildlife, standards have not been developed yet for assessing the quality of physical sound resources (the acoustic environment), separate from human or wildlife perception. Scientists are also working to differentiate between impacts to wildlife that result from the noise itself or the presence of the noise source

4.1.5.7 Threats

The naturally and culturally appropriate acoustic environment at GETT and EISE could be threatened by human-produced sound. Specific threats include: noise from park facilities and operations, noise from nearby development, transportation, and aircraft, and noise from visitor vehicles, music, shouting, and electronics (NPS NSNSD 2015a, 2016b).

The park's GMP noted that some of the most problem acoustical issues were related to traffic, loud music, and tour buses (NPS 1999a). Noise levels within the parks vary seasonally. During high visitation months (April through October) there are crowds, automobile congestion, and tour buses. These months are also the time when wildlife is most active (e.g., breeding, nesting, foraging) and could experience disturbance due to increased noise levels. However, even on the busiest days, there are parts of the parks that are little visited and where visitors can find solitude (NPS 1999a). During the winter months and on weekends during November through March, the parks are often quiet (NPS 1999a).

Sources of Expertise

The NPS Natural Sounds and Night Skies Division scientists help parks manage sounds in a way that balances the various expectations of park visitors with the protection of park resources. They provide technical assistance to parks in the form of acoustical monitoring, data collection and analysis, and in developing acoustic baselines for planning and reporting purposes. For more information, see http://www.nature.nps.gov/sound/.

4.2 Water and Water-related Resources

4.2.1 Stream Water Quality

4.2.1.1 Relevance and Context

Water quality is ecologically significant as it affects aquatic communities and ecosystems (Karr et al. 1986). MIDN parks such as GETT and EISE are affected by a variety of pollutants stemming from sources ranging from residential development, industrial discharges, urban and agricultural runoff, and airborne pollutants (Carpenter et al. 1996). The MIDN selected lotic systems for monitoring because they are the dominant aquatic resource across the Network's parks. The NPS (2002) has identified minimum core surface water quality standards for temperature, pH, dissolved oxygen, and specific conductance for freshwater resources. Monitoring these core water quality parameters is required as part of any water quality monitoring program funded by the NPS Water Resources Division. Other parameters that are deemed important, but not crucial for NPS monitoring, are water flow/discharge for flowing waters and some qualitative assessment of stage/level, and water column profiles for non-flowing waterbodies (NPS 2002). The MIDN, along with park staff, sample the core water quality metrics at some streams in GETT and EISE, additionally, water chemistry samples (major cations/anions) are collected and qualitative information on flow/discharge is recorded. Collection of nutrient samples (TN/TP) may take place in the future. The MIDN selected these parameters along with the benthic aquatic macroinvertebrate community, as primary vital signs for monitoring due to the clear connection to stream conditions (Comiskey and Callahan 2008).

The PA Department of Environmental Protection and US EPA also assess water quality and impairments to water quality. Surface water quality criteria for are set forth in the Pennsylvania Code §93.7 (2016b, refer to Appendix Table 58 for water quality parameters). When a waterbody is found to be impaired a Total Maximum Daily Load (TMDL) is required to be developed for the waterbody. The goal of a TMDL is to bring the waterbody into compliance with water quality standards by establishing the maximum amount of a pollutant that can be present while still meeting public health water quality standards and maintaining the designated beneficial uses for those waters. Both parks in their entirety are covered by the Chesapeake Bay TMDL for nitrogen, phosphorus and sediment (Adams County Conservation District & Adams County Office of Planning and Development [ACCD] 2011). Rock Creek (GETT), Stevens Run (GETT), and Willoughby Run (EISE) have been noted as needing TMDLs (US EPA 2016a).

Streams within GETT and EISE drain the surrounding highlands, and primarily flow in a southerly direction through lowlands, and eventually drain into the Potomac River and the Chesapeake Bay. Rock Creek and Willoughby Run are the major streams within GETT. Willoughby Run drains south into Marsh Creek at EISE. Tributaries to Rock Creek include Stevens Run, which drains to the north, and Plum Run which drains to the south. Marsh and Rock Creeks join at the Maryland border to form the Monocacy River (NPS 1999a). None of the surface waters in either GETT or EISE were designated as wild and scenic rivers, exceptional value, or high quality streams (ACCD 2011, NPS 2014, Pennsylvania Code §93.7 2016a). Streams and runs within GETT and EISE primarily have classified designated uses for warm water resident fishes and migratory fishes, although Marsh Creek

(EISE) is designated for cold water resident fishes and migratory fishes (Table 19, Appendix Table 56, Pennsylvania Code §93.7 2016a).

Table 19. Designated water quality uses for surface waters in GETT and EISE (Pennsylvania Code §93.7 2016a).

Park	Cold water resident fishes, migratory fishes	Warm water resident fishes, migratory fishes
GETT	n/a	Plum Run and tributaries, Rock Creek and tributaries
EISE	Marsh Creek	Willoughby Run tributaries

Gettysburg National Military Park

The main water resources at GETT include a ~3.2 km section of Rock Creek and two tributaries of Rock Creek named Plum Run (Plum Run West and Plum Run East) (Figure 29). The western portion of Plum Run drains the southern section of the park and flows southward past the Round Tops and Devil's Den area of GETT before exiting the park. The eastern section of Plum Run drains the East Cavalry Battle Site. The Rock Creek watershed is 163 km^2 (63 mi^2) and the confluence of Rock Creek and Marsh Creek form the Monocacy River (Watershed Alliance of Adams County 2015a, 2015b).

In the northwest section of GETT, Pitzer's Run and Spangler's Run drain into Willoughby Run. On the east side of GETT numerous small drainages, including Blocher's Run, Stevens Run, Culp Run, Winebrenner's Run, Jones Bridge Run, Spangler's Spring Run, Guinn Run, and Wright Avenue Run, drain into Rock Creek. Sections of the main branch of Rock Creek also flow through the parks. In the southcentral portion of GETT, Heagy's Woods Run joins Plum Run West, which is the prominent stream in that area. Plum Run West eventually joins Rock Creek outside the park's boundary. In the East Cavalry Field Unit of GETT, Plum Run East joins White Run, which eventually flows into Rock Creek outside the Parks boundaries (NPS 2014).

Gettysburg NMP and Eisenhower NHS Water Quality Sampling

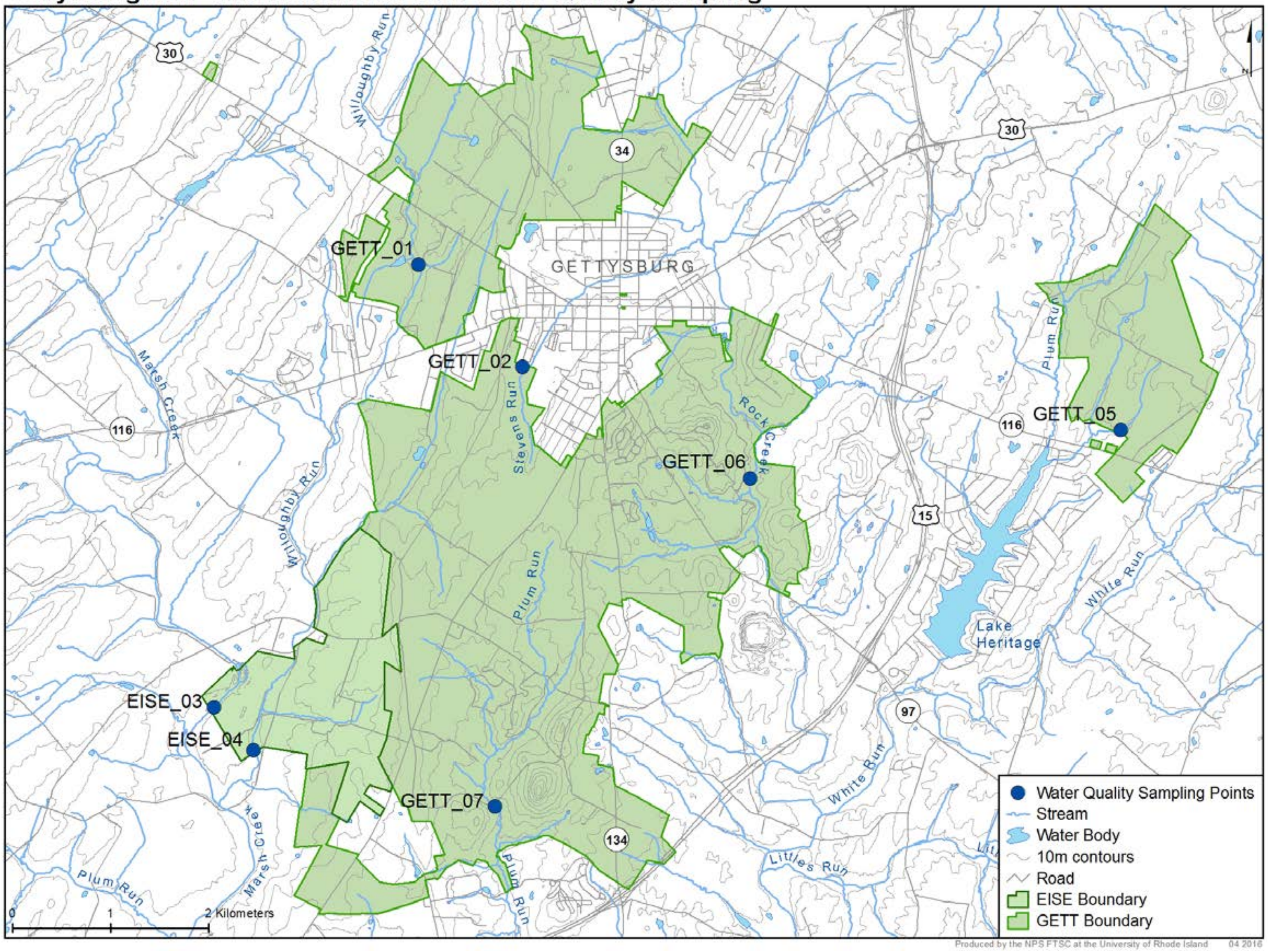


Figure 29. Streams at GETT and EISE and MIDN water quality sampling stations. Note: GETT_02 and GETT_05 are no longer sampled by the MIDN Network (N. Dammeyer, personal communication 14 April 2016).

Eisenhower National Historic Site

The water resources at EISE include a 0.48 km section of Marsh Creek and a 1.13 km section of Willoughby Run, a tributary of Marsh Creek. Marsh Creek is a 199 km^2 (77 mi^2) watershed in Adams County, PA (Figure 29). Marsh Creek and Rock Creek (in GETT) combine to form the Monocacy River, which then drains to the Potomac River. Both Marsh Creek and Willoughby Run flow through a variety of landscapes including orchards, farmland, villages, commercial and industrial centers, and woodlands (Watershed Alliance of Adams County 2015a). Marsh Creek is a large stream that varies from 5 m to nearly 15 m wide. The upstream boundary of EISE crosses Marsh Creek in the vicinity of a municipal dam and an associated impounded section. Downstream of the dam there are several stream channels around various islands. The channels reform into a single channel several hundred meters prior to exiting the park (Atkinson 2008). Willoughby Run flows nearly parallel to Marsh Creek approximately 0.3 km to its east end, and is much smaller with a main channel width of 3 m to 8 m.

4.2.1.2 Data and Methods

Baseline water quality data, inventory, and analyses were collected for GETT and EISE in 1999 (NPS 1999b). The baseline inventory presented results from surface water quality data retrievals from six of the US EPA’s national databases. Twenty seven stations were located within GETT park boundaries (Figure 30) and one station (GETT 0018) was located within EISE. Many of the monitoring stations represented either one-time or intensive single-year sampling efforts by the collecting agencies. At GETT, the stations yielding the longest-term records (1975 to 1980) within park boundaries were: (1) Rock Creek 1000 feet from Culp's Hill (GETT 0035); (2) Rock Creek just upstream from Spangler's Spring (GETT 0030); (3) Rock Creek below sewage plant effluent (GETT 0040); (4) Rock Creek at confluence with Culp's Run (GETT 0048); and (5) Plum Run at the Warren Avenue Bridge (GETT 0013). At EISE (GETT 0018) the period of record was limited to 1974 to 1980 (Figure 30) (NPS 1999b).

The PA DEP assesses impairments to surface waters and categorizes them as either attaining or non-attaining for their designated uses. The last assessment of stream water quality for streams within GETT and EISE was conducted in 2002 and 2004 (US EPA 2016a). In addition, geospatial data on attainment was available from the PASDA GIS portal. The metadata for the PASDA geospatial data states that they are updated “nightly” (PASDA 2016); however, it is likely that these data were based on the 2002 and 2004 assessments, as more recent assessments could not be found and none of the stream reaches for either park were mentioned in the 2016 draft PA integrated water quality report (US EPA 2016a, PADEP 2016) (Figure 31).

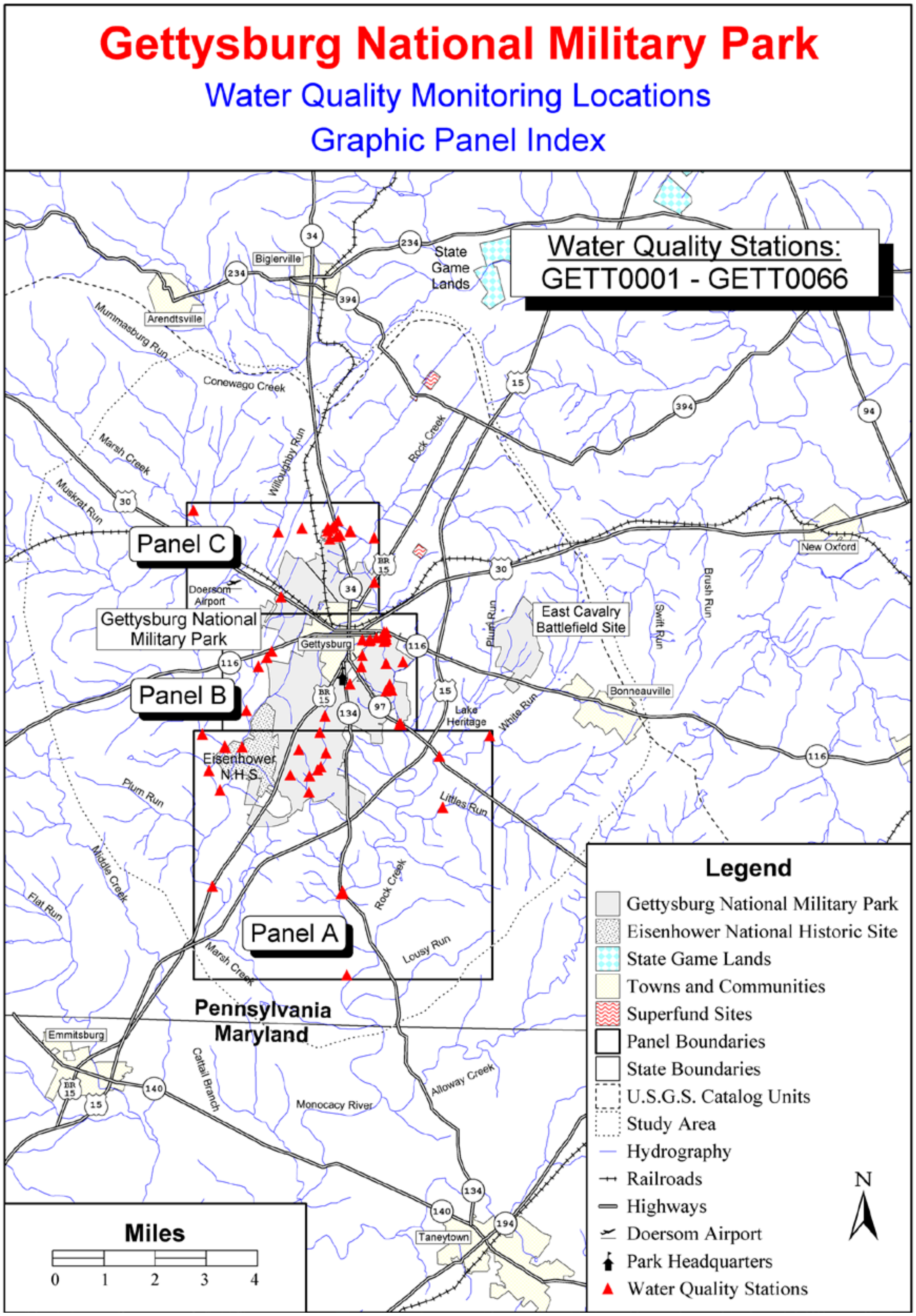


Figure 30. Water quality stations summarized by the NPS baseline water quality survey of 1999. Stations sampled within GETT and EISE boundaries are shown in gray shaded area (map excerpted from NPS 1999b).

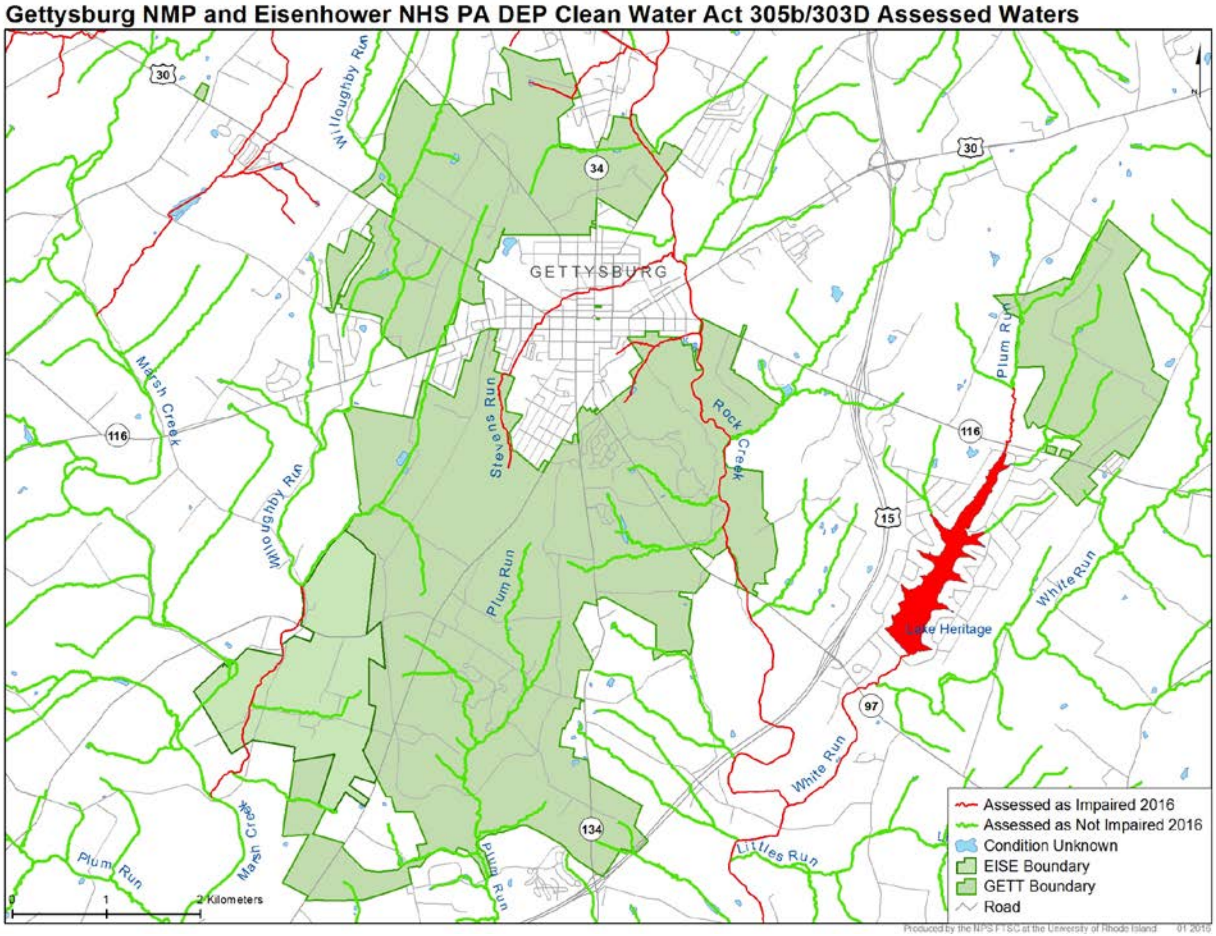


Figure 31. PA DEP assessed waters (PASDA 2016) in vicinity of GETT and EISE.

The park's natural resource staff, supported by the MIDN, samples water quality at monthly intervals (2010 to present) at five stations in GETT (as of this NRCA only discrete water quality data were available for interpretation): Willoughby Run (upstream of EISE_04), Stevens Run (GETT_02), an unnamed tributary of Plum Run in the east Calvary Field unit of GETT (GETT_05), Rock Creek (GETT_06), and at Plum Run (GETT_07) (Figure 29). Continuous water quality monitoring was recently initiated at Plum Run (GETT_07) but these data were not yet available for interpretation. As of 2016, GETT_02 and GETT_05 are no longer sampled for water quality (N. Dammeyer, personal communication, 14 April 2016). Water quality samples are also collected (2010 to present) at two stations within EISE on Marsh Creek (EISE_03) and Willoughby Run (EISE_04) (Figure 29). Water quality parameters that were measured include dissolved oxygen, pH, specific conductance, and water temperature (N. Dammeyer, personal communication, email 3 April 2014; Note: only data through December 2014 were available as of the writing of this NRCA). The MIDN takes monthly grab samples that are analyzed for water chemistry (ANC, DOC, SiO_2, NH_4, NO_3, and PO4) at four stations within the parks (EISE_04, GETT_05, GETT_06, and GETT_07 from April 2010 to December 2011) (N. Dammeyer, personal communication, email 3 April 2014). As of this writing, these data have not yet been analyzed or interpreted).

4.2.1.3 Reference Condition and Status of the Resource (current condition and trends)

Surface water quality standards have been set by the PA DEP (Pennsylvania Code §93.7 2016b) and the US EPA (2016a) which assess surface waters as either attaining or not attaining their designated uses. The MIDN has not yet evaluated the condition of their surface water quality monitoring at GETT and EISE; however, the MIDN data were evaluated based on state water quality standards (Pennsylvania Code §93.7 2016b). It must be noted that this evaluation of the MIDN data provides a general evaluation of the parks' current water quality, as the US EPA and State have not conducted a formal assessment of these streams since 2002. Condition categories were assigned based on best professional judgement using the following criteria:

- Good: MIDN water quality parameter was within acceptable state water quality criteria (Pennsylvania Code §93.7) for >75% of the sampling events.
- Moderate Concern: MIDN water quality parameter was within acceptable state water quality criteria (Pennsylvania Code §93.7) for 25%-75% of the sampling events.
- Significant Concern: MIDN water quality parameter was within acceptable state water quality criteria (Pennsylvania Code §93.7) for <25% of the sampling events.

Threshold ranges for specific conductance were based on those set forth in Yetter et al. (2013) as there are no PA criteria for this parameter. Yetter et al. (2013) based their thresholds on the US EPA definition of a range of 150 – 500 µS/cm as supporting good mixed fisheries. However, since many headwater streams generally have specific conductance between 2 to 100 µS/cm but can have levels as high as 1500 µS/cm, Yetter et al. (2013) used the following criteria to assess specific conductance:

- Good: 2 to 500 µS/cm
- Moderate concern: 500 to 1500 µS/cm
- Significant concern: values above 1500 µS/cm

The evaluation of condition for other water quality parameters (e.g., siltation, toxics) was based on the US EPA 2002 and 2004 assessment (US EPA 2016a).

Gettysburg National Military Park

The PASDA (2016) and US EPA (2016a) classified the water quality of Stevens Run and Rock Creek as impaired based on the latest assessment done in 2002 and 2004. Stevens Run was impaired by nutrients, unknown toxicity, water/flow variability, siltation, and channelization from a variety of sources (Table 20, Figure 31). Rock Creek was impaired by nutrients from agricultural runoff and municipal point sources (Table 20, Figure 31).

Rock Creek and Stevens Run streams were also assessed as needing a TMDL by the US EPA in 2002 (Table 20). Impairments listed as needing a TMDL were siltation and nutrients (excess nitrogen and phosphorus) for Rock Creek; while Stevens Run was listed as needing a TMDL for siltation, nutrients (excess nitrogen and phosphorus), and toxic chemicals (Table 20) (US EPA 2016a). As of 2016, TMDLs had not yet been developed for these two streams. The assessment for siltation, nutrients, and toxic chemicals for these GETT streams was evaluated as moderate concern due to requiring a TMDL, but with low confidence and no trend estimated as the assessment was over ten years old and the MIDN does not sample these parameters (Table 21).

Table 20. Non-attaining streams at GETT and EISE (PASDA 2016, US EPA 2016a).

Stream	Impairments (2002, 2004)	Sources	Comments
Rock Creek (GETT)	Siltation, nutrients (excess N, P)	Agricultural, municipal nonpoint sources	TMDL Needed (siltation & nutrients)
Stevens Run (GETT)	Siltation, nutrients (excess N, P), toxic chemicals	Industrial point source, urban runoff/storm sewers, small residential runoff, channelization	TMDL Needed (siltation, nutrients, & toxic chemicals)
Willoughby Run (EISE)	Organic enrichment/low dissolved oxygen, siltation, other habitat alterations	Agricultural	TMDL Needed (low dissolved oxygen & siltation)

Table 21. Water quality metrics and condition estimates based on recent MIDN water quality monitoring. Refer to Appendix Tables 57 and 58 for water quality criteria thresholds.

Metric and threshold range	GETT Condition[1]	EISE Condition[1]	Description
Dissolved oxygen (>5.0 mg/l)	>5.0 mg/l ~88% of the sampling events. Good	>5.0 mg/l ~98% of the sampling events.. Good	MIDN data indicated that dissolved oxygen was within acceptable thresholds for the majority (>75%) of sampling events.
Nutrients	moderate concern, trend unknown	condition and trend were unknown	Rock Creek and Stevens Run (both in GETT) were listed as impaired and needing a TMDL. Nutrients have not been assessed at EISE.
pH (range 5-9)	pH was within range 98% of the sampling events. Good	pH was within range 93% of the sampling events. Good	pH was within acceptable thresholds for the majority (>75%) of MIDN sampling events.
Siltation	moderate concern, trend unknown	moderate concern, trend unknown	Rock Creek and Stevens Run (both in GETT), and Willoughby Run (EISE) were listed as impaired and as needing a TMDL.
Specific conductance (µS/cm)	Specific conductance was within range 88% of the sampling events. Good (2-500 µS/cm)	Specific conductance was within range 83% of the sampling events. Good (2-500 µS/cm)	Specific conductance was within thresholds for the majority (>75%) of MIDN sampling events.

Table 21 (continued). Water quality metrics and condition estimates based on recent MIDN water quality monitoring. Refer to Appendix Tables 57 and 58 for water quality criteria thresholds.

Metric and threshold range	GETT Condition[1]	EISE Condition[1]	Description
Temperature (°C)	Temperature was within range an average 83% of the sampling events for WWF[2]. Good	Good (Willoughby Run) to Moderate (Marsh Creek) concern	Willoughby Run (EISE) was within WWF[2] range 76% of the time, while Marsh Creek (EISE) was within CWF[2] range only 32% of the sampling events.
Toxic chemicals	moderate concern, trend unknown	condition and trend unknown	Stevens Run (GETT) was listed as impaired and needing a TMDL. Toxic chemicals have not been assessed at EISE.

[1] Condition based on preliminary raw data from MIDN monthly water quality monitoring (2010 to 2014). Condition and trend may be subject to change after further analyses are completed.

[2] CWF: Cold water resident fishes; WWF: Warm water resident fishes.

The threshold for dissolved oxygen concentrations for WWF fishery is <5.0 mg/l (Pennsylvania Code §93.7 2016b, refer to Appendix Table 57). Only Rock Creek (GETT_06) had acceptable DO readings during all MIDN sampling events (Figure 32). A tributary of Plum Run in the east Calvary Field unit of GETT (GETT_05) had acceptable DO levels 73% of the sampling events (low DO values were observed during the summer months, which is common as DO tends to be negatively correlated with water temperature). Stevens Run (GETT_02) and Plum Run in the main unit (GETT_07) had acceptable DO readings >85% of the sampling events, while Willoughby Run (GETT_01) had acceptable values 93% of the sampling events (Figure 32). Taken together, dissolved oxygen levels were above the desired threshold during 88% of the sampling events for GETT streams, and the condition for dissolved oxygen was evaluated as good condition. The MIDN has not yet estimated trends, so the trend was unknown (Table 21). The data suggest that if the park is concerned about maintaining WWF habitat year round, the summer months are the critical season to monitor potential aquatic community stress and if possible take corrective measures.

MIDN pH values were within the acceptable range 94% to 100% of the sampling events at all GETT sampling locations (Pennsylvania Code §93: range 6.0 to 9.0 inclusive, refer to Appendix Table 57). Higher than desired pH levels were only observed on a few occasions at Willoughby Run (GETT_01) and Rock Creek (GETT_06) (Figure 32).

Based on these observations water quality related to pH was evaluated as good condition. The MIDN has not yet estimated trends, so the trend was unknown (Table 21). Additionally, daily precipitation data were downloaded from the NADP (2016) (station PA00, Arendtsville, PA) to evaluate if spikes in pH were related to precipitation events. It did not appear, based on visual examination of these two data sets, that the spikes in pH were related to precipitation (Figure 32).

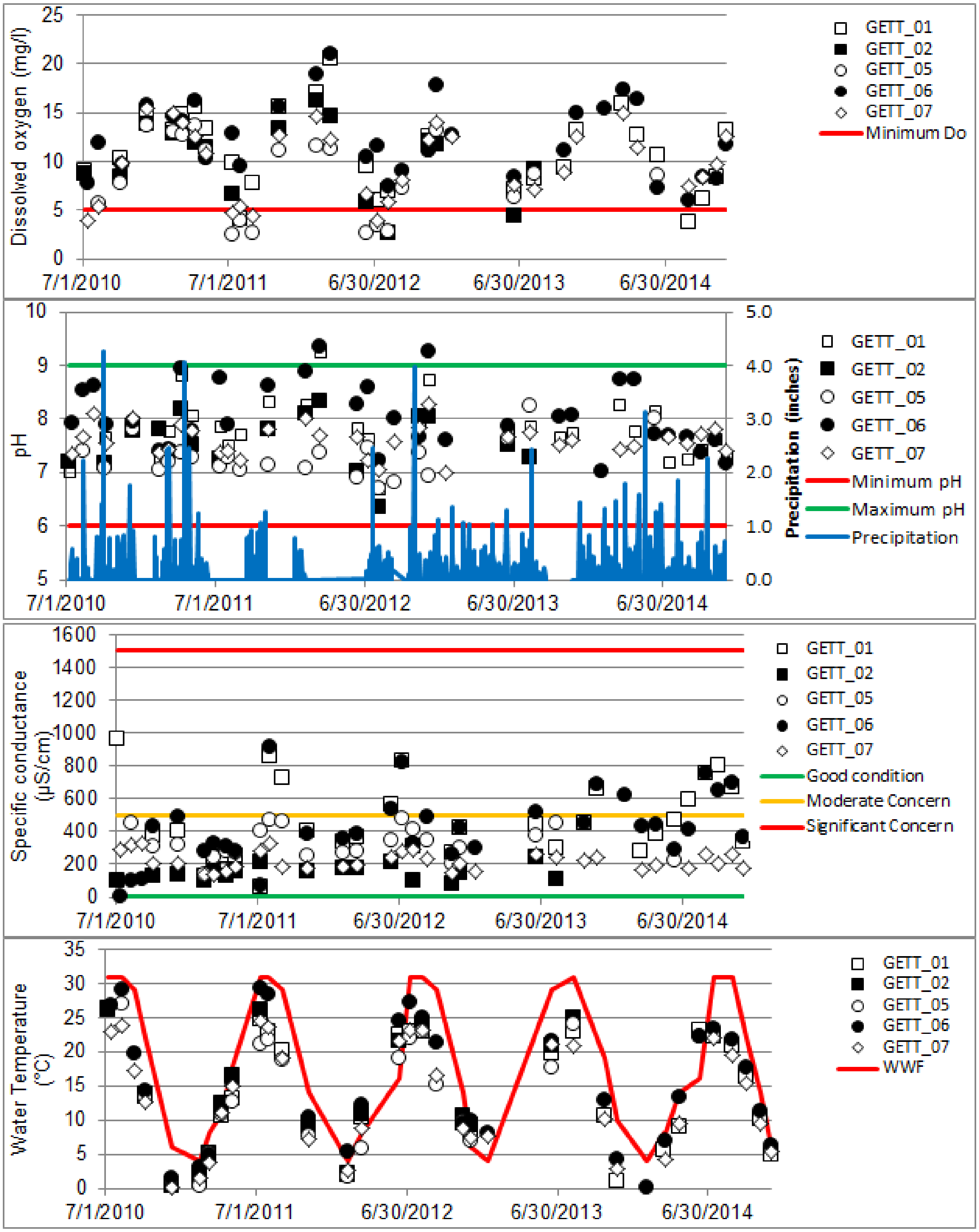


Figure 32. MIDN monthly water quality monitoring at GETT. Top: dissolved oxygen, middle: pH/precipitation and specific conductance; bottom: temperature. Threshold values for are indicated by red and green lines (Pennsylvania Code §93.7, refer to Appendix Table 57, Appendix Table 58). Precipitation data courtesy of NTN 2016.

MIDN specific conductance values were within good condition range for all of the sampling events at Steven's Run (GETT_02), Plum Run East (GETT_05), and Plum Run (GETT_07) (range 2 to 500 µS/cm, refer to Appendix Table 57) (Figure 32). Willoughby Run (GETT_01) and Rock Creek (GETT_06) had values in the moderate concern range 33% and 27% of the sampling events, respectively (range 500-1500 µS/cm). None of the sampling events had values in the significant concern range (>1500 µS/cm). Taken together 88% of the sampling events for specific conductance were within the good range, and the condition was evaluated as good (Figure 32). The MIDN has not yet estimated trends, so the trend was unknown (Table 21).

All GETT streams were designated as WWF (Pennsylvania Code §93.7 2016a). MIDN temperature data indicated that the streams within GETT were within the acceptable temperature ranges for WWF 76% to 88% of the sampling events (Figure 32, refer to Appendix Table 58 for seasonal temperature thresholds). Overall, the streams at GETT fell within the acceptable temperature ranges for WWF ~83% of the sampling events, and therefore water temperature was evaluated as good condition. The MIDN has not yet estimated trends, so the trend was unknown (Table 21).

Eisenhower National Historic Site

Willoughby Run was assessed as impaired and needing a TMDL in 2002 and 2004 for low dissolved oxygen and siltation, as of 2016 a TMDL had not yet been developed for this stream (Table 20). The condition for siltation was moderate concern, but with low confidence and an unknown trend since the assessment data were over ten years old (Table 21).

Nutrients were not listed as impairment for Willoughby Run by the US EPA; however, the last assessment for this parameter was in 2002 and 2004 (US EPA 2016a). The MIDN and park staff do not sample nutrients. Therefore, the condition for nutrients was assessed as unknown (Table 21).

The MIDN had more recent data than the US EPA for dissolved oxygen at Willoughby Run. These data indicated that dissolved oxygen concentrations were within acceptable ranges (Pennsylvania Code §93.7 for WWF and CWF fishery threshold of <5.0 mg/l, refer to Appendix Table 57) at Marsh Creek (EISE_03) and Willoughby Run (EISE_04) 100% and 96% of the sampling events, respectively (Figure 33). Since the MIDN data were more recent then the US EPA assessment, the condition for dissolved oxygen criteria was evaluated as having a good condition for EISE streams. The MIDN has not yet estimated trends, so the trend was unknown (Table 21).

MIDN data for pH was within the acceptable range (Pennsylvania Code §93: range 6.0 to 9.0 inclusive, refer to Appendix Table 57) 100% of the sampling events at Marsh Creek (EISE_03) and 86% of the sampling events at Willoughby Run (EISE_04). Higher than desired pH levels were only observed on a few occasions at Willoughby Run (Figure 33).

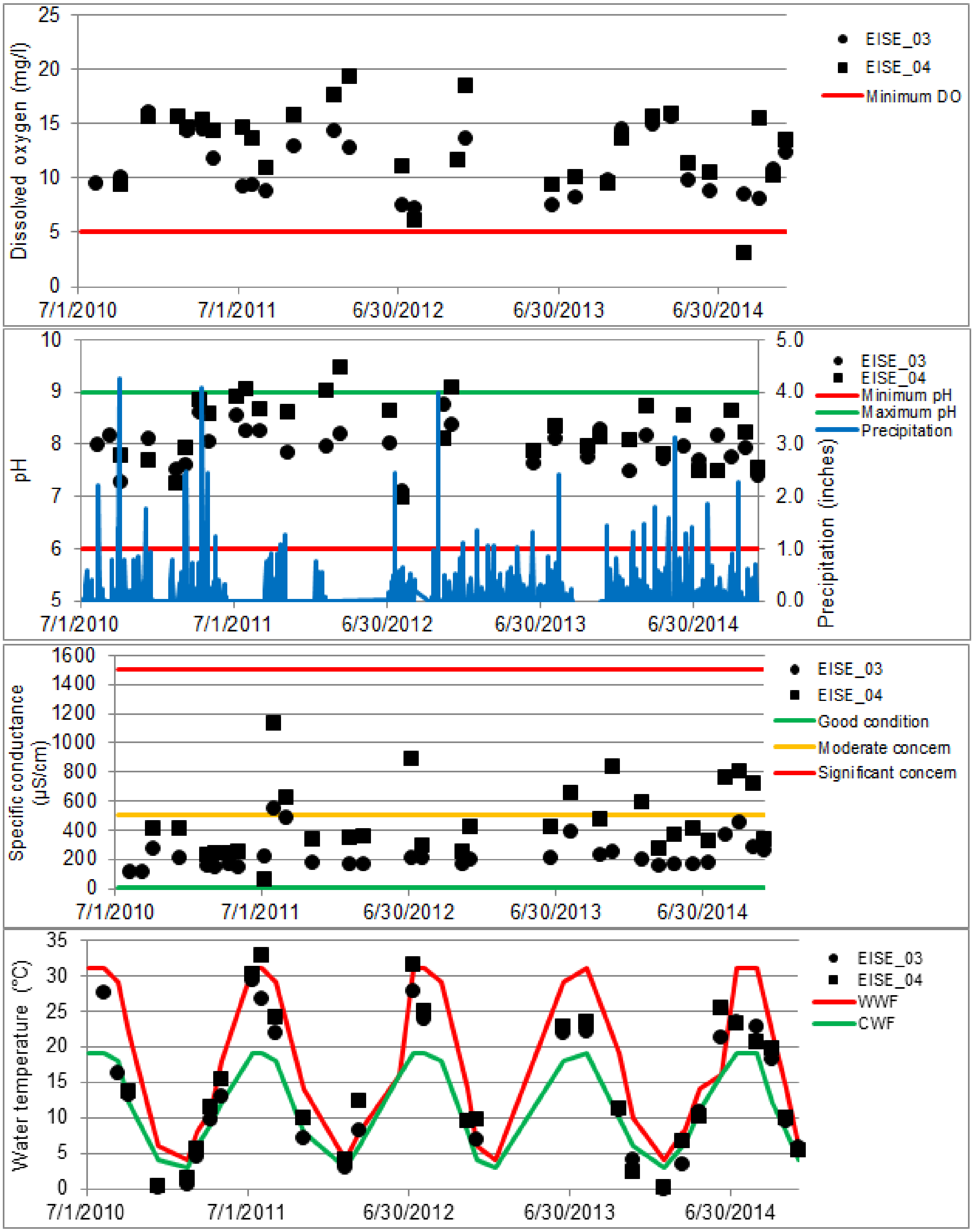


Figure 33. MIDN monthly water quality monitoring at EISE. Top: dissolved oxygen, middle: pH/precipitation and specific conductance; bottom: temperature. Threshold values for are indicated by red and green lines (Pennsylvania Code §93.7, refer to Appendix Table 57, Appendix Table 58). Precipitation data courtesy of NTN 2016.

Based on these observations water quality related to pH was evaluated as good condition. The MIDN has not yet estimated trends, so the trend was unknown (Table 21). Additionally, daily precipitation data were downloaded from the NADP (station PA00, Arendtsville, PA) to evaluate if spikes in pH were related to precipitation events. It did not appear, based on visual examination of these two data sets, that the spikes in pH were related to precipitation (Figure 33).

MIDN data for specific conductance was within the good condition range for 97% of the sampling events at Marsh Creek (EISE_03) (range 2 to 500 µS/cm, refer to Appendix Table 57). At Willoughby Run (EISE_04) specific conductance was in good condition range 69% of the events and was in the moderate concern range (500-1500 µS/cm) 31% of the events (Figure 33). None of the sampling events had values in the significant concern range (>1500 µS/cm). Taken together the streams at EISE were within the good range for specific conductance for 83% of the sampling events and specific conductance was evaluated as good condition. The MIDN has not yet estimated trends, so the trend was unknown (Table 21).

At EISE, Marsh Creek has a designated use for CWF, while Willoughby Run has WWF designation (refer to Appendix Table 58 for seasonal temperature thresholds). Marsh Creek (EISE_03) was within the acceptable temperature CWF ranges for 32% of the sampling events, and thus the condition of this stream was evaluated as moderate concern (Figure 33, Table 21). Temperature at Willoughby Run was within acceptable WWF temperature limits for 76% of the sampling events and was evaluated as in good condition (Figure 33, Table 21). The MIDN has not yet estimated trends, so the trend was unknown (Table 21).

4.2.1.4 Confidence in Assessment

The confidence in the assessment of water quality parameters collected by the MIDN (dissolved oxygen, pH, specific conductance, and temperature) was medium because the water quality data are presently monitored on a regular basis but have not been completely analyzed by the MIDN. Additionally, the MIDN water quality data were a “snapshot in time” and thus detailed inferences using these data should be approached with caution. The confidence in other water quality parameters (nutrients, siltation, and toxics) was low as these are not sampled by the MIDN and the last assessment by the state and/or US EPA was over ten years a

4.2.1.5 Data Gaps

The MIDN has recently initiated continuous water quality monitoring at Plum Run in GETT (GETT_07). The Network currently monitors water temperature, dissolved oxygen, pH, and specific conductance. Continuous water quality monitoring at other locations might be beneficial as water quality parameters (e.g., dissolved oxygen, pH) can fluctuate on various temporal scales and be influenced by external events such as precipitation and flow rates. Flow data are a critical data gap as it can be correlated with water quality and water quantity within the watershed, and thus may influence stream water quality parameters. TMDLs need to be developed for Rock Creek (GETT), Stevens Run (GETT) and Willoughby Run (EISE) (US EPA 2016a), however, as of 2016 these TMDLs were not in place and assessment of possible impairments by the state and/or US EPA appears to have been discontinued for these streams. The park could expand their monitoring to include these parameters or urge the state to include streams within the parks in future state water quality assessment programs.

4.2.1.6 Threats

The Adams County Stormwater Management Plan (ACCD 2011) listed several factors that were causes of impairment to the streams within Adams County. Although their assessment was based on the 2004 impaired waters assessment, these factors may still be causing impairments to water quality in GETT and EISE. For example, agricultural activities such as grazing and farming, and urban runoff could contribute to siltation and low dissolved oxygen. Urban runoff from storm sewers and residential runoff could contribute to elevated nutrient levels. Variability in water flow could be caused by urban runoff/storm sewers, small residential runoff, and upstream impoundments (as in the case of Marsh Creek). Industrial point sources could contribute to toxic chemicals in waterbodies (ACCD 2011). Suggestions for improving stream water quality could include the installation of riparian forest buffers. Riparian forest buffers filter and trap excess nutrients, sediment, and pollution (ACCD 2011).

The major water supplier in the Gettysburg area, Gettysburg Municipal Authority, has groundwater withdrawal wells in both Marsh and Rock Creek watersheds and a surface water withdrawal on Marsh Creek. Wastewater from the public supply service area is routed to treatment plants which discharge into both creeks and likely impacts water quality in these streams. Additionally, water withdrawals can exceed low-flow conditions on occasion, and the quantified water deficits represented a potential shortfall of water under stressed conditions, which would be exacerbated by future population growth (Moltz and Palmer 2012).

Other potential threats to water quality include impacts from past industrial sites such as the Westinghouse Elevator Plant (constructed in 1968). This plant was located adjacent to the northern boundary of GETT and is a Superfund site. The Westinghouse Plant was a manufacturer of elevator and escalator components and the plant utilized solvents such as trichloroethene and 1,1,1-trichloroethane, in addition to lubricating oils, paints, and insulation board. Water and soil samples collected in 1983–1984 confirmed the presence of volatile organic compounds in on-plant and off-plant groundwater and soils (Thornberry-Ehrlich 2009, US EPA 2016b). In 1992, the US EPA record of decision selected extraction and treatment of groundwater, air stripping of contaminants from ground water, and carbon adsorption of contaminants as possible measures for remediation. In 1995, the US EPA's selected remedy for the soils at the Westinghouse Elevator Plant was "No Additional Action" as other considered alternatives would produce little or no environmental benefit at substantial cost (US EPA 2016b).

4.2.2 Wetlands, Vernal Pools, and Ponds

4.2.2.1 Relevance and Context

Wetlands within GETT and EISE are associated with streams and include floodplain forests, forested swamps, shrub swamps, and graminoid marshes. Many of the wetlands are seepage swamps, which are relatively small forested or shrub-dominated wetlands found on lower slopes where water emerges at the surface in a diffuse flow. Wetlands types that are present in the parks are palustrine emergent freshwaters, forests/shrub freshwater wetlands and ponds (Table 22). The wetlands at GETT and EISE have been altered by subsequent generations of landowners and farmers that drained historic wetlands and wet areas with field drains, or tiles (NPS 1999a). Wetlands are important refugia for plants as well as habitat for nesting and migrating birds. Many other animals such as amphibians, turtles, dragonflies, and damselflies also depend on specific wetland habitats for all or a portion of their life cycles (NPS 2014). Two obligate vernal pool amphibians, the wood frog (*Lithobates sylvaticus*) and spotted salamander (*Ambystoma maculatum*) have been documented at GETT. Additionally, there were several plants that are found in association with vernal pool habitat that have also been recorded in both parks; however, the presence of vernal pools within the parks has not been verified. (Pennsylvania Natural Heritage Program [PNHP] 2015a) (Table 23).

Table 22. Areal extent of wetlands at GETT and EISE (classification follows National Wetland Inventory data from 2016). Areal extent is based on park updated wetland areas (GIS data file "wetgnmp" courtesy of C. Musselman).

Wetland Classification	GETT (ha)	EISE (ha)
Freshwater Emergent Wetland	16.5	0.7
Freshwater Forested/Shrub Wetland	36.6	6.8
Pond	7.6	-
Unknown1	5.0	-

[1] In-house draft GIS data layer did not indicate wetlands type and data layer did not overlap with NWI data, so wetland classification was unknown.

Table 23. Obligate vernal pool animals and common wetland plants found in association with vernal pool habitat (PNHP 2015a).

Scientific Name	Common Name	Recorded in Park(s)
Animals		
Ambystoma maculatum	Spotted salamander	GETT
Ambystoma opacum	Marbled salamander	No
Ambystoma jeffersonianum	Jefferson salamander	No
Eubranchipus vernalis	Springtime fairy shrimp	No
Lithobates sylvaticus	Wood frog	GETT
Scaphiopus holbrookii	Eastern spadefoot	No
Plants		
Acer rubrum	Red maple	EISE, GETT
Carex canescens	Silvery sedge	No
Carex crinita	Fringed sedge	GETT

Table 23 (continued). Obligate vernal pool animals and common wetland plants found in association with vernal pool habitat (PNHP 2015a).

Scientific Name	Common Name	Recorded in Park(s)
Plants (continued)		
Carex gynandra	Nodding sedge	GETT
Carex lupulina	Hop sedge	GETT
Carex vesicaria	Blister sedge	No
Cephalanthus occidentalis	Buttonbush	GETT
Dulichium arundinaceum	Three-way sedge	No
Glyceria acutiflora,	Creeping mannagrass	No
Glyceria canadensis	Rattlesnake mannagrass	No
Glyceria melicaria	Melic mannagrass	No
Glyceria septentrionalis	Floating mannagrass	GETT
Ilex verticillata	Winterberry	GETT
Leersia oryzoides	Rice cut-grass	EISE, GETT
Nyssa sylvatica	Black gum	GETT
Osmunda regalis	Royal fern	No
Osmunda cinnamomea	Cinnamon fern	No
Quercus bicolor	Swamp white oak	EISE, GETT
Quercus palustris	Pin oak	EISE, GETT
Scirpus ancistrochaetus	Northeastern bulrush	No
Scirpus cyperinus	Wool-grass	EISE, GETT
Thelypteris palustris	Marsh fern	GETT
Torreyochloa pallida	Pale false mannagrass	No
Vaccinium corymbosum	Highbush blueberry	GETT

4.2.2.2 Data and Methods

The U.S. Fish and Wildlife Service identified and mapped wetlands in GETT in 1989 and incorporated them into the National Wetlands Inventory (NWI) database. The U.S. Natural Resources Conservation Service (formerly the U.S. Soil Conservation Service) has identified hydric soils in the park. Pennsylvania State University researchers identified three additional wetland areas as part of a larger study of floral communities in 1986-1987 (Yahner et al. 1992). Most of the approximately 50 wetlands identified in the park were in the palustrine system, with classes of freshwater emergent, forest/shrub wetlands, and open water (Table 22, Figure 34). Wetlands in the park were small (generally less than 2 ha in size) (NPS 1999a). Though relatively coarse in terms of identifying smaller (< 0.5 ha) wetlands and accurately delineating their boundaries, the NWI mapping at the 1:40,000 scale can be relatively robust compared with other publically available sources of wetland spatial data (e.g. VegMap) (refer to Sharpe et al. 2016). In 1997, park staff began updating the 1989 NWI wetland areas for GETT and EISE by in-the-field delineation by trained wetland scientists (C. Musselman, personal communication, 31 May 2016). The GETT-EISE wetland map is continuously updated and is an internal NPS, draft map, and as such metadata has not yet been developed and wetland types were not included in the data layer (in-house GIS data "wetgnmp"). To determine the type of wetlands within the parks the in-house draft wetlands data layer was overlapped with the most recent NWI data layer (2016) to determine wetland classification (Table 22).

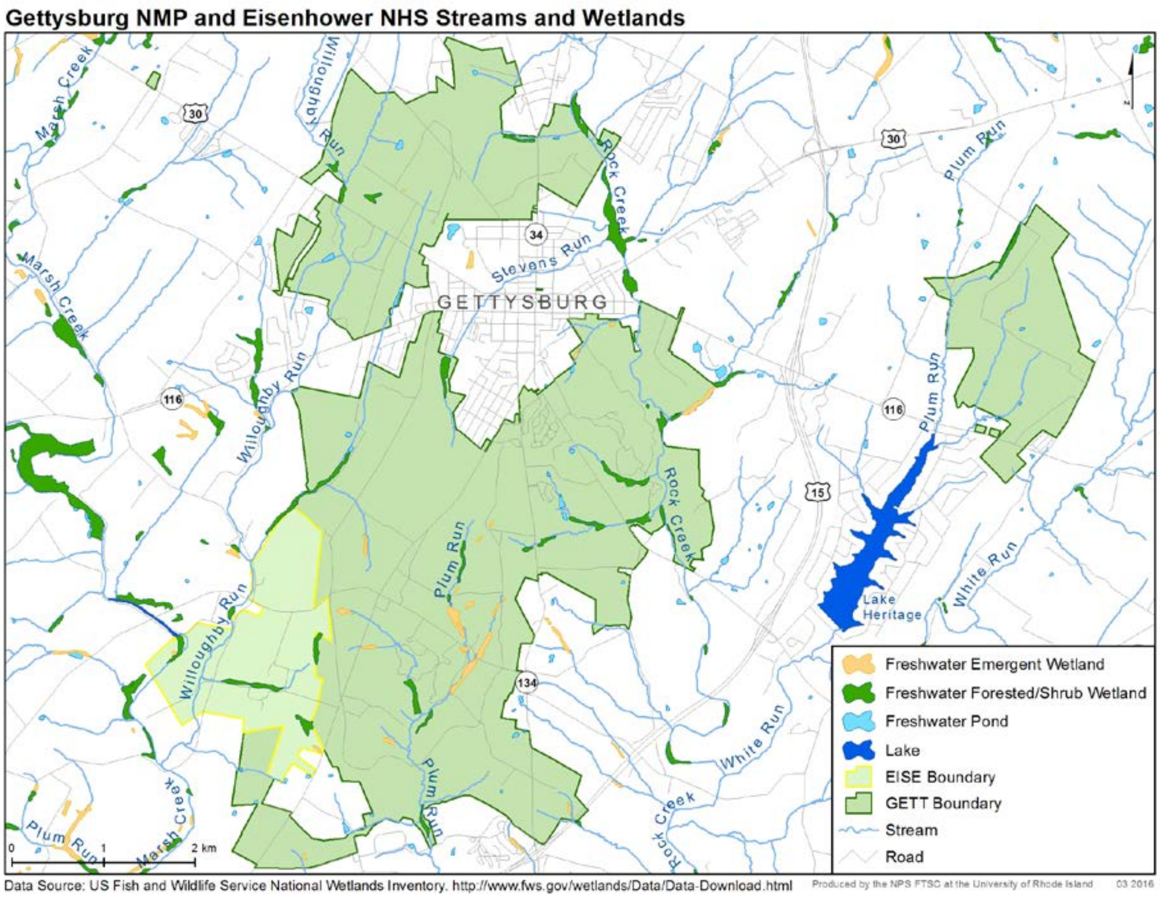


Figure 34. Wetlands at GETT and EISE. Data source NWI (1:40,000 scale) and in-house GIS data layer "wetgnmp" courtesy of C. Musselman.

To determine the condition of the wetlands at GETT and EISE, this NRCA followed the methods presented by Faber-Langendoen et al. (2012) in their multi-metric approach to assess wetland systems. These authors suggested a three tier approach to assess wetlands condition: Level 1: remote assessment based on landscape scale metrics (GIS based), Level 2: rapid assessment metrics using simple field assessments, and Level 3: intensive assessments that would require rigorous, field based methods that provide higher resolution information on the wetland. The only data that were available to assess the wetlands at GETT and EISE were Level 1: GIS based assessment using the in-house wetland draft GIS data and the National Land Cover Database (NLCD) from 2011 (Homer et al. 2015). The metrics used to assess the condition of the wetlands were: wetland patch size with condition based on small patches (<5 ha) after Faber-Langendoen et al. (2012) (Figure 35), land use within 100m buffer around the wetlands, the core landscape (the land use in the 100m to 250m buffer width from the wetland), and supporting landscape (the land use within a 250m to 500m buffer from the wetland). Estimates of land use in each zone were calculated based on the amount of natural lands and anthropogenic lands in each buffer (Table 24, Figure 36). Thresholds for condition followed those presented by Faber-Langendoen et al. (2012) (Table 25).

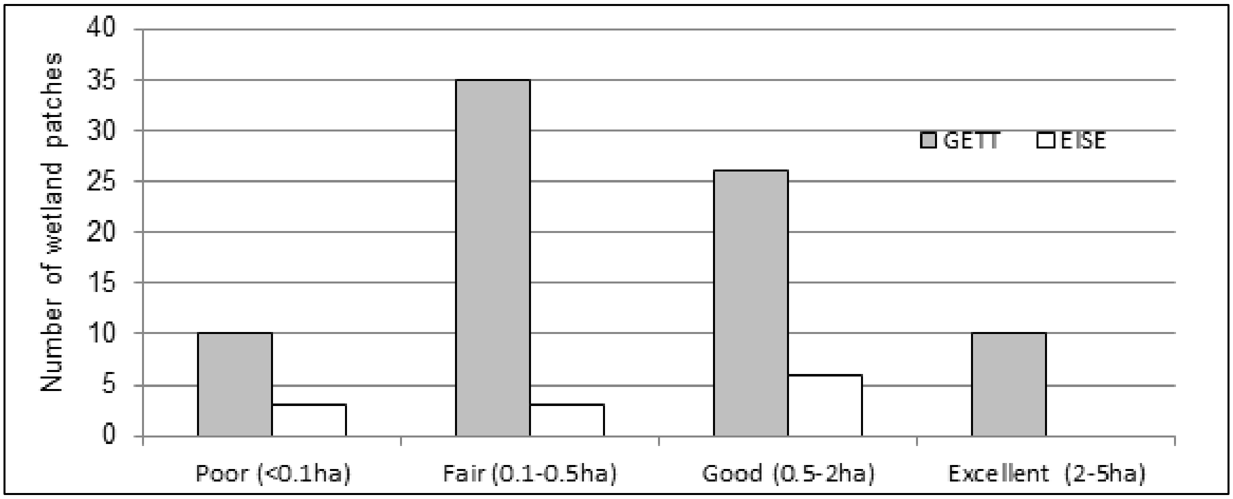


Figure 35. Size distribution of wetland patches at GETT and EISE. Condition categories after Faber-Langendoen et al. (2012) for small wetland patches. Data source NWI (1:40,000 scale) and in-house GIS data layer “wetgnmp” courtesy of C. Musselman.

Table 24. NLCD 2011 (Homer et al. 2015) grid code, land use description, and classification used to estimate the land use condition around wetlands.

NLCD Grid Code	NLCD Land Use description	Classification
11	Open Water	natural
21	Developed, Open Space	anthropogenic
22	Developed, Low Intensity	anthropogenic
23	Developed, Medium Intensity	anthropogenic
24	Developed, High Intensity	anthropogenic
31	Barren Land	anthropogenic
41	Deciduous Forest	natural
42	Evergreen Forest	natural
43	Mixed Forest	natural

Table24 (continued). NLCD 2011 (Homer et al. 2015) grid code, land use description, and classification used to estimate the land use condition around wetlands.

NLCD Grid Code	NLCD Land Use description	Classification
52	Shrub/Scrub	natural
71	Herbaceous	natural
81	Hay/Pasture	anthropogenic
82	Cultivated Crops	anthropogenic
90	Woody Wetlands	natural
95	Emergent Herbaceous Wetlands	natural

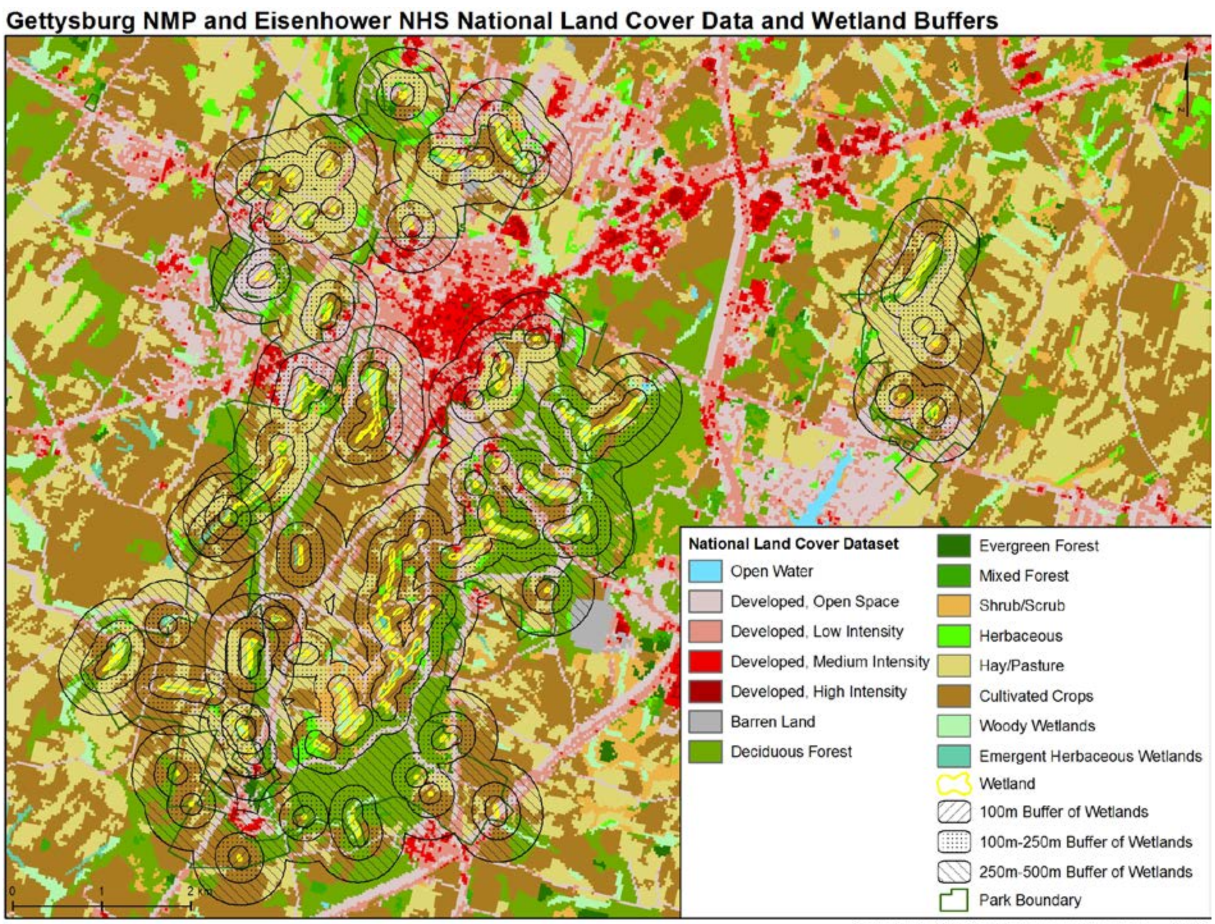


Figure 36. Land use within the immediate 100m buffer around wetlands, the 100-250m core landscape, and 250-500m supporting landscape buffer areas around wetlands at GETT and EISE. Land use data were from 2011 National Land Cover Data.

Table 25. Metrics used to assess condition of wetlands at GETT (G) and EISE (E). Condition was assessed based on surrounding land use (NLCD 2011 data) as site specific information was not available.

Metric	Good Condition	Moderate Concern	Significant Concern	GETT Condition	EISE Condition
Wetland Patch Size for very small wetlands (>5ha) Percent of wetlands in each size category is given in parentheses.	0.5 - 5ha (G = 44%) (E = 50%)	0.1 – 0.5ha (G = 43%) (E = 25%)	< 0.1ha (G = 12%) (E = 25%)	Average score: 25.3	Average score: 20.8
Wetland buffer index (0-100m buffer around wetlands)	60% - 100% embedded in natural habitat	20% - 60% embedded in natural habitat	< 20% embedded in natural habitat	37% natural lands (217ha)	30% natural lands (22ha)
Core landscape (100m -250m) zone from wetlands				26% natural lands (290ha)	13% natural lands (21ha)
Supporting Landscape (250m-500m) zone from wetlands				26% natural lands (474ha)	16% natural lands (49ha)

The integrity of the wetland patch can be assessed, to a degree, by its size, as diversity of plants and animals may be higher in occurrence in larger wetlands patches and larger patches may be more resistant to stressors (Faber-Langendoen et al. 2012). The core landscape evaluates landscape connectivity and addresses the ecological dynamics surrounding wetlands. The percent of natural landscape versus anthropogenic landscape use (e.g., agricultural land, developed land) provides an estimate of connectivity among wetlands. Landscapes with more connectivity (e.g., natural lands) may be more likely to maintain populations of various species that inhabit wetlands (Faber-Langendoen et al. 2012). For example, amphibians and reptiles are especially sensitive to the habitats surrounding a wetland because they spend the majority of their lives foraging, resting, hibernating in the adjacent terrestrial habitat, and dispersal corridors (Semlitsch 1998). The supporting landscape metric uses landuse as an index to measure the intensity of development in the vicinity of the wetland. The intensity of human activity in the landscape has a proportionate impact on the ecological processes of natural ecosystems as human land uses often directly or indirectly alters many natural ecological processes (Faber-Langendoen et al. 2012).

4.2.2.3 Reference Condition and Status of the Resource (current condition and trends)

At GETT, the condition of the wetlands, based on the percent of patches in each condition category was assessed as significant concern. All three land use metrics scored in the moderate concern range (Table 24). Similarly at EISE, wetland patch size scored as significant concern. The wetland buffer index at EISE scored in the moderate concern range, but both the core landscape and supporting landscape scored in the significant concern range (Table 24). Trends were not assessed as this was in initial attempt to estimate the condition of the wetlands based on remote sensing (GIS data) and based on best professional judgement. High resolution field data should be collected in order to fully assess the wetlands at the GETT and EISE.

4.2.2.4 Confidence in Assessment

The confidence in the assessment was moderate. The 2011 NLCD data provide a general description of the condition based on surrounding landuse; however, finer scale, site specific data for wetland areas within the parks were lacking. Additionally, the battlefield rehabilitation maintenance (e.g., thinning of thickets, mowing, and prescribed burns) may have altered some of the land use surrounding the wetlands.

4.2.2.5 Data Gaps

This NRCA is a first attempt to assess wetland condition. This assessment of wetland condition is somewhat coarse in that it relies heavily on NLCD landscape data from 2011, and a combination of remotely sensed (NWI - 40,000 scale) and non-verified wetland spatial data from the parks. These are important caveats to keep in mind, but they should not detract from the fact that this assessment and the data herein provide sound planning level information at the landscape level for park management. Faber-Langendoen et al. (2012) detail finer scale metrics for the assessment of wetlands, such as wetland patch size, vegetation cover (invasive and native plants), hydrology (e.g., pH, specific conductance, nutrient concentration, hydroperiod), and presence of amphibians. The wetlands at GETT and EISE were surveyed over 20 years ago. A focal survey of wetland types, condition, and species composition would be beneficial, especially if the guidelines set forth by

Faber-Langendoen et al. (2012) were used. Federal Geographic Data Committee (FGDC) compliant metadata associated with the in-house draft GIS wetland data should be developed.

4.2.2.6 Threats

Wetlands can be threatened by a variety of anthropogenic and natural threats. Cattle grazing in wetland pastures can negatively impact water quality, and cause soil compaction and erosion (NPS 1999a). Road runoff (e.g., salt) can negatively impact water quality. Groundwater withdrawals can impact wetland hydroperiods and may negatively impact wetland flora and fauna. Invasive and exotic plants and animals also can threaten wetlands by crowding out native species. Unfortunately, there were no fine scale data (e.g., presence/percent cover of invasive plants or native plants, water quality, hydroperiod) available to directly assess specific threats to wetlands at GETT and EISE.

4.2.3 Aquatic Macroinvertebrates

4.2.3.1 Relevance and Context

The MIDN vital signs program recognized aquatic macroinvertebrates as among the most important components of the MIDN Inventory and Monitoring program (MIDN 2011, Comiskey and Callahan 2008). Aquatic macroinvertebrates perform essential roles in stream ecosystem function and are often used by regulatory agencies to document stream condition under the Clean Water Act (Barbour et al. 1999, MIDN 2011, PA DEP 2013). They are useful for stream monitoring because they are easy to sample and identify, common in most freshwater habitats, represented by many taxa with varying degrees of sensitivity to their environment, are mostly sedentary and cannot readily escape pollution or environmental stress, and are sufficiently long lived enough that they will respond to stress (Barbour et al. 1999). Additionally, monitoring aquatic macroinvertebrates can identify the presence of invasive species (e.g., invasive crayfish) that may threaten the native macroinvertebrate community (Lieb et al. 2007).

4.2.3.2 Data and Methods

Crayfish were inventoried at ten Pennsylvania National Parks, including GETT and EISE, by Lieb et al. (2007) in 2005, when nine sites at GETT and two sites at EISE were sampled (Figure 37).

Aquatic macroinvertebrate sampling was initiated by the MIDN at GETT and EISE in 2009 and continues to the present (a 5-year report is in preparation and was not available and only data to 2013 were available as of the writing of this NRCA, N. Dammeyer, personal communication, 1 September 2015). Five sites were sampled in April of each year: four locations at GETT: upper Willoughby Run, Rock Creek, Plum Run, and Stevens Run (Stevens Run, GETT_02, was only sampled in 2009 and 2010) one at EISE (on lower Willoughby Run) (Figure 37). The MIDN along with park staff sampled macroinvertebrates in 100-m stream lengths using a 500-micron, D-frame net. The MIDN calculated various metrics that were based on the PA Riffle-Run Index of Biotic Integrity (PA-RRIBI) and the PA Multihabitat Index of Biotic Integrity for low gradient Streams (PA-HIBI) (PA DEP 2013, N. Dammeyer, personal communication, 1 September 2015) (Figure 38). The MIDN calculated metrics were:

- family richness, genus richness,
- total taxa richness,

- total number of individuals in sample, percent of Ephemeroptera,
- percent of sample of Plecoptera and Trichoptera excluding caddisflies in the family Hydropsychidae,
- Hilsenhoff Biotic Index at the Genus and Family level,
- rarefied (estimated) number of families and genera,
- percent of clingers (excluding Simuliidae and Hydropsychidae)
- percent of the two most abundant taxa,
- percent of scrapers,
- modified Beck's index,
- Shannon diversity index, and
- percent abundance of intolerant taxa.

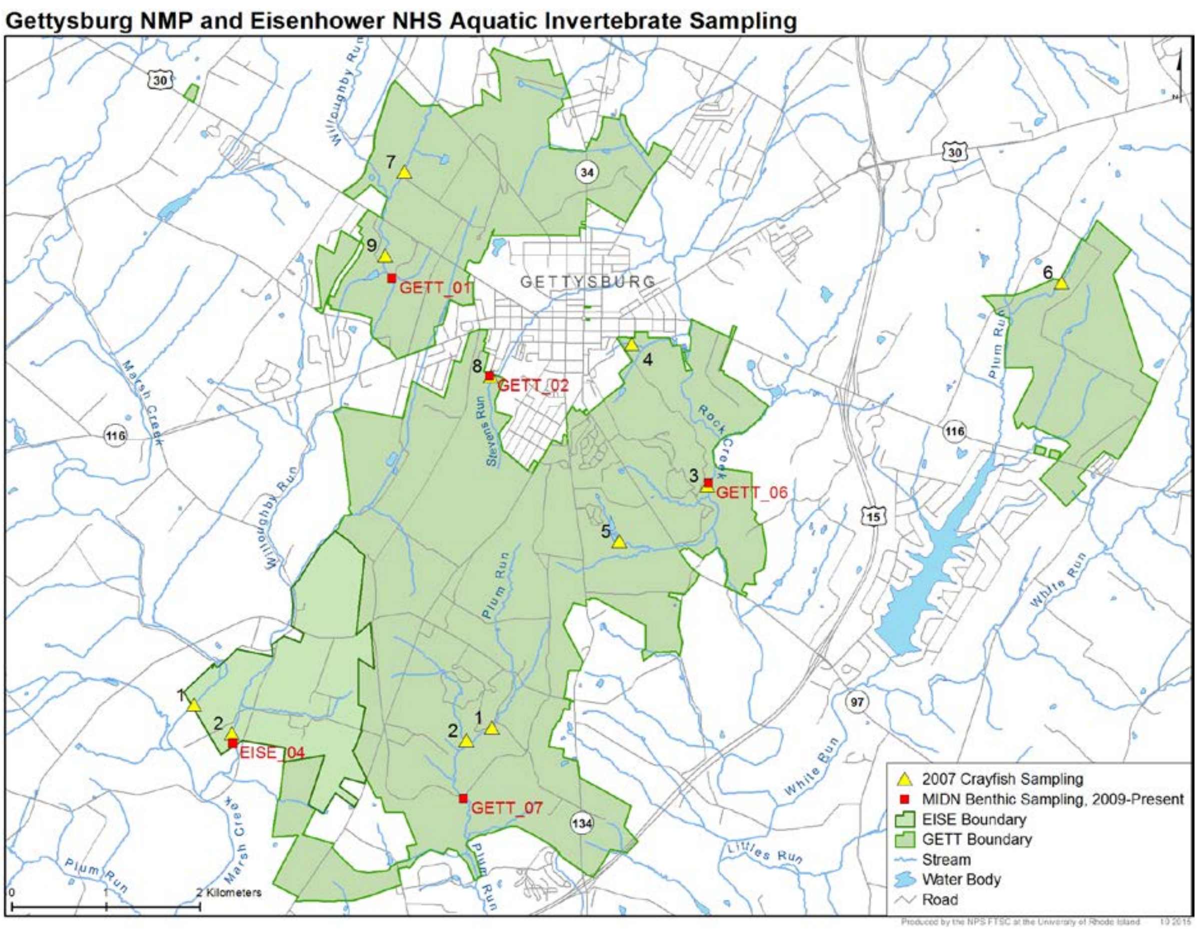


Figure 37. Crayfish and MIDN aquatic macroinvertebrate sampling sites at GETT and EISE. Note: GETT_02 was only sampled in 2009 and 2010, and is no longer sampled.

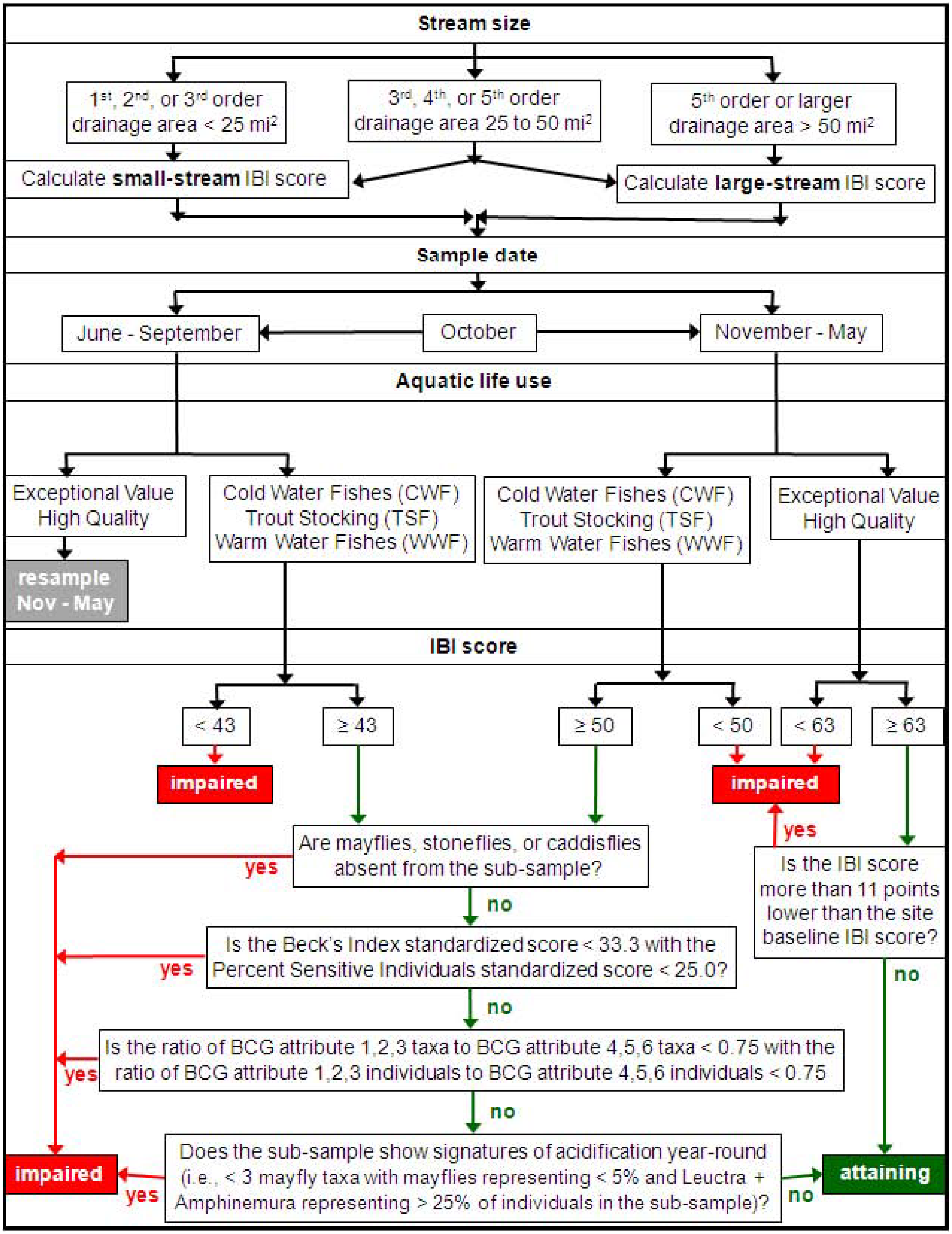


Figure 38. PA DEP (2013) IBI schematic diagram and IBI scores used to estimate aquatic macroinvertebrate community condition (diagram excerpted from PA DEP 2013).

4.2.3.3 Reference Condition and Status of the Resource (current condition and trends)

The status of the crayfish community was based on the presence of invasive crayfish and best professional judgement was used to assess the condition. The threshold value to assess the condition for the aquatic macroinvertebrate community using the MIDN sampling data was based on the PA index of biotic integrity for wadeable freestone riffle-run streams (PA DEP 2013). The threshold IBI score for GETT streams (WWF, sampled in April) for impaired aquatic macroinvertebrate communities was a score of <50 (refer to Figure 38, PA DEP 2013). Lower Willoughby Run (EISE_04) at EISE is considered a low-gradient stream and the threshold value for impaired communities was 55 based on the Multihabitat Aquatic Life Use Benchmark set forth by the PA DEP (2007). However, since the MIDN sampling methods were slightly different from the PA methods the MIDN values should be interpreted with caution (N. Dammeyer, personal communication, 23 March 2016).

Gettysburg National Military Park

At GETT, four crayfish species were observed by Lieb (2007): *Cambarus bartonii*, *Cambarus* sp., *Orconectes virilis*, and *Orconectes* sp. The invasive virile crayfish (*O. virilis*) comprised 72% of the relative abundance (127 of 177 total individuals collected) at GETT and dominated collections (>75% of the individuals found) at five of the nine GETT sites. Lieb et al. (2007) hypothesized that this invasive crayfish may have completely eliminated native crayfish from sections of three streams within the park (an unnamed tributary to Willoughby Run, Rock Creek, and Stevens Run). The crayfish community was evaluated as significant concern based on best professional judgement. Since there was only one crayfish survey, the trend in the crayfish community was unknown.

The multi-metric IBI calculated based on MIDN aquatic macroinvertebrate sampling for the three GETT locations (Upper Willoughby Run [GETT_01], Rock Creek [GETT_06], and Plum Run [GETT_07]) was below the threshold value of 50 in all sampling years (Figure 39). Since the community has been impaired for the five years of available data the condition of the aquatic invertebrate community was assessed as significant concern with an unchanging trend (Table 26).

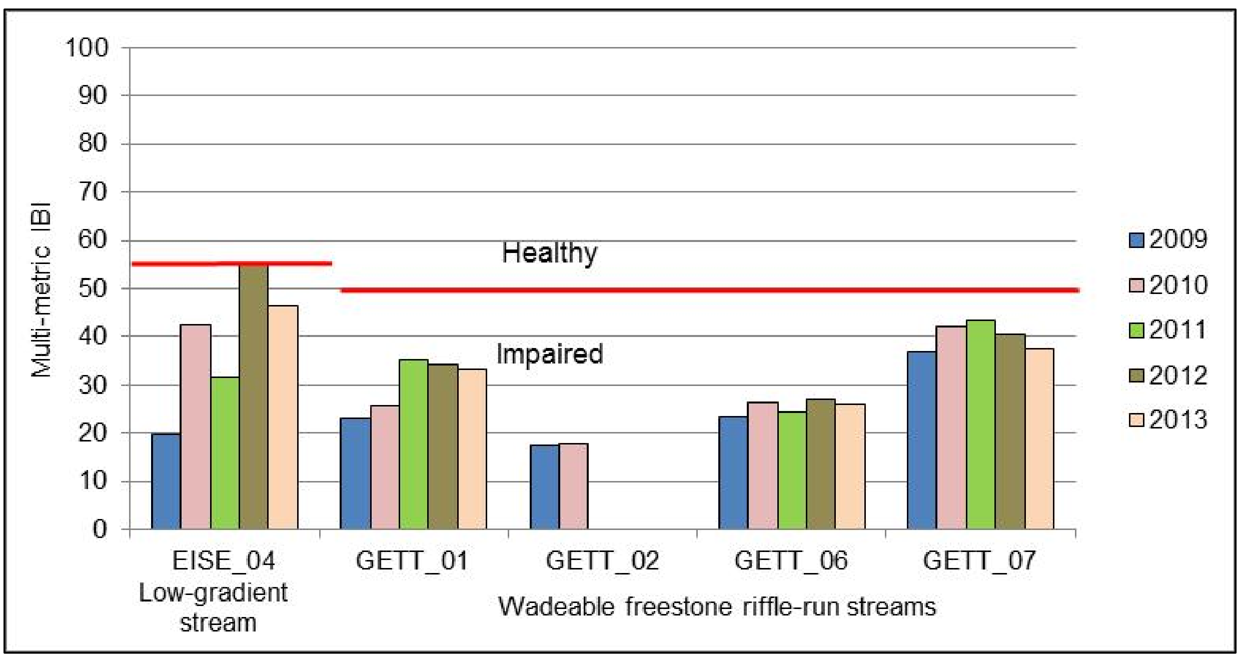


Figure 39. MIDN calculated multi-metric IBI for aquatic macroinvertebrate monitoring sites in GETT and EISE (data courtesy of MIDN). Red line indicates threshold for healthy communities in low-gradient

stream (EISE_04, after PA DEP 2007) and wadeable freestone riffle-run streams (GETT stations, after PA DEP 2013).

Table 26. Assessment of condition for aquatic macroinvertebrate communities at GETT and EISE.

Metric	GETT Condition	EISE Condition	Description
Crayfish community	Significant concern (trend unknown)	Significant concern (trend unknown)	Invasive crayfish dominate most areas in both parks and may have extirpated native crayfish species.
Aquatic Invertebrate Community	Significant concern, unchanging trend	Significant concern, unchanging trend	The community at both parks was evaluated as impaired in the 5 sampling years (2009-2013).

Eisenhower National Historic Site

During the crayfish inventory at Marsh Creek and Willoughby Run, four species were observed: *Orconectes rusticus, Orconectes virilis, Orconectes* sp., and *Procambarus* sp. (Lieb 2007). Both *O. rusticus* (rusty crayfish) and *O. virilis* are considered invasive in PA (USGS NAS 2015). The rusty crayfish comprised 95% of the relative abundance (349 of 367 total individuals collected) at EISE. These two invasive species were prevalent at both stream sites sampled, together comprised 98% of the relative abundance of all crayfish collected, and may have extirpated native crayfish from the section of Marsh Creek that flows through EISE (Lieb et al. 2007). Therefore, the crayfish community was assessed as significant concern. Since there was only one crayfish survey, the trend in the cray fish community was unknown.

The multi-metric IBI calculated based on MIDN aquatic macroinvertebrate for lower Willoughby Run (EISE_04) was below the threshold value of 55 in all of the sampling years (Figure 39). Since the community has been impaired for the five years of available data the condition of the aquatic invertebrate community was assessed as significant concern with an unchanging trend (Table 26).

4.2.3.4 Confidence in Assessment

The confident in the assessment of the crayfish community was medium as there has only been one study that was conducted 10 years ago. The confidence in the assessment for aquatic invertebrate community was high since there were five years of recent data (2009-2013).

4.2.3.5 Data Gaps

The crayfish community could be sampled again to determine the abundance of invasive species and if native species have been extirpated. The MIDN samples aquatic invertebrates on a regular basis and plans to continue to survey these communities. One possible augmentation to the MIDN sampling could be to incorporate the facets from the Piedmont Region Maryland Biological Stream Survey (MBSS) (Southerland et al. 2005). The MBSS not only samples aquatic macroinvertebrates but also incorporates fish community condition, water chemistry, physical habitat description, and land use information to assess the quality of streams.

4.2.3.6 Threats

Exotic crayfish appear to be problematic at GETT and EISE (based on the 2005 sampling). Each park had streams that supported high densities of invasive crayfish and were completely devoid of native crayfish species (Lieb et al. 2007). Water and habitat quality can influence benthic macroinvertebrate community structure. Some of the streams in both parks (GETT: Rock Creek and Stevens Run, EISE: Willoughby Run) were assessed as impaired and as needing TMDLs by the state (refer to Stream Water Quality section). Recent MIDN water quality sampling for some parameters (dissolved oxygen, pH, specific conductance, and temperature) were generally within acceptable limits; however, other parameters such as nutrients, siltation, and toxics have not been sampled by the MIDN and have been assessed as causing impairments to some streams which may in turn negatively impact the aquatic macroinvertebrate communities at GETT and EISE.

4.2.4 Fish Community

4.2.4.1 Relevance and Context

Freshwater fish communities are useful indicators of environmental condition, and fish community structure is often used as an index of condition (e.g., Karr 1986, Barbour et al. 1999, Vile 2008). Fish assemblages generally include a range of species that represent a variety of trophic levels (e.g., insectivore, generalists, piscivores, herbivores, planktivores). For example, the structure of fish assemblages tends to be reflective of environmental health. The environmental requirements, life history, and distributions for fish are comparatively well known. Fish are relatively easy to collect and identify, and can be sampled and released back into the environment unharmed. Aquatic life uses for water quality are typically characterized in terms of fisheries assemblages and the ability of water quality (e.g., temperature, alkalinity, bacteria concentrations, and water chemistry) to support viable communities (Vile 2008, Pennsylvania Code §93.7 2016a, 2016b). Streams and runs within GETT and EISE are primarily classified for warm water resident fishes and migratory fishes, although Marsh Creek (EISE) is designated for cold water resident fishes and migratory fishes.

4.2.4.2 Data and Methods

Fish were surveyed at both GETT and EISE in 2004 during the MIDN fish inventory using either towed electrofishing gear or backpack electrofishing gear. At both parks, sections of streams selected for surveys included representative or typical habitat and any unique habitats encountered (Atkinson 2008). The 2004 survey was the only time fish have been sampled at these parks.

The New Jersey Department of Environmental Protection IBI (NJ DEP, Vile 2008) was applied to the fish survey data as a general indication of the condition of the GETT and EISE fish community. This IBI is consistent with theoretical framework designed by Karr et al. (1986) for analyzing fish assemblage data in its use of several biological metrics to assess fish community richness, trophic composition, abundance, and condition. Karr’s (1986) framework is also the basis for the US EPA fish community bioassessment of wadeable streams (Table 27). Streams with drainage areas less than 13 km^2 (5 mi^2) are excluded from IBI scoring because of naturally occurring low species richness

(Vile 2008). The NJ DEP method scores 10 metrics based upon the degree of deviation from appropriate reference conditions as: 5 (none to slight deviation); 3 (moderate deviation); and 1 (significant deviation) (Vile 2008). The scores are summed and assigned to a condition category based on the score. The maximum score for these 10 metrics is 50, with a score of 50 representing excellent biotic integrity. A score less than 29 indicates a stream has poor biological integrity, with a score of 10 being the lowest a site can receive. Nine of the 10 metrics used by Vile (2008) could be estimated from Atkinson's (2008) fish community data from GETT and EISE (the metric of proportion for fish with external anomalies was not used). The ranges for the condition ratings were modified for nine metrics and three condition estimates, but still adhered to Vile's (2008) rating system, yielding a maximum score of 45 (33 to 45: excellent/good, 27 to 32: moderate, and 9 to 26: poor) (Table 27).

Table 27. Reference IBI metrics for GETT and EISE fish assemblages (based on Vile 2008).

IBI Metric	**(Good, score=5)**	**(Moderate, score=3)**	**(Poor, score=1)**
Total number of fish species[1]	≥15	10-14	≤9
Number of benthic insectivores[1]	≥5	3-4	≤2
Number of trout and/or sunfish (not including green sunfish or bluegill)[1]	≥5	2-4	≤2
Number of pollution intolerant species[1]	≥3	1-2	<1
Percent of pollution tolerant individuals	<20%	20-45%	>45%
Percent of individuals as generalists	<20%	20-45%	>45%
Percent of individuals as insectivorous cyprinids	>45%	20-45%	<20%
Percent of individuals as trout **OR** Percent of individuals piscivores, excluding American eel (whichever gives higher score)	>10% / >5%	3-10% / 1-5%	<3% / <1%
Number of individuals in sample, excluding tolerant species	>250	75-250	<75
Total Score	33-45	27-32	9-26

[1] Metric values, after Vile (2008), were based on the Rock Creek (GETT) watershed size of 63 mi^2 and a Marsh Creek (EISE) watershed size of 71 mi^2.

There is a fish community IBI developed for the Piedmont Region of Maryland (Southerland et al. 2005); however, two (fish density and biomass) of the six metrics could not be derived from Atkinson's (2008) data and using best professional judgment it was decided that the New Jersey IBI would be a better index for the stream fish community at GETT and EISE. The Maryland Piedmont IBI is presented herein (Table 28) as it could be a useful index to use in the future to assess the condition of fish community at GETT and EISE.

Table 28. Potential IBI metrics for GETT and EISE fish assemblages based on the Maryland Eastern Piedmont Region (Southerland et al. 2005). This IBI could not be applied to Atkinson's (2008) data due inadequate information for two of six metrics, but is presented herein for informational purposes.

IBI Metric	(Good, score=5)	(Moderate, score=3)	(Poor, score=1)
Abundance per square meter[1]	≥1.25	0.25-1.24	≤0.25
Number of benthic species[2]	≥0.26	0.09-0.25	≤0.09
Percent of pollution tolerant individuals	≤45%	46-68%	>68%
Percent of individuals as generalists, omnivores, insectivores	≤80%	81-99%	100%
Biomass per square meter[1]	≥8.6	4.0-8.5	<4.0
Percent lithosphilic spawners	≥61%	23-60%	<32%

[1] There was inadequate information in Atkinson's (2008) data to evaluate the metric.

[2] Metric was adjusted for catchment size, refer to Southerland et al. (2005).

Gettysburg National Military Park

The 2004 MIDN Inventory by Atkinson (2008) was the first and only time streams at GETT were surveyed for fish (Figure 40). Rock Creek was surveyed using 200 m sections, while Plum Run West was subdivided in to 100 m sections. Both streams were sampled during August and September. The survey identified 18 species of fish (Table 29). Rock Creek, the largest stream in the park, had the highest diversity with 16 species encountered. The dominant species in Rock Creek (50 or more individuals observed) included: bluntnose minnow (*Pimephales notatus*), green sunfish (*Lepomis cyanellus*), white sucker (*Catostomus commersoni*), and greenside darter (*Etheostoma blennioides*) (Atkinson 2008). Plum Run West was dominated by blacknose dace (*Rhinichthys atratulus*), bluntnose minnow, green sunfish, and creek chub (*Semotilus atromaculatus*). Only three species were collected within Plum Run East: creek chub, blacknose dace and bluegill (*Lepomis macrochirus*). None of the species encountered were threatened or endangered although five native transplants were observed (Table 29).

Eisenhower National Historic Site

The 2004 MIDN Inventory by Atkinson (2008) was also the first and only time streams at EISE were surveyed for fish (Figure 40). Marsh Creek was large enough to be subdivided in to 200 m sections. Both Marsh Creek and Willoughby Run were sampled during August and September 2004. The survey identified 31 species of fish (Table 29) and the streams at EISE supported the highest densities of fish per area compared to other aquatic systems within MIDN parks (Atkinson 2008). High densities in Marsh Creek were attributable to three dominant species including bluntnose minnow (over 5,500 individuals), central stonerollers (*Campostoma anomalum*, over 3,500 individuals), and blacknose dace (over 1,200 individuals). Willoughby Run, a much smaller stream than Marsh Creek, had similar densities per area but the densities were attributable to two species: bluntnose minnow (over 1,700 individuals) and banded killifish (*Fundulus diaphanous*, over 1,400 individuals) (Atkinson 2008). None of the species encountered were threatened or endangered although nine native transplants were observed (Table 29).

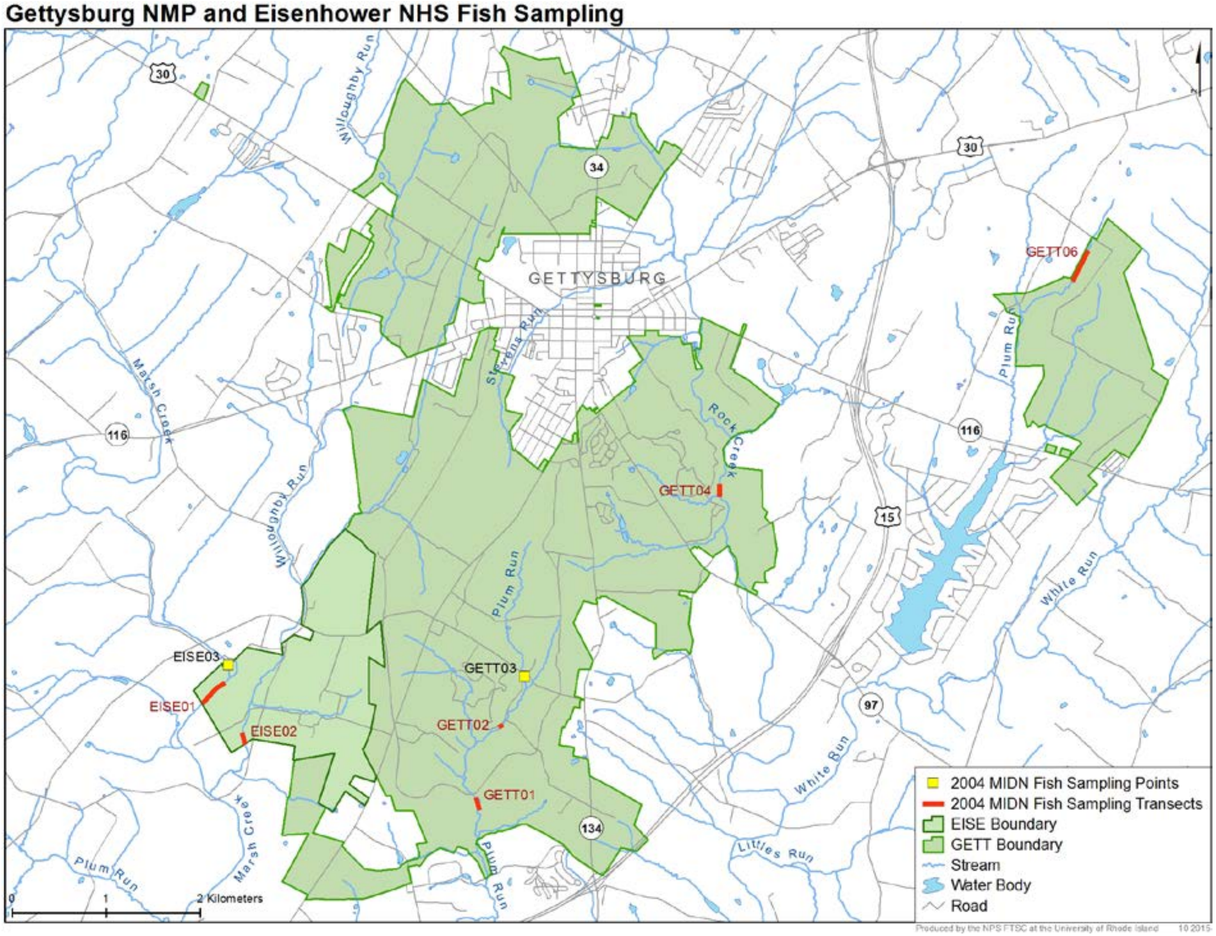


Figure 40. Fish sampling stations (data from Atkinson 2008). Note that sampling locations and names for fish the sampling are not consistent with the MIDN water quality and aquatic invertebrate sampling.

Table 29. Fish species, trophic guild, and number of individuals observed at GETT and EISE (data from Atkinson 2008). "-" denotes fish species was not observed.

Scientific Name	Common Name	Tropic Guild[1]	Nativity Status[2]	GETT 2004	EISE 2004
Ambloplites rupestris	Rock bass	I, P	Native transplant	-	4
Ameiurus natalis	Yellow bullhead	BI, TS	Native	5	81
Anguilla rostrata	American eel	P, TS	Native	-	1
Campostoma anomalum[3]	Central stoneroller	H	Native	42	3685

[1] Tropic guilds after Vile (2008): BI: benthic insectivore; G: generalist; H: herbivore; I: insectivore; IS: intolerant species; P: piscivore; O: omnivore; TS: tolerant species.

[2] Nativity status from USGS Nonindigenous Aquatic Species Database (2015).

[3] Species was not listed in Vile (2008) and trophic guild was determined using other methods (e.g., Fishbase.org 2015).

Table 29 (continued). Fish species, trophic guild, and number of individuals observed at GETT and EISE (data from Atkinson 2008). "-" denotes fish species was not observed.

Scientific Name	Common Name	Tropic Guild[1]	Nativity Status[2]	GETT 2004	EISE 2004
Catostomus commersoni	White sucker	BI, TS	Native	138	136
Cyprinella analostana	Satinfin shiner	I	Native	1	-
Cyprinella spiloptera	Spotfin shiner	I	Native	-	42
Etheostoma blennioides [3]	Greenside darter	BI	Native transplant	62	472
Etheostoma flabellare [3]	Fantail darter	Bi	Native	58	419
Etheostoma olmstedi	Tessellated darter	BI	Native	-	84
Exoglossum maxillingua	Cutlips minnow	BI, IS	Native	-	29
Fundulus diaphanus	Banded killifish	G, TS	Native	2	1741
Hybognathus regius	Eastern silvery minnow	H	Native	12	-
Hypentelium nigricans	Northern hogsucker	BI, IS	Native	-	9
Lepomis auritus	Redbreast sunfish	G	Native	8	26
Lepomis cyanellus	Green sunfish	G, TS	Native transplant	235	381
Lepomis gibbosus	Pumpkinseed	G	Native	30	39
Lepomis macrochirus	Bluegill	G, TS	Native transplant	25	43
Luxilus cornutus	Common shiner	I	Native	-	319
Micropterus dolomieu	Smallmouth bass	P	Native transplant	-	3
Micropterus salmoides	Largemouth bass	P	Native transplant	7	83
Nocomis micropogon [3]	River chub	I	Native	-	1
Notemigonus crysoleucas	Golden shiner	O	Native transplant	24	1
Notropis amoenus	Comely shiner	I	Native	-	47
Notropis hudsonius	Spottail shiner	I	Native	-	526
Notropis rubellus [3]	Rosyface shiner	I	Native	-	6
Noturus insignis	Margined madtom	BI, IS	Native	-	34
Pimephales notatus	Bluntnose minnow	O	Native	318	7014
Pimephales promelas	Fathead minnow	O	Native transplant	-	9
Pomoxis nigromaculatus	Black crappie	I, P	Native transplant	-	6
Rhinichthys atratulus	Blacknose dace	BI	Native	1105	1213

[1] Tropic guilds after Vile (2008): BI: benthic insectivore; G: generalist; H: herbivore; I: insectivore; IS: intolerant species; P: piscivore; O: omnivore; TS: tolerant species.

[2] Nativity status from USGS Nonindigenous Aquatic Species Database (2015).

[3] Species was not listed in Vile (2008) and trophic guild was determined using other methods (e.g., Fishbase.org 2015).

Table 29 (continued). Fish species, trophic guild, and number of individuals observed at GETT and EISE (data from Atkinson 2008). "-" denotes fish species was not observed.

Scientific Name	Common Name	Tropic Guild[1]	Nativity Status[2]	GETT 2004	EISE 2004
Rhinichthys cataractae	Longnose dace	BI	Native	11	357
Semotilus atromaculatus	Creek chub	I	Native	504	40
Total Taxa				**18**	**31**
Total Individuals				**2,587**	**16,851**

[1] Tropic guilds after Vile (2008): BI: benthic insectivore; G: generalist; H: herbivore; I: insectivore; IS: intolerant species; P: piscivore; O: omnivore; TS: tolerant species.

[2] Nativity status from USGS Nonindigenous Aquatic Species Database (2015).

[3] Species was not listed in Vile (2008) and trophic guild was determined using other methods (e.g., Fishbase.org 2015).

4.2.4.3 Reference Condition and Status of the Resource (current condition and trends)

Vile's (2008) reference condition metrics were applied to the fish assemblage data for Rock Creek (GETT) and Marsh Creek and Willoughby Run (EISE) as these streams had drainage areas greater than 13 km^2 (5 mi^2) (Table 30).

Gettysburg National Military Park

Overall the condition of the fish community in Rock Creek was rated as good. However, there were four metrics that scored as moderate concern; such as the high abundance of pollution tolerant species, low numbers of sunfish, and low numbers of insectivorous cyprinids and pisicivores (Table 30). Trends could not be evaluated since the fish assemblages at GETT have only been sampled once (Atkinson 2008).

Eisenhower National Historic Site

The condition of the fish community in Marsh Creek was rated as good, with only two of the nine metrics ranking as poor in quality. The low scores were attributable to low numbers of insectivorous cyprinids and piscivores (Table 30). Willoughby Run scored as moderate condition, within only two of the nine metrics ranking as in good condition (Table 30). Low numbers of insectivores, sunfish species, insectivorous cyprinids and pisicivores, and high abundances of pollution tolerant and generalist species were responsible for the moderate concern condition of this fish community. Trends could not be evaluated since the fish assemblages at EISE have only been sampled once (Atkinson 2008).

American eel populations have recently declined in several states in the eastern US (Haro et al. 2000). American eels are currently found within several of the MIDN parks including EISE (one individual was observed).

4.2.4.4 Confidence in Assessment

Confidence in the data was medium as they were collected over ten years ago. Another fish survey would be beneficial for both GETT and EISE.

Table 30. IBI values for fish community biotic metrics and score (in parentheses after Vile 2008) for stream fish sampled at GETT and EISE in 2004 (after data in Atkinson 2008).

Index of Biotic Integrity Metric[1]	GETT	EISE	
	Rock Creek	Marsh Creek	EISE- Willoughby Run
Total number of fish species	16 (5)	30 (5)	21 (5)
Number of benthic insectivores	5 (5)	17 (5)	3 (3)
Number of trout and/or sunfish (not including green sunfish or bluegill)	3 (3)	6 (5)	4 (3)
Number of pollution intolerant species	5 (5)	6 (5)	3 (5)
Percent of pollution tolerant individuals	42.9% (3)	2.3% (5)	52.6% (1)
Percent of individuals as generalists	9.2% (5)	0.8% (5)	44.3% (3)
Percent of individuals as insectivorous cyprinids	8.3% (3)	0.8% (1)	1.5% (1)
Percent of individuals as trout OR Percent of individuals piscivores (whichever gives higher score) [2]	1.1% (3)	0.6% (1)	0.6% (1)
Number of individuals in sample, excluding tolerant species	532 (5)	12,592 (5)	3,959 (5)
Sum of scores (out of a maximum of 45)[1]	37	37	27
Condition			
Trend	Trend was unknown as there has only been one sampling event in 2004.		

[1] Index of Biotic Integrity metrics after Vile (2008). Condition for scores for metrics (in parentheses): 1=poor, 3=moderate, 5=good. Index was modified for nine of ten available metrics.

[2] The percent of individuals as piscivores gave the highest score.

4.2.4.5 Data Gaps

The only data gap was age of the fish assemblage data which were over 10 years old. The fish community at GETT and EISE is not a priority vital sign for the MIDN Network Monitoring and therefore future monitoring is not planned (Comiskey and Callahan 2008). A current survey of EISE and GETT fish assemblages would be beneficial, especially if the data were collected in a manner sufficient to apply an IBI to assess community condition, such as the one developed for the Maryland Piedmont Region (e.g., Southerland et al. 2005)

4.2.4.6 Threats

There were a number of fish species that were recorded at GETT and/or EISE that were the result of introductions of outside of their native ranges (e.g., non-natives as opposed to exotic or invasive species). These species included several Centrarchids such as: bluegill, green sunfish, largemouth bass (*Micropterus salmoides*), rock bass (*Ambloplites rupestris*), and smallmouth bass (*Micropterus dolomieu*). All are now considered as naturalized species and generally accepted as components of the native fish fauna (Atkinson 2008). Other introduced species include the black crappie (*Pomoxis nigromaculatus*), greenside darter, and fathead minnow (*Pimephales promelas*). Golden shiners (*Notemigonus crysoleucas*) are propagated extensively for use as bait and have been widely introduced both within and beyond their original range through release. The populations observed, especially at GETT, are likely the result of such introduction.

While it is generally acknowledged that aquatic systems within Atlantic Slope drainages have been somewhat degraded from pre-colonial conditions, the primary challenge would be to limit future degradations in an attempt to preserve and/or restore water quality and associated fish species assemblages (Atkinson 2008). The principal threats and management issues that may negatively impact fish communities at GETT and EISE were related to activities associated with development, agriculture or other disturbances upstream of the park (Atkinson 2008). Rock Creek (GETT) and Willoughby Run (EISE) were both listed as impaired by the PA DEP and as needing TMDLs (PASDA 2016, US EPA 2016a). Rock Creek was impaired by siltation and nutrients while Willoughby Run was impaired by organic enrichment/low dissolved oxygen, siltation, and other habitat alterations (refer to Stream Water Quality section). Water quality can influence fish communities and impaired water quality was noted by the PA DEP for streams within the parks. Water quality impairment could be caused by both point and non-point source pollution including residential and agricultural runoff, urban stormwater discharge, increased erosion and subsequent sedimentation, and toxic chemicals (PASDA 2016, US EPA 2016a).

4.3 Ecosystem Integrity

4.3.1 Forest Communities, Woodlots, and Vegetation Associations

4.3.1.1 Relevance and Context

The identification, description, and mapping of plant communities provide important information about vegetation associations and allow inferences about the location and abundance of other species associated with these communities. A current and accurate map of park vegetation is one of the 12 basic natural resource inventories recommended by the NPS Inventory and Monitoring Program (Perles et al. 2006). Mapping efforts allow for the identification of various vegetation types in the field and supply resource managers with a detailed accurate digital map of the park's vegetation communities. The resulting digital map and spatial data layer can be used for assessing park resources as well as planning and management needs (Perles et al. 2006).

The Mid-Atlantic region is primarily a forested ecoregion. Forests are an essential part of the regional landscape and provide habitat for a diversity of wildlife (Comiskey et al. 2009, Comiskey and Callahan 2008). Information on forest community structure and composition is critical to developing desired conditions and park management goals relating to native and non-native plant communities. The MIDN has selected several vital signs associated with forest ecosystem health that are currently monitored at GETT. Due to the lack of forested habitat at EISE, forest vegetation is not monitored within this park (Comiskey et al. 2009).

Forested woodlots at GETT were important resources for the residents of the area before the Battle of Gettysburg. Open-grown white oak (*Quercus alba*) was the dominant vegetation in the 1863 woodlots that were being used as pastures. The park presently incorporates about 2,423 ha, with 799 ha occupied by woodlots and woodlands ranging in size from 2 to 24 ha (Bowersox et al. 2004). Before the battle, the woodlots had an uneven-aged structure that was maintained by frequent partial cutting. When the park was established, cutting practices within the woodlots ceased and second and third growth understory developed (Bowersox et al. 2004). Additionally, the overabundance of white-tailed deer (*Odocoileus virginianus*) in the 1980s adversely affected the cultural integrity of both parks by negatively impacting forest regeneration, reducing growth of crops, and altering the presence and appearance of understory vegetation thereby making preservation of historic woodlots and interpretation of the battle events difficult for NPS staff (refer to White-tailed Deer section). The park is currently managing the woodlots in an effort to restore them to the historic nature and is culling deer to reduce their abundance to a management goal of 10 deer forested km^{-2} (Bowersox et al. 2004, Stainbrook and Diefenbach et al. 2012).

4.3.1.2 Data and Methods

Vegetation at GETT and EISE has been monitored at various times over the past several decades, and has ranged from flora inventories (Yahner et al. 1992), focal studies of woodlot plant communities (Bowersox et al. 2004), vegetation association mapping (Perles et al. 2006), and long-term monitoring by the MIDN (Comiskey and Wakamiya 2011).

Yahner et al (1992) conducted a flora survey at GETT and EISE in 1986-1987. This project inventoried vascular species, determined the abundance and distribution of dominant species, described land-use, land-cover, and forest types, and mapped the parks' wetland areas. The survey sites were located in forested areas with at least 25% forest canopy closure. At each site a 10-m radius circle, and two circular 2-m^2 plots (placed 5-m to east and west of the center of the survey site) were inventoried for vascular plants. Metrics measured included: number of overstory trees and saplings, snags, diameter at breast height (DBH), relative density, relative dominance, relative frequencies, and importance values for each overstory and sapling species (Yahner et al. 1992).

Bowersox et al. (2002, 2004) conducted a series of studies in the historic woodlots at GETT to assist with management plans to maintain the structure and species composition of these areas. These studies evaluated the effects of various-sized openings in the canopy, with and without foraging by white-tailed deer, on understory vegetation from 1986-1987 and 1990-1996. Surveys of understory vegetation were conducted in six woodlots (Biesecker, Bushman Hill, Cobean, Pitzer, Slyder, and Spangler) at GETT.

The vegetation of GETT and EISE was mapped based on 2003 aerial photography and field sampling in 2004 as part of the U.S. Geological Survey/NPS Vegetation Mapping Program (Perles et al. 2006) (Figure 41). The goal of the mapping effort was to produce an up-to-date digital geospatial vegetation database for the park. Perles et al. (2006) determined that the vegetation at GETT and EISE could be described by 15 vegetation associations: Chestnut Oak Forest, Dry Oak – Mixed Hardwood Forest, Tuliptree Forest, Modified Successional Forest, Conifer Plantation, Virginia Pine Successional Forest, Sycamore – Mixed Hardwood Floodplain Forest, Bottomland Mixed Hardwood Forest, Palustrine Shrub Thicket, Successional Old Field, Agricultural Field, Pasture, Orchard, Wet Meadow, and Reed Canary Grass Riverine Grassland (Figure 41). However, battlefield rehabilitation at GETT, such as woodlot health cuts (Figure 42), has significantly altered the vegetation in many sections of the park; so much so, that the vegetation map completed by Perles et al. (2006) was significantly out of date even before that report was published.

Since 2007, the MIDN has monitored forest plots at GETT to assess forest ecosystem integrity; forest cover is low at EISE and thus is not monitored (Comiskey and Wakamiya 2011). Metrics, condition thresholds, and an assessment of condition have been presented by the MIDN in several reports and Resource Briefs (Comiskey 2015, Comiskey and Wheeler 2015, Comiskey and Wakamiya 2011). Forest vegetation plots were randomly located within the forested area at GETT (587.7 ha) using a generalized random-tessellation stratified approach. Each 20-m X 20-m plot contained three nested microplots and 12 quadrats (Comiskey and Wakamiya 2011). There were 32 forest monitoring plots at GETT, one-fourth of which were monitored every four years from 2007 to present (Figure 41). Specific MIDN forest monitoring objectives were (after Comiskey et al. 2009):

- determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species;
- determine the status and trends in the density and composition of tree seedlings and selected herbaceous species that are indicators of deer browse;
- detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests;

- determine the status and trends in forest coarse woody debris and the availability of snags; and
- determine the status and trends in soil chemistry by measuring Ca:Al and C:N ratios to assess the extent of base cation depletion, increased aluminum availability and/or nitrogen saturation impacting MIDN forest soils.

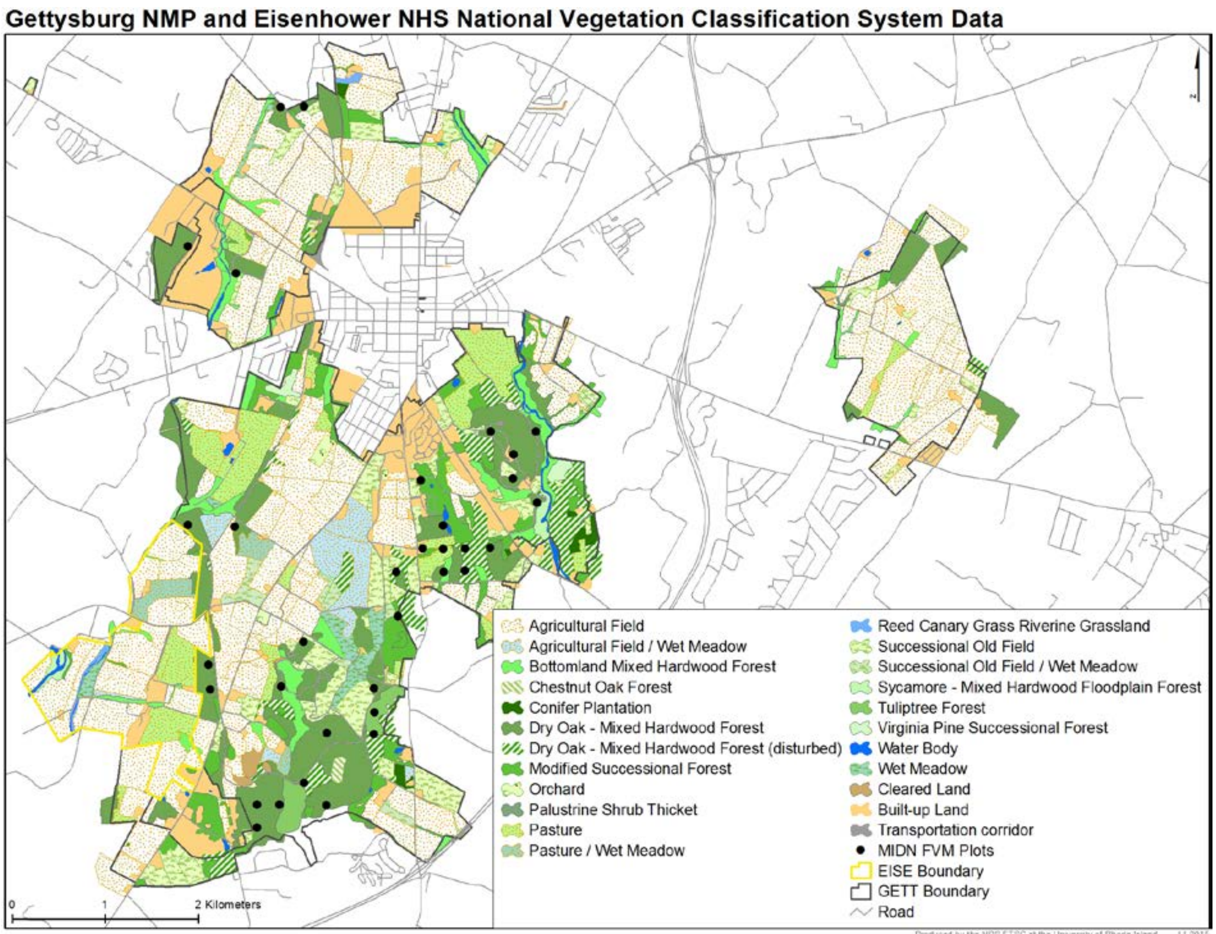


Figure 41. MIDN forest vegetation monitoring plots at GETT and vegetation associations at GETT and EISE. Vegetation was mapped in 2003-2004 as part of the NVC program (Perles et al. 2006).

The MIDN also focused on indicator plant species and taxa for monitoring. Species selected included invasive exotics, deer-browse indicators (plants preferred or avoided by deer), and vines that may reach into the forest canopy (refer to Appendix Table 56) (Comiskey and Wakamiya 2011, 2012). The MIDN has established thresholds for these metrics (refer to Table 31) and these thresholds were used to assess condition.

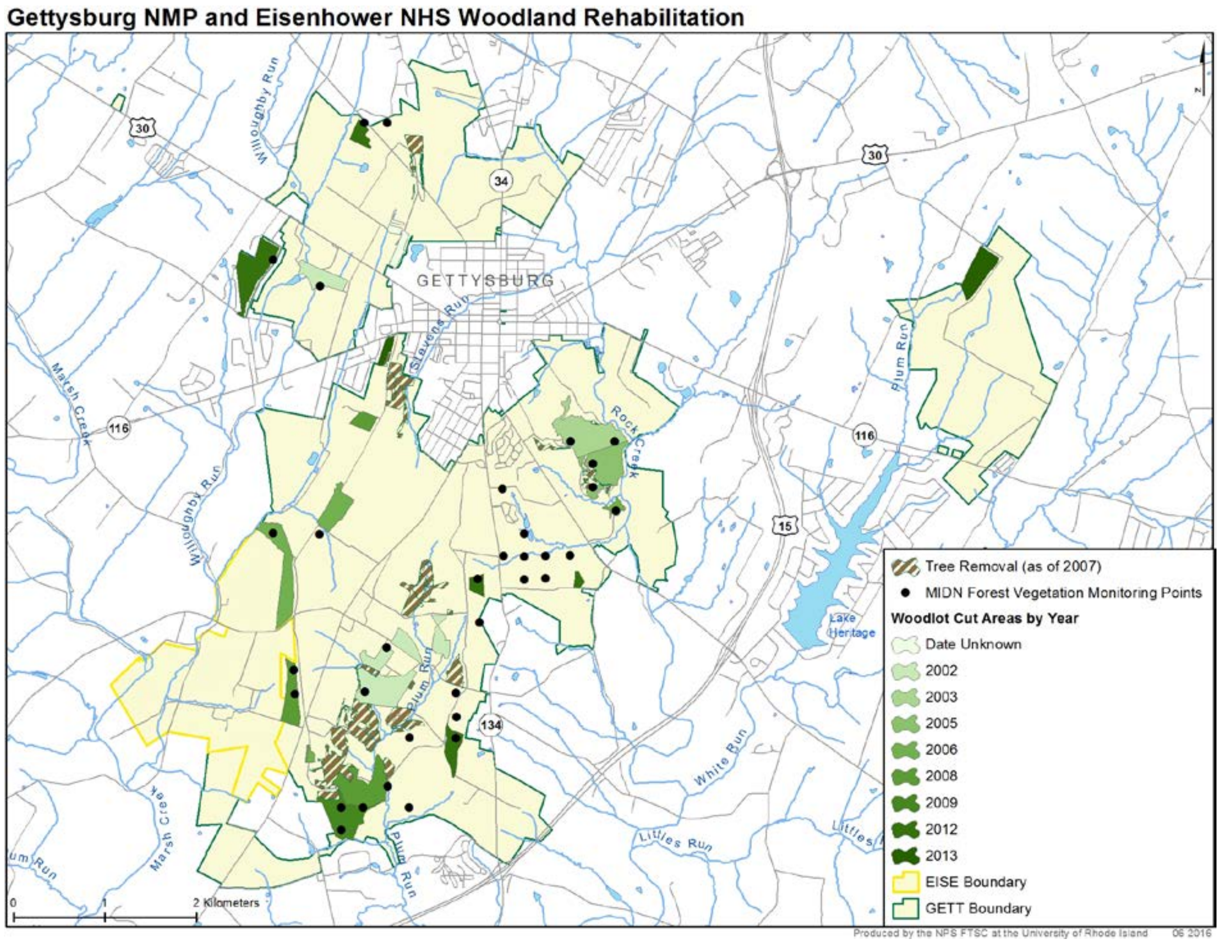


Figure 42. Woodlot health cuts at GETT and EISE (GIS data courtesy of C. Musselman, GETT).

4.3.1.3 Reference Condition and Status of the Resource (current condition and trends)

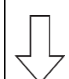
Gettysburg National Military Park

The most current and comprehensive data for forest integrity at GETT were those reported by Comiskey and Wakamiya (2011) in their 2007 to 2010 report that included data metrics from all 32 forest monitoring plots. The MIDN has established thresholds for these metrics (refer to Table 31) and these thresholds were used to assess condition (refer to Comiskey and Wakamiya 2011). These results are summarized herein and were used to evaluate the condition of forest vegetation at GETT (Table 31). Additional information on trends was from Comiskey and Wheeler's (2015) 2013 summary report, which compared a subset of plots (24 of 32 plots) sampled in 2007-2009 (census 1) to those same plots sampled in 2011-2013 (census 2). These temporal trend analyses were preliminary as just three-quarters the plots had been resampled (Comiskey and Wheeler 2015).

- Structural Stage of forest (an indicator of disturbance and habitat availability for species dependent on specific structural stages): The structural stage of the forests at GETT was good with 61% of the forest observed to be late successional and 85% to be mature and late successional stages (data from 32 plots). The trend was unchanging from census 1 to census 2.

- Canopy Tree Condition (an assessment of foliage condition in canopy trees, extensive foliar damage can be an indicator of a wide variety of stressors including, but not limited to: forest pests, pathogens, air quality and/or climate change impacts): Twenty-three of the vegetation plots at GETT were assessed as in good condition for canopy tree condition, while ten were of moderate concern (none were rated as significant concern). Based on NRCA guidelines (refer to Table 7) the average condition was assessed as good for this metric. Comiskey and Wakamiya (2011) did not observe any high priority pests (e.g., Asian longhorned beetle [ALB], emerald ash borer [EAB], and sudden oak death [SOD]) in the vegetation plots at GETT. However, EAB was documented in traps set at GETT by the US Forest Service in 2015 (D. Reiner, personal communication, 17 May 2016). Trend from census 1 to census 2 was not presented by Comiskey and Wheeler (2015).
- Snags (snags are standing dead biomass that are an important element of forests, providing nesting and feeding habitat for birds and other vertebrates, additionally, they are an indicator of the structural age and health of the forest): GETT forests had 11.36 medium-large snags (≥30 cm diameter) per hectare and 10.5% of snags were ≥30 cm DBH and this metric was rated as good condition. Trend from census 1 to census 2 was not presented by Comiskey and Wheeler (2015).
- Coarse Woody Debris (a measure of tree volume): The amount of coarse woody debris (CWD) was rated as good for GETT, with CWD accounting for 21% of the live tree volume. Trend from census 1 to census 2 was not presented by Comiskey and Wheeler (2015).
- Forest Regeneration (regeneration, as measured by the density of saplings and seedlings, in the mid-Atlantic region is primarily affected by deer browsing; however, dense undergrowth can also be an indicator of invasive exotic species that can suppress seedling growth). Tree seedlings were measured in quadrats and a score applied that was weighted according to the height class (exotic tree species and species that do not reach the canopy are excluded from the seedling index score) (refer to Table 31). In census 2 (2011-2013), GETT had a "good" tree seedling regeneration index that not only increased from the census 1 (2007-2009), but had done so at a level above that required under heavy deer-browse pressure (Comiskey and Wheeler 2015). This growth rate was the second highest of all parks sampled in census 1 and census 2, thus the trend in forest regeneration was evaluated, based on this preliminary analyses, as improving. The frequency of invasive indicator species (number of plots with exotics) was highest at GETT (compared to other MIDN parks) with all plots having exotics present. GETT also had the highest percentage of plots with exotics and had the highest average number of exotic species per plot compared to other MIDN parks. The most common invasive species in the vegetation plots were Japanese barberry (*Berberis thunbergii)* and Japanese stiltgrass (*Microstegium vimineum).* Most exotics increased in plots from census 1 to census 2, thus the trend for invasive species in the plots was evaluated as deteriorating. Using data from all 32 plots (2009-2011data), the forest regeneration metric scored nine plots in good condition, ten plots in moderate condition, and 13 plots in poor condition.

Table 31. MIDN Forest integrity condition metrics, thresholds, and scores, based on MIDN forest vegetation monitoring from all 32 plots sampled from 2007-2010 (Comiskey and Wakamiya 2011). Trends were based on Comiskey and Wheeler (2015).

Metric	 Good Condition	 Moderate Concern	 Significant Concern	**GETT Condition** (2007-2010), 32 plots sampled		**GETT Trend** census 1 (2007-2009) compared to census 2 (2011-2013), 24 of 32 plots re-surveyed (preliminary analyses)	
Structural Stage	>25% late successional	<25% late successional	<25% combined mature and late successional		61% late successional, 85% mature and late successional (based on 32 plots)		Unchanging
Canopy Tree Condition[1]	<10% with foliar damage, and no pests present, and BBD severity ≤2	10-50% with foliar damage, or evidence of HWA, EHS, or BC, BBD severity >2	>50% with foliar damage, or evidence of ALB, EHS, or BC		Average score2 = 84.8 23 plots: good condition 10 plots: moderate condition 0 plot: significant concern	Trend unknown	
Snags	≥10% trees and shrubs ≥10 cm DBH are snags, and >10% trees ≥30 cm DBH are snags	<10% trees and shrubs, ≥10 cm DBH are snags or <10% trees ≥30 cm DBH are snags	<5per ha, 30 cm DBH are snags		10.49% snags ≥30 cm 11.36 snags ha-1 ≥30 cm (based on 32 plots)	Trend unknown	
Course Woody Debris	>15% of live tree volume	5-15% of live tree volume	<5% of live tree volume		21% of live tree volume (based on 22 plots)	Trend unknown	
Forest Regeneration (stocking index)	>8 seedlings m^{-2}	2-8 seedlings per m^{-2}	<2 seedlings per m^{-2}		Average condition score[2] = 43.7 9 plots: good condition 10 plots: moderate condition 13 plots: significant concern	 	Growth rate was improving Invasive presence increased so trend was deteriorating

[1] Pest and disease abbreviations: ALB: Asian longhorned beetle, BBD: Beech bark disease, BC: Butternut canker, EAB: Emerald ash borer, EHS: Elongate hemlock scale, HWA: Hemlock woolly adelgid, SOD: Sudden oak death. DBH: Diameter at breast height.

[2] Average score based on NRCA guidelines for combining condition metrics (refer to Table 7).

Table 31 (continued). MIDN Forest integrity condition metrics, thresholds, and scores, based on MIDN forest vegetation monitoring from all 32 plots sampled from 2007-2010 (Comiskey and Wakamiya 2011). Trends were based on Comiskey and Wheeler (2015).

Metric	Good Condition	Moderate Concern	Significant Concern	GETT Condition (2007-2010), 32 plots sampled		GETT Trend census 1 (2007-2009) compared to census 2 (2011-2013), 24 of 32 plots re-surveyed (preliminary analyses)	
Soil Chemistry (acidification)	Ca:Al ratio >4	no threshold available	no threshold available		Ca:Al ratio = 37.13 (based on 8 plots in 2010)		Unchanging
Soil Chemistry	C:N ratio >25	C:N ratio 20-25	C:N ratio <20		C:N ratio = 14.29 (based on 8 plots in 2010)		Unchanging
Average condition of forest integrity					Average score[2] = 78.6		Unchanging[2]

[1] Pest and disease abbreviations: ALB: Asian longhorned beetle, BBD: Beech bark disease, BC: Butternut canker, EAB: Emerald ash borer, EHS: Elongate hemlock scale, HWA: Hemlock woolly adelgid, SOD: Sudden oak death. DBH: Diameter at breast height.

[2] Average score based on NRCA guidelines for combining condition metrics (refer to Table 7).

- Soil Chemistry was measured as the ratio of Ca:Al (measure of acidification) and C:N (measure of nitrification). A threshold for "good" condition was only available for Ca:Al chemistry due to differing extraction methods used by the MIDN (Comiskey and Wheeler 2015). The Ca:Al chemistry was rated as good, while the C:N metric was rated as significant concern for GETT(but these data need to be interpreted with caution as soil sampling was only conducted in 2010 and the sample size is based on one quarter of the established plots).

The average score of the forest vegetation integrity metrics measured by Comiskey and Wakamiya (2011) from 2007 to 2010 was good (Table 31). Therefore the condition of the forest at GETT was assessed as in good condition.

The trend in structural stage was unchanging from census1 to 2. Forest regeneration from census 1 to census 2 for tree seedlings was improving but was deteriorating for invasive plants. The trend for soil chemistry was unchanging based on 8 plots (sampled in 2010 and 2013), but these data need to be interpreted with caution as there was disagreement among soil scientists as to whether these metrics were sufficient for interpreting acid deposition stress on forest soils (Comiskey and Wheeler 2015). Comiskey and Wheeler (2015) did not present trends for canopy tree condition, snags, or CWD from census 1 to census 2 (Table 31).

4.3.1.4 Confidence in Assessment

The confidence in the assessment was high, as the MIDN has established protocols and metrics to evaluate forest vegetation integrity at GETT and the vegetation plots are monitored on a routine basis.

4.3.1.5 Data Gaps

Once the battlefield rehabilitation is completed a new map of the vegetation associations should be conducted based on the classification work presented in Perles et al. (2006). Integrating draft in-house GIS data layers with the NVC vegetation data and developing FGDC compliant metadata would be beneficial to update the vegetation mapping.

4.3.1.6 Threats

Invasive vegetation has been noted as a threat to forests and lands within both GETT and EISE (Bowersox et al. 2004, Perles et al. 2006). However, the NPS has implemented a series of management actions (e.g., prescribed burns, chemical and mechanical treatment) that are aimed at controlling invasive vegetation (NPS 2014). While woodlot health cuts are integral to the battlefield rehabilitation goals, they also may increase the presence and persistence of invasive vegetation by opening up the tree canopy

Comiskey and Wakamiya (2011) did not observe any high priority pest species in the vegetation plots at GETT. Although there are several forest pests that are present in Adams County and the counties surrounding Adams County (Table 32), the USDA Forest Service (2015) risk assessment for the area in the vicinity of GETT and EISE was rated as low with only 1-4% of the treed area at risk (Figure 43). However, the emerald ash borer was documented in GETT by the US Forest Service in

2015 (D. Reiner, personal communication, 16 May 2016) and this pest could potentially infest a large proportion of ash trees in the park.

Table 32. Insect forest pests and their host species present in Adams County and/or surrounding counties (USDA Forest Service 2015). Bold text indicates species used by the MIDN as indicator forest pest species. Note that some species tracked by MIDN were not present in either Adams County or the surrounding counties (refer to Table 30 for MIDN tracked pests).

Scientific Name	Common Name	Present in Adams County	Present in surrounding counties[1]	Host Tree(s)
Adelges tsugae	Hemlock woolly adelgid	X	C, F, Y, Ca, Fr	Eastern and Carolina Hemlock
Agrilus planipennis[2]	Emerald ash borer	X	C, F, Y, Ca, Fr	Ash trees
Asterolecanium minus	Oak Pit Scale		F, Y	Various oak species
Carulaspis juniperi	Juniper scale		C, Y	Junipers, cypresses, false cypresses and incense cedar
Ceratocystis fagacearum	Oak wilt	X	C, F	Oak trees
Coleophora laricella	Larch casebearer		C, F, Fr	Larch, tamarack
Cronartium ribicola	White pine blister rust	X	C, F, Y, Ca	White pine, other pines
Cryphonectria parasitica	Chestnut blight	X	C, F, Y, Fr	American chestnut, chinkapins
Discula destructiva	Dogwood anthracnose	X	C, F, Y, Ca, Fr	Flowering and Pacific dogwood
Drycosmus kuriphilus	Chestnut gall wasp		Y, Fr	American chestnut, chinkapins
Fenusa pusilla	Birch leafminer		C	Birch trees
Hylastes opacus	European bark beetle		C, Y, Ca	Scots pine, other pines, occasionally other conifers
Lepidosaphes ulmi	Oystershell scale		Y, Fr	Shade trees and shrubs (over 130 species) including lilac, ash, dogwood, maple and willow
Lymantria dispar	Gypsy moth	X	C, F, Y, Ca, Fr	Hardwood trees
Phytophthora cinnamomi	Leaflitter disease / Phytophthora root rot		C, Fr	Various species including rhododendrons, azaleas, chestnuts, oaks, cedars, and pines
Plagiodera versicolora	Imported willow leaf beetle		F, Ca, Fr	Willow and poplar trees

[1] Forest pests present in surrounding counties could be a threat to GETT/EISE if their range expands. County codes: C: Cumberland Cty PA, F: Franklin Cty PA, Y: York Cty PA, Ca: Carroll Cty MD, Fr: Fredrick Cty MD.

[2] Documented in GETT by US Forest Service in 2015 (D. Reiner, personal communication, 17 May 2016).

Table 32 (continued). Insect forest pests and their host species present in Adams County and/or surrounding counties (USDA Forest Service 2015). Bold text indicates species used by the MIDN as indicator forest pest species. Note that some species tracked by MIDN were not present in either Adams County or the surrounding counties (refer to Table 30 for MIDN tracked pests).

Scientific Name	Common Name	Present in Adams County	Present in surrounding counties[1]	Host Tree(s)
Popillia japonica	Japanese beetle	X	C, F, Y, Ca, Fr	Numerous host plants, including trees, shrubs, and garden crops
Pristiphora erichsonii	Larch sawfly		F	Larch, tamarack
Scolytus multistriatus	Smaller European elm bark beetle		C, Y, Fr	Elm trees
Scolytus schevyrewi	Banded elm bark beetle		Fr	Elm trees
Sirococcus clavigignenti juglandacearum	Butternut canker	X	C, F, Y, Ca, Fr	Butternut; may infest but not damage other Juglans spp.
Taeniothrips inconsequens	Pear thrips		Fr	Maples, fruit trees
Tomicus piniperda	Pine shoot beetle	X	C, F, Y, Fr	Pines

[1] Forest pests present in surrounding counties could be a threat to GETT/EISE if their range expands. County codes: C: Cumberland Cty PA, F: Franklin Cty PA, Y: York Cty PA, Ca: Carroll Cty MD, Fr: Fredrick Cty MD.

[2] Documented in GETT by US Forest Service in 2015 (D. Reiner, personal communication, 17 May 2016).

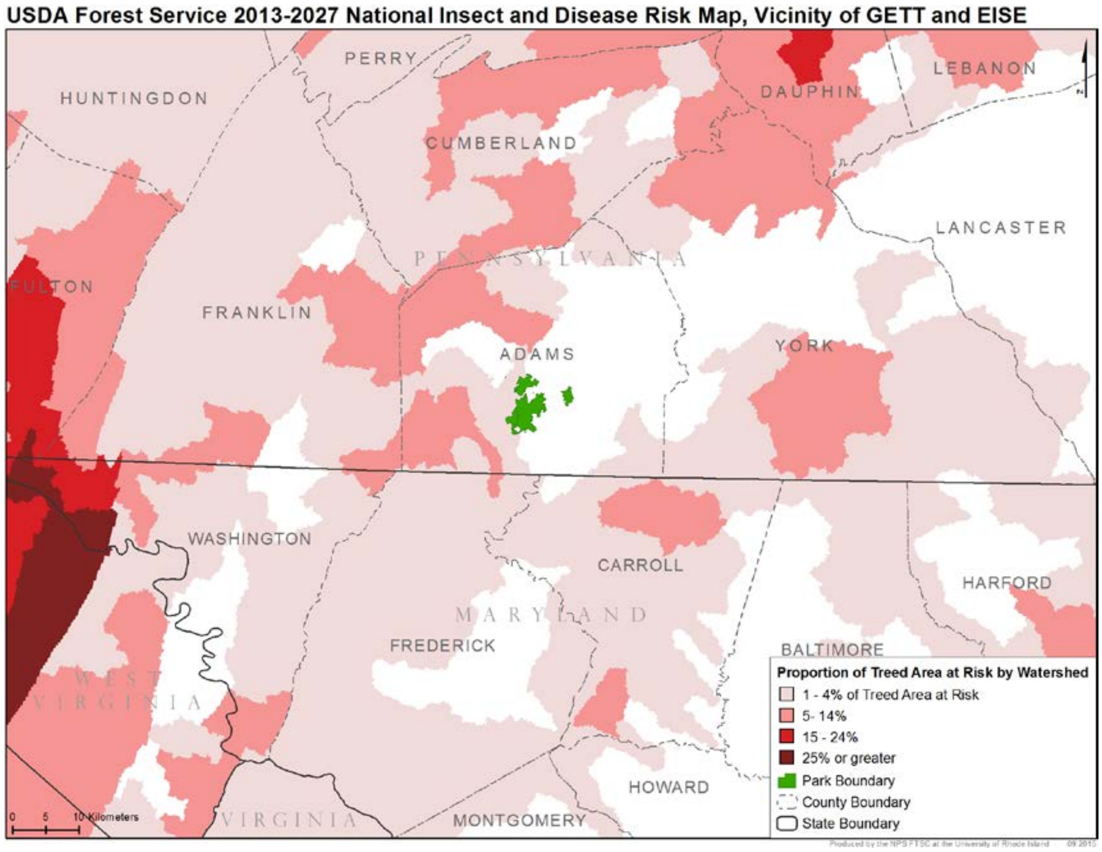


Figure 43. USDA Forest Service forest pest and disease risk map for the area in the vicinity of GETT and EISE (USDA Forest Service 2015).

4.3.2 Plant Species of Interest (State-listed and Invasive Species)

4.3.2.1 Relevance and Context

The NPS works to sustain and recover many populations of federally listed threatened and endangered (T&E) species. One of the NPS missions is to reduce the risk of extinction of plants (and animals) in the parks, and to restore species that have occurred in parks historically but have been lost due to human activities. The NPS seeks to be proactive in determining the status of rare species and cooperating with other agencies to conserve declining species to avoid listing under the Endangered Species Act (NPS 2016a).

Native and rare plants can be threatened by invasive and non-native species. Documenting and managing non-native and invasive plants is part of the NPS Strategic Plan for Managing Invasive Non-native Plants on NPS lands (NPS 1996) and as such, vegetation monitoring and management fits within a context of NPS policy and law aiming to preserve and protect native species, functioning ecosystems, and cultural and historical resources. The NPS Strategic Plan of 2001-2005 established goals related to invasive plant management. One of the long-term goals was that exotic vegetation should be contained on 6.3% of targeted acres of parkland (Goal Ia1B) at the National level (NPS 2000). Non-native invasive plants can negatively affect and/or threaten native species diversity and ecosystems, and seriously degrade the cultural landscape.

Vegetation management is an important part of the cultural and natural resource goals for GETT and EISE. The parks' primary goals regarding vegetation are to restore and perpetuate the battlefield as it appeared at the time of the Battle of Gettysburg in July 1863 and to preserve resident flora that are compatible with the goal of historic accuracy (NPS 2016b).

4.3.2.2 Data and Methods

Field surveys were conducted in 2004 and 2005 to document the presence of federally-listed and state-listed plant species of special concern in GETT and EISE (Kunsman 2006). The surveys attempted to confirm the presence of species of special concern that had been documented in previous years as well as to discover the presence of species of special concern that had not been previously documented. Kunsman (2006) used the 15 vegetation association identified by Perles et al. (2006) to select areas of the park(s) that would likely have suitable habitat and/or vegetation associations to support species of special concern (Figure 44). Once those were identified, Kunsman (2006) used field surveys and visual reconnaissance to document the presence of species of special concern. This method did not use transects or survey plots.

Invasive plant species have not specifically been mapped at GETT and EISE, but have been noted during various vegetation surveys (Yahner et al 1992, Perles et al. 2006, Comiskey and Wakamiya 2011). Perles et al. (2006) noted that invasive exotic plant species were an important threat to the native vegetation at both parks. During MIDN forest vegetation monitoring, Comiskey and Wakamiya (2011) observed the frequency (number of forest vegetation plots) of exotics was highest at GETT where all 32 forest plots had exotic species present). Species such as multiflora rose (*Rosa multiflora*), Japanese barberry, tree of heaven (*Ailanthus altissima*), Asiatic tearthumb (*Persicaria perfoliata*), Japanese stilt grass, Japanese honeysuckle (*Lonicera japonica*), Amur honeysuckle (*Lonicera maackii*), and Morrow's honeysuckle (*Lonicera morrowii*) were documented in the parks during this study.

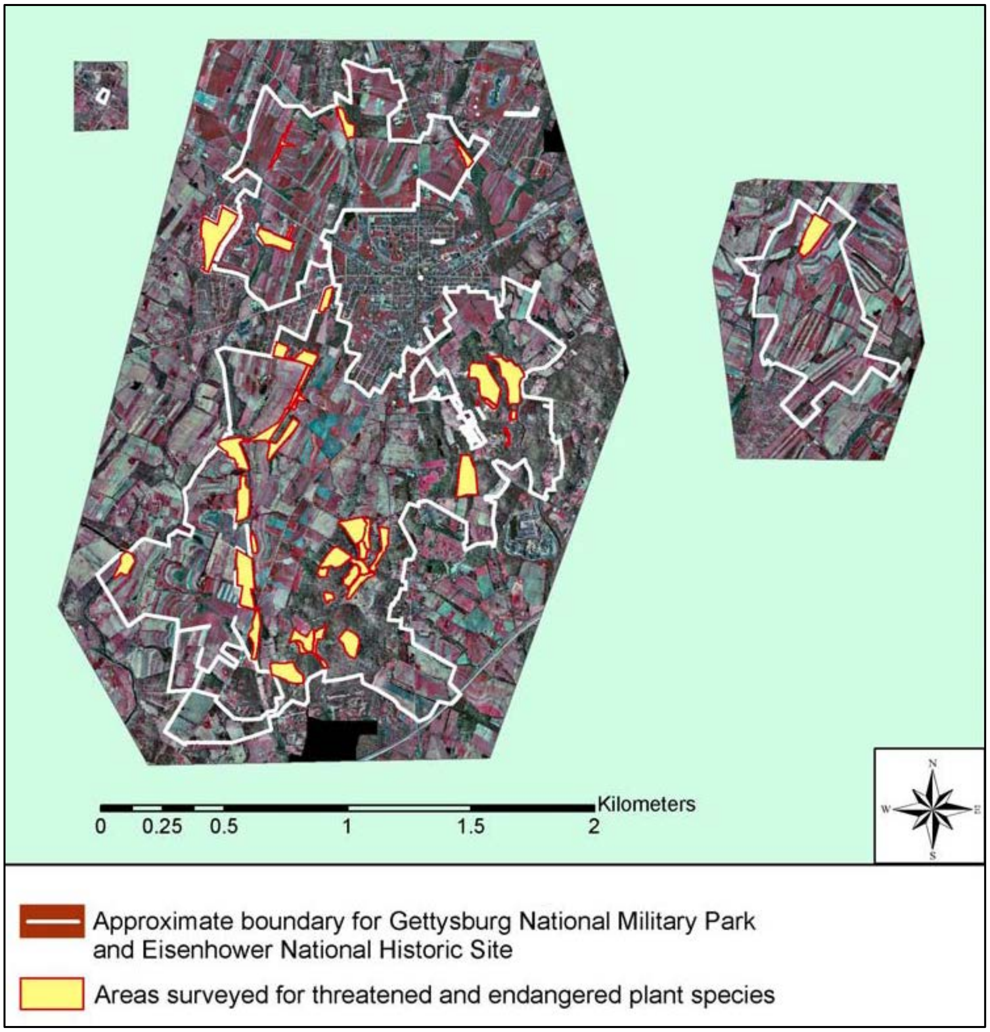


Figure 44. Field surveys for plant species of special concern in GETT and EISE, 2004–2005 (figure excerpted from Kunsman 2006).

4.3.2.3 Reference Condition and Status of the Resource (current condition and trends)

Gettysburg National Military Park

Flora records for GETT (Yahner et al. 1992, Kunsman 2006, Perles et al. 2006, NPSpecies 2015) indicated that 933 species have been recorded (either historically or within the past 10 years) in the park (refer to Appendix Table 56).

Thirty-five state-listed plant species (3.8% of all species) were recorded at GETT (Kunsman 2006, Perles et al. 2006, NPSpecies 2015) (Table 33). Fifteen species were state-listed as endangered, 11 were state-listed threatened, six were state-listed rare, one was special concern, one was vulnerable, and one was tentatively undetermined (Table 33).

Table 33. State-listed species of special concern observed at GETT (G) and EISE (E). Nomenclature follows ITIS.gov, non-accepted synonyms (as listed in NPSpecies 2015) are indicated in parentheses. No federally-listed plants were recorded at either GETT or EISE.

Scientific Name	Common Name	Status[1]	Habitat[2]
Aplectrum hyemale (G)	Puttyroot	R	DO
Asclepias variegate (G)	Redring milkweed	E, UC	n/a
Bromus kalmia (G)	Artic brome	T	MSF
Carex buxbaumii (G)	Buxbaum's sedge	R	OF, WM, BHF, DO
Carex shortiana (G)	Short's sedge	R, UR	P, WM
Carex tetanica (G)	Rigid sedge	T	AF, P, WM
Carya laciniosa (G, E)	Shellbark hickory	SC, UR	SHF
Cypripedium parviflorum var. pubescens (G)	Large yellow lady's-slipper	V	DO
Dichanthelium dichotomum var dichotomum (G)	Cypress panicgrass	E	n/a
Dichanthelium (Panicum) oligosanthes (D. oligosanthes var. scribnerianum) (G)	Heller's rosette grass	T, UR	AF, OF
Eleocharis elliptica (G)	Elliptic spikerush	E	n/a
Eleocharis obtusa (G, E)	Blunt spikerush	E	n/a
Helianthemum bicknellii (G)	Bicknell's hoary rockrose	E	OF
Ilex opaca (G)	American holly	T	n/a
Juncus biflorus (G)	Grass-leaved rush	T	OF, WM
Juncus brachycarpus (G)	Short-fruited rush	E	OF, WM
Lithospermum canescens (G)	Hoary puccoon	T, UR	MSF
Luzula bulbosa (G)	Bulbose wood-rush	E, UC	n/a
Lysimachia hybrid (G)	Lowland yellow loosestrife	T, UC	n/a
Orontium aquaticum (G)	Goldenclob	R	n/a
Packera anonyma (synonym Senecio anonymus) (G)	Small's ragwort	R, UC	n/a
Panicum (gettingeri) philadelphicum (synonym P. tuckermanii) (G, E)	Philadelphia panicgrass	T	n/a

[1] State listed status as designated by USDA Plants Database 2016 and PA NHP 2015.E: Endangered, R: Rare, SC: Special Concern, T: Threatened, UR: status under review, TU: status tentatively undetermined but in danger of population decline. V: Vulnerable, UC: species listed as unconfirmed in NPSpecies 2015.

[2] AF: Agricultural Field; BHF: Bottomland Mixed Hardwood Forest; CP: Conifer Plantation; DO: Dry Oak-Mixed Hardwood Forest; MSF: Modified Successional Forest; OF: Successional Old Field; P: Pasture; PST: Palustrine Shrub Thicket; SHF: Sycamore-Mixed Hardwood Floodplain Forest; TF: Tuliptree Forest; VP: Virginia Pine Successional Forest; WM: Wet Meadow. n/a: species was in Perles et al. 2006 and/or NPSpecies 2015 but vegetation association was not specifically noted.

Table 33 (continued). State-listed species of special concern observed at GETT (G) and EISE (E). Nomenclature follows ITIS.gov, non-accepted synonyms (as listed in NPSpecies 2015) are indicated in parentheses. No federally-listed plants were recorded at either GETT or EISE.

Scientific Name	Common Name	Status[1]	Habitat[2]
Penstemon laevigatus (G, E)	Eastern smooth beardtongue	TU	OF, WM
Phlox pilosa (G)	Downy phlox	E	DO, OF
Prenanthes serpentaria (G)	Lion's foot	T, UR	DO
Quercus shumardii (G)	Shumard's oak	E	DO, P, WM
Ranunculus fascicularis (G)	Early (tufted) buttercup	E, UC	AF, P, WM
Ranunculus pusillus (G)	Low spearwort	E, UR	AF, P, WM
Ribes missouriense (G)	Missouri gooseberry	E	BHF, DO, MSF
Rudbeckia fulgida (G)	Orange coneflower	T, UR	AF, MSF, OF, P, WM
Stylosanthes biflora (G)	Sidebeak pencilflower	E, UR	OF, MSF
Symphyotrichum puniceum var. puniceum (Aster firmus) (G)	Purplestem aster	T	n/a
Tipularia discolor (G)	Crippled cranefly orchid	R	DO
Triosteum angustifolium (G)	Yellowfruit horse-gentian	E, TU	DO
Veratrum virginicum (G)	Virginia bunchflower	E, UR, UC	n/a

[1] State listed status as designated by USDA Plants Database 2016 and PA NHP 2015.E: Endangered, R: Rare, SC: Special Concern, T: Threatened, UR: status under review, TU: status tentatively undetermined but in danger of population decline. V: Vulnerable, UC: species listed as unconfirmed in NPSpecies 2015.

[2] AF: Agricultural Field; BHF: Bottomland Mixed Hardwood Forest; CP: Conifer Plantation; DO: Dry Oak-Mixed Hardwood Forest; MSF: Modified Successional Forest; OF: Successional Old Field; P: Pasture; PST: Palustrine Shrub Thicket; SHF: Sycamore-Mixed Hardwood Floodplain Forest; TF: Tuliptree Forest; VP: Virginia Pine Successional Forest; WM: Wet Meadow. n/a: species was in Perles et al. 2006 and/or NPSpecies 2015 but vegetation association was not specifically noted.

Forty-five invasive plants or potentially invasive plants (5% of all species) (Table 34) and 158 non-native plants (17% of all species) were recorded at GETT (Appendix Table 56). Invasive plants were found in ten of the 15 vegetation associations that Perles et al. (2006) described for GETT and EISE (Table 34). Comiskey and Wakamiya (2011) recorded exotic species in all 32 of the MIDN forest vegetation monitoring plots at GETT. Additionally, they recorded 12 species of exotics in their plots and GETT had the highest average number of exotic species per plot (four species) compared to other MIDN parks.

Eisenhower National Historic Site

Flora records for EISE (Yahner et al. 1992, Kunsman 2006, NPSspecies 2015) indicated that 258 species have been recorded (either historically or within the past 10 years) in the park (refer to Appendix Table 56).

Table 34. Pennsylvania state listed invasive plant species observed at GETT (G) and EISE (E) (Perles et al. 2006, NPSpecies 2015, PA DCNR 2016).

Scientific Name	Common Name	Habitat (GETT and EISE combined)[1]
PA DCNR listed Invasive Plants		
Acer platanoides (G, E)	Norway maple	n/a
Aegopodium podagraria (G)	Bishop's goutweed	n/a
Ailanthus altissima (G, E)	Tree of heaven	n/a
Albizia julibrissin (G)	Mimosa	n/a
Alliaria petiolata (G, E)	Garlic mustard	BHF, CP, DO, SHF, TF, VP
Alnus glutinosa (G)	Black Alder	n/a
Berberis thunbergii (G, E)	Japanese barberry	BHF, CP, DO, MSF, TF, VP
Bromus sterilis (G)	Poverty brome	n/a
Celastrus orbiculatus (G)	Asian Bittersweet	n/a
Centaurea stoebe ssp. micranthos (G)	Spotted knapweed	n/a
Chelidonium majus (G)	Greater celandine	n/a
Cirsium arvense (G, E)	Canada thistle	AF
Cirsium vulgare (G, E)	Bull thistle	n/a
Conium maculatum (G)	Poison hemlock	n/a
Datura stramonium (G)	Jimsonweed	n/a
Elaeagnus angustifolia (G)	Russian olive	n/a
Elaeagnus umbellata (G)	Autumn olive	BHF, OF
Euonymus alatus (G)	Winged euonymus	n/a
PA DCNR listed Invasive Plants		
Hedera helix (G)	English ivy	n/a
Hesperis matronalis (E, G)	Dames rocket	n/a
Lespedeza cuneata (G)	Chinese lespedeza	n/a
Ligustrum obtusifolium (G)	Border privet	MSF
Ligustrum vulgare (G)	European privet	BHF, MSF, VP

[1] Habitat after Perles et al. 2006: AF: Agricultural Field; BHF: Bottomland Mixed Hardwood Forest; CP: Conifer Plantation; DO: Dry Oak-Mixed Hardwood Forest; MSF: Modified Successional Forest; OF: Successional Old Field; PST: Palustrine Shrub Thicket; SHF: Sycamore-Mixed Hardwood Floodplain Forest; TF: Tuliptree Forest; VP: Virginia Pine Successional Forest; WM: Wet Meadow. n/a: species was in Perles et al. 2006 and/or NPSpecies 2015 but vegetation association was not specifically noted.

Table 35. Pennsylvania state listed invasive plant species observed at GETT (G) and EISE (E) (Perles et al. 2006, NPSpecies 2015, PA DCNR 2016).

Scientific Name	Common Name	Habitat (GETT and EISE combined)[1]
PA DCNR listed Invasive Plants (continued)		
Lonicera japonica (G, E)	Japanese honeysuckle	BHF, DO, MSF, OF, SHF, TF, VP
Lonicera morrowii (G, E)	Marrow's honeysuckle	BHF, MSF, OF
Lonicera maackii (G, E)	Amur honeysuckle	n/a
Lonicera tatarica (G)	Tartarian honeysuckle	n/a
Lysimachia nummularia (G, E)	Creeping jenny	BHF, WM
Microstegium vimineum (G, E)	Japanese stilitgrass	BHF, CP, DO, SHF, TF, VP
Ornithogalum umbellatum (G, E)	Star of Bethlehem	n/a
Persicaria caespitosum (G, E)	Oriental ladysthumb	DO, SHF, TF, VP
Persicaria perfoliata (G, E)	Mile-a-minute	SHF
Perilla frutescens (G)	Beefsteakplant	n/a
Rhamnus (Frangula) alnus (G)	Glossy buckthorn	n/a
Rhamnus cathartica (G)	Common buckthorn	n/a
Rosa multiflora (G, E)	Multiflora rose	BHF, CP, DO, MSF, OF, TF, VP, WM
Rubus phoenicolasius (G)	Wine raspberry	BHF, MSF, TF
Ulmus pumila (G)	Siberian elm	n/a
PA DCNR Watch Listed Invasive Plants		
Arthraxon hispidus (G, E)	Small carpetgrass	n/a
Hemerocallis fulva (G, E)	Orange daylily	n/a
Holcus lanatus (G)	Common velvetgrass	n/a
Morus alba (G, E)	White mulberry	n/a
Poa trivialis (G)	Rough bluegrass	BHF
Schedonorus arundinaceus (G)	Tall fescue	PST, WM
Vinca minor (G)	Common periwinkle	n/a

[1] Habitat after Perles et al. 2006: AF: Agricultural Field; BHF: Bottomland Mixed Hardwood Forest; CP: Conifer Plantation; DO: Dry Oak-Mixed Hardwood Forest; MSF: Modified Successional Forest; OF: Successional Old Field; PST: Palustrine Shrub Thicket; SHF: Sycamore-Mixed Hardwood Floodplain Forest; TF: Tuliptree Forest; VP: Virginia Pine Successional Forest; WM: Wet Meadow. n/a: species was in Perles et al. 2006 and/or NPSpecies 2015 but vegetation association was not specifically noted.

Three state-listed plants (1% of all species) have been recorded at EISE (Kunsman 2006, Perles et al. 2006, NPSpecies 2015) (Table 33). The status of one additional species: Eastern smooth beardtongue (*Penstemon laevigatus*), is tentatively undetermined but could be in danger of population decline according to the PA NHP (2015) (Table 33).

Nineteen invasive plants or potentially invasive plants (7% of all species) (Table 34) and 52 non-native plants (20% of all species) were recorded at EISE (Appendix Table 56). Since Perles et al. (2006) did not distinguish vegetation associations between GETT and EISE it is unknown which vegetation associations specifically at EISE contained invasive species. The MIDN does not have forest vegetation monitoring plots at EISE due to the lack of forested habitat, and therefore further information on exotics related to MIDN monitoring was not available.

The condition for plant species of concern was evaluated as unknown for both GETT and EISE Table 35) since there were no thresholds available to assess condition; however, the last survey for threatened and endangered species was done over ten years ago and may not be representative of the current species in GETT and EISE. Neither GETT nor EISE have been mapped for the areal extent of invasive plants as suggested by NPS (2000) guidelines; however, the MIDN forest vegetation monitoring indicated that exotic species at GETT were prevalent in the park and therefore invasive vegetation was evaluated as significant concern based on best professional judgement (Table 35). The condition of invasive plants at EISE was evaluated as unknown since invasives have been documented at EISE and recent data on the abundance and distribution were not available. However, both parks were taking proactive management actions, such as mechanical removal, chemical treatment, and prescribed burns, to reduce the abundance and distribution of invasive and exotic plants.

Table 36. Condition estimates for plant species of concern and invasive vegetation.

Metric	Good Condition	Moderate Concern	Significant Concern	GETT Condition	EISE Condition
Status of plant species of concern	Thresholds not available			Unknown	Unknown
Status of invasive plants	Thresholds not available or applicable to park[1]			Significant concern	Unknown

[1] Areal mapping of invasive species (as per NPS 2000 guidelines) was not available, but MIDN forest monitoring data and best professional judgement were used to assess condition.

4.3.2.4 Confidence in Assessment

The confidence in the assessment for both threatened and endangered species and invasive vegetation was low. Surveys for threatened and endangered plant species were conducted in 2004-2005 and may not be representative of the current species found in the parks. Invasive vegetation is present in the parks but the density and/or areal coverage was unknown.

4.3.2.5 Data Gaps

Plant species of special concern were last surveyed in 2004-2005 and another survey would be beneficial. The MIDN (Comiskey and Wakamiya 2011) has established protocols and metrics to evaluate invasive plants, but this was only within the forest vegetation plots. Invasive vegetation has been noted in several other vegetation associations (e.g., agricultural fields, palustrine shrub thicket, and wet meadows), but the density and extent were not known.

4.3.2.6 Threats

Nine of the 23 species of concern were found exclusively in forested areas, and an additional five were found in both forested and field habitats (Table 33). Kunsman (2006) noted that forest species, as far as their occurrences in GETT and EISE, grew in relatively stable habitats. The primary threats to their populations include competition from certain exotic species (e.g., Japanese barberry, stilt grass, and multiflora rose). An additional nine species were found in field habitats (with an additional five found in both field and forested habitats) (Table 33). Kunsman (2006) noted that these were successional species in their ecological requirements, thriving in open, grassland-type habitats, such as old fields and meadows. These types of habitats tend to be relatively temporary, and unless artificially maintained by a management practices (e.g., mowing, prescribed burns) would proceed by natural succession toward the establishment of habitats more dominated or completely dominated by woody plants, and with the subsequent loss of the species of special concern adapted to the previous successional stage. These successional species face a major threat if their required ecological stage is not continually maintained by some form of active management (Kunsman 2006).

Non-native invasive plants can negatively effect and/or threaten native species diversity and ecosystems, and seriously degrade the cultural landscape. NPS staff work to combat several invasive plant species such as the multiflora rose, Japanese barberry, tree of heaven, mile-a-minute (*Persicaria perfoliata*), and Canada thistle (*Cirsium arvense*). Park staff with the help of the Mid-Atlantic Plant Management Team treats these exotic species by chemical methods, mechanical methods, hand pulling and sprays (NPS 2016b).

Prescribed burns have recently (October 2013, September 2015, and April 2016) taken place at GETT and EISE. The prescribed burns are used to maintain the conditions of the battlefield as experienced by the soldiers who fought here; perpetuate the open space character of the landscape; maintain wildlife habitat; reduce shrub and woody species components, and reduce fuels in wooded areas to reduce fire hazard. Prescribed burns also help reduce invasive shrub encroachments and assist in promoting the establishment of native grasses on the historic earthworks and open fields, and thereby restoring the historic integrity of the Civil War battlefield scene and reducing the current demands for mechanical mowing and chemical treatment (NPS 2014, 2016c). Prescribed burns were conducted in two fields at GETT on 18 September 2015 and at the Munshower Field on 18 April 2016 (Figures 45 to 47).

Figure 45. Prescribed burn at GETT, 18 September 2015.

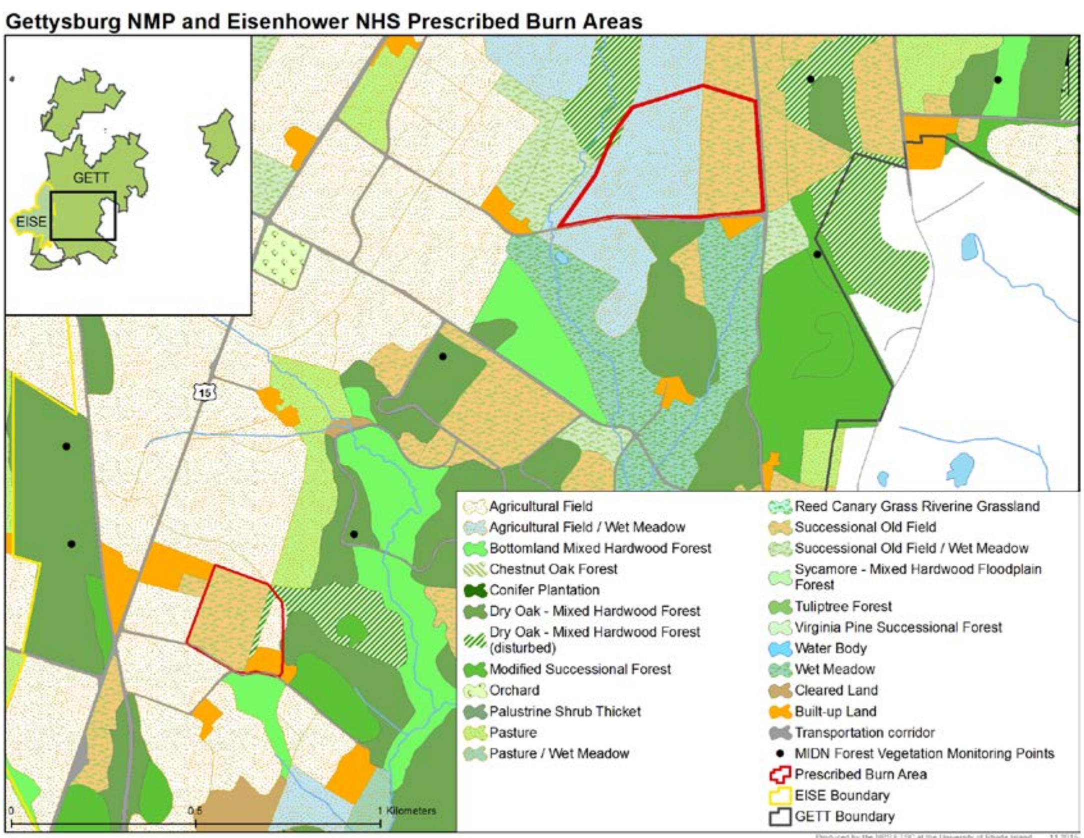


Figure 46. Prescribed burn areas (18 September 2015), MIDN forest monitoring plots, and NVC vegetation associations.

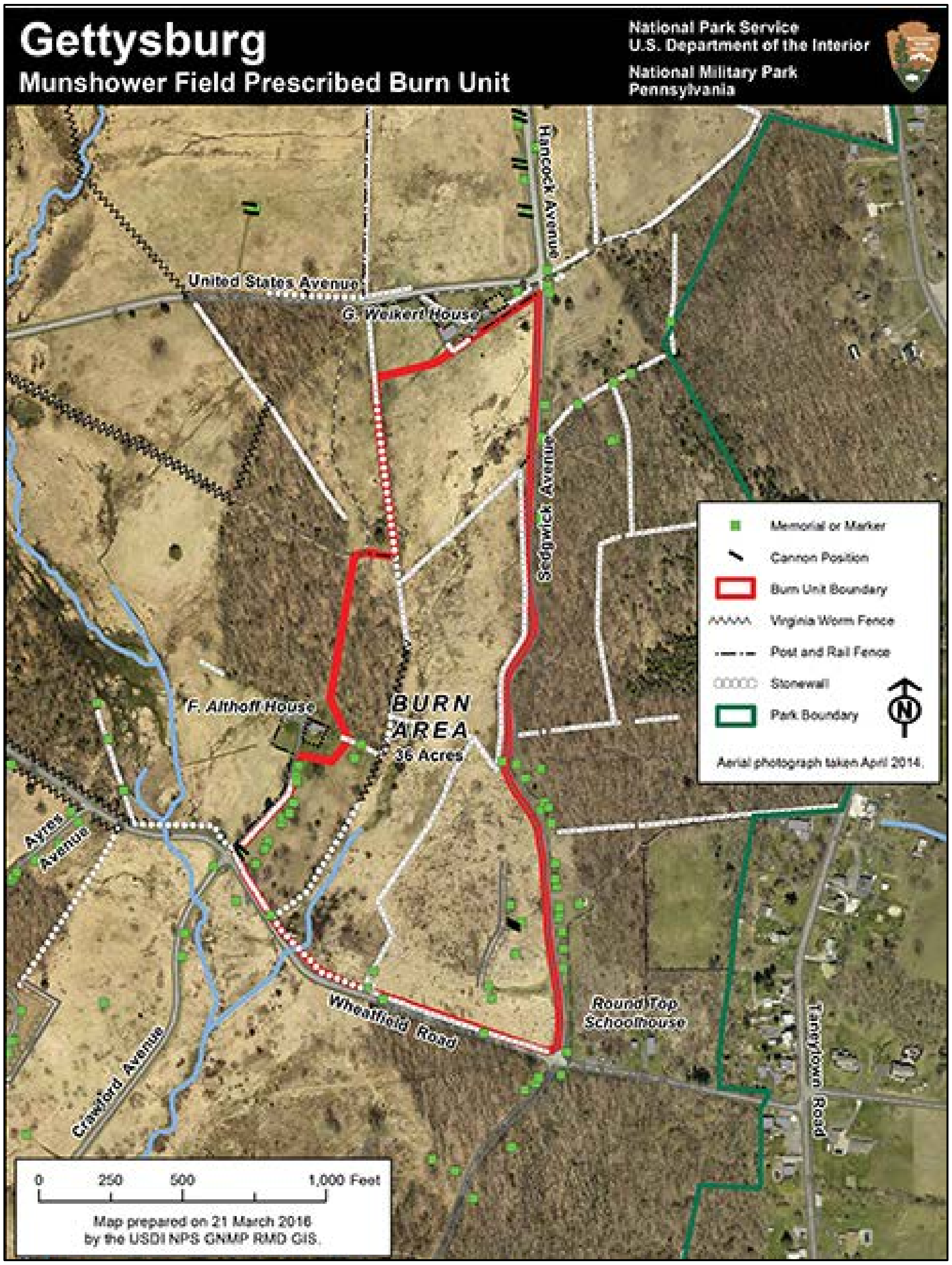


Figure 47. Munshower field prescribed burn area on 18 April 2016. Map source: NPS 2016c, https://www.nps.gov/gett/learn/news/nps-fire-managers-plan-prescribed-fire.htm

4.3.3 Agricultural Fields and Grasslands

4.3.3.1 Relevance and Context

Park management to maintain the historic and cultural landscape at GETT and EISE strongly influences vegetation within the parks. Agricultural fields and grasslands were the most common vegetation association in the parks, covering over 50% of the parks' area (Perles et al. 2006). Agricultural fields, successional old fields, active and inactive pastures, wet meadows, and reed canary grass riverine grassland areas, all contribute to the abundance of grasslands in the parks.

These large expanses of grasslands are primarily managed as a cultural resource to restore and perpetuate the battlefield as it appeared at the time of the Battle of Gettysburg, but they also provide critical habitat for a variety of flora and fauna, such as grassland obligate bird species, turtles and snakes, small mammals, and rare plant species.

The parks' grasslands provide habitat for several species of birds and mammals, including bobolink (*Dolichonyx oryzivorus*), grasshopper sparrow (*Ammodramus savannarum*), eastern meadowlark (*Sturnella magna*), loggerhead shrike (*Lanius ludovicianus*), short-eared owl (*Asio flammeus*), upland sandpiper (*Bartramia longicauda*), northern harrier (*Circus cyaneus*), barn owl (*Tyto alba*), and least shrew (*Cryptotis parva*) (e.g., Peterjohn 2006). Wet meadows and successional old fields also provide habitat for several rare plant species, including rigid sedge (*Carex tetanica*), bog rush (*Juncus biflorus*), whiteroot rush (*Juncus brachycarpus*), Buxbaum's sedge (*Carex buxbaumii*), low spearwort (*Ranunculus pusillus*), orange coneflower (*Rudbeckia fulgida*), hoary frostweed (*Helianthemum bicknellii*), Heller's rosette grass (*Dichanthelium oligosanthes* var. *oligosanthes*), eastern smooth beardtongue (*Penstemon laevigatus*), and sidebeak pencilflower (*Stylosanthes biflora*) (Yahner et al. 2001b, Perles et al. 2006).

4.3.3.2 Data and Methods

The NVC vegetation mapping effort classified the agricultural fields and grasslands into several alliances (Table 36, Figure 48) (Perles et al. 2006). However, battlefield rehabilitation at GETT has significantly altered the vegetation in many sections of the park since the mapping effort; and the vegetation map completed by Perles et al. (2006) was significantly out of date even before that report was published. The park has maintained an in-house draft GIS database of the battlefield rehabilitation efforts (C. Musselman. personal communication, email 8 June 2016) and based on these GIS data there are approximately 782 ha of agricultural fields, grasslands, and crops at GETT and 248 ha of meadows/grasslands and pastures at EISE (Figure 48). The fields at GETT and EISE have not been specifically surveyed except when they were included as a habitat during focal surveys for other species such as mammals and grassland birds (e.g., Yahner et al. 2001b, Hart 2006b, Peterjohn 2007).

Table 37. Field habitat[1] at GETT and EISE.

Type	GETT ha	EISE ha
Cropland	46.8	0
Grass/Meadow	653.3	200.4
Pasture	81.5	47.6
Total	781.5	248.0

[1] Area calculated from in-house draft GIS databases (GIS data courtesy of C. Musselman).

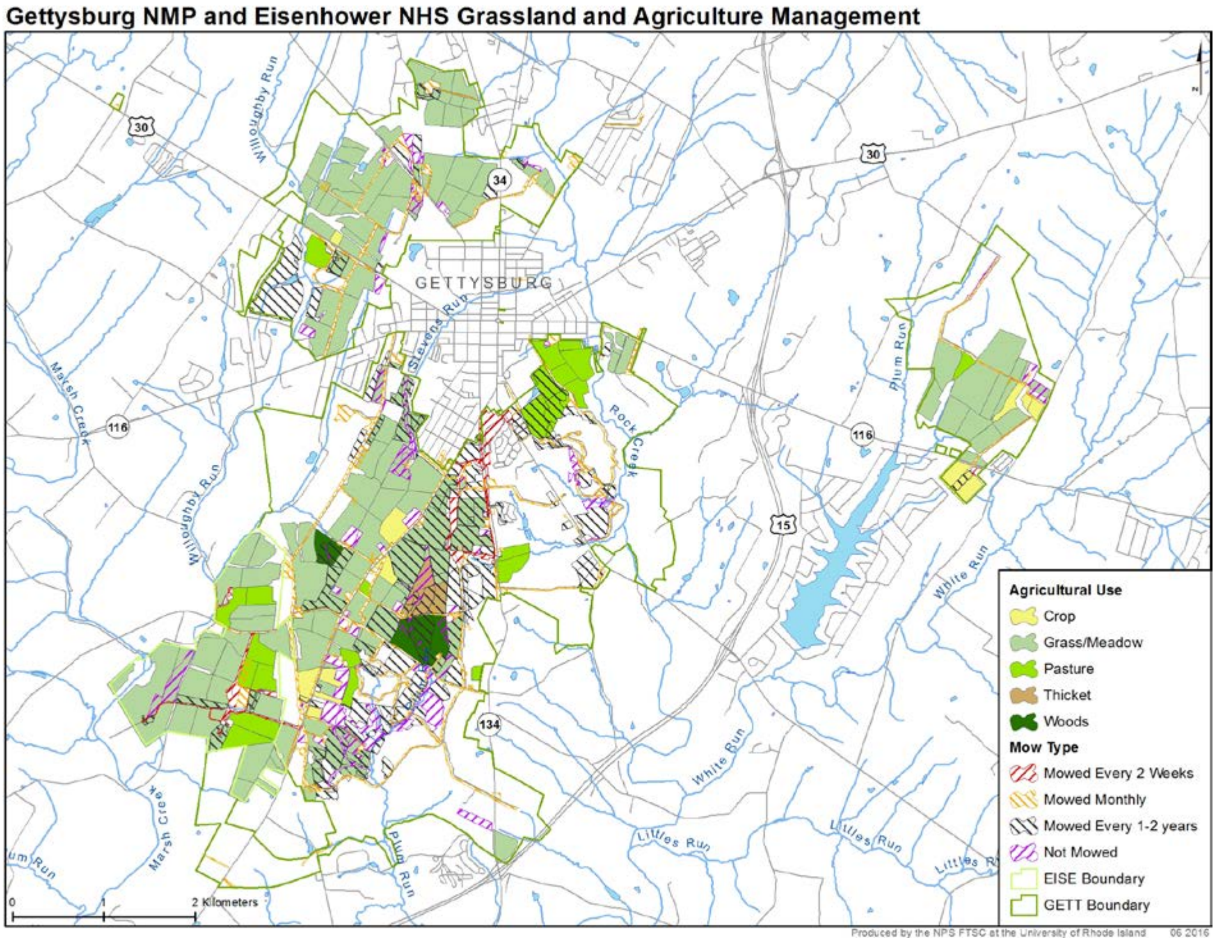


Figure 48. Grassland and agricultural lands GETT and EISE. Current mowing management plans are also shown (Draft GIS data courtesy of C. Musselman).

4.3.3.3 Reference Condition and Status of the Resource (current condition and trends)

At both parks, the grasslands are hayfields or active pastures (grazed by horses and cattle) and are managed through agricultural leases and/or fields maintained by the NPS. The parks have a mowing plan in place for some fields that consists of four classes: mowed every two weeks, mowed monthly, mowed every one to two years, and not mowed (Figure 48). Most grasslands in the parks are composed of introduced cool-season grasses, but GETT maintains a few fields dominated by switchgrass (*Panicum virgatum*) and is creating additional warm-season grasslands (Peterjohn 2007). Other management activities, such as the removal of trees from specific sites to produce open landscapes that existed at the time of the battle or prescribed burns to reduce woody and invasive vegetation, may produce additional grassland or shrubland habitats in the future (NPS 2014).

Yetter et al. (2013) in their NRCA for Allegheny Portage Railroad NHS developed a suite of potential metrics and thresholds to assess the condition of agricultural fields in cultural parks. The metrics were modeled after Peterjohn's (2006) management suggestions for grassland birds for cultural parks in the MIDN Network. The metrics put forth by Yetter et al. (2013) were (refer to Table 37):

- field patch size: larger the contiguous patch size is beneficial (reduces habitat fragmentation);
- perimeter to area (P:A) ratio of the fields: patch shapes that minimize the amount of edge are beneficial (e.g., predation is to likely to occur near habitat edges);
- mow plans: mowing after grassland bird nestlings have fledged, and mowing to prevent succession to woody habitat;
- Floristic Quality Index (FQI) score: an indication of the structural and species composition of the grassland, monocultures are less desirable.

Table 38. Metrics and thresholds used to assess the condition of agricultural fields and grasslands (after Yetter et al. 2013).

Metric	Good Condition	Moderate Concern	Significant Concern	Description
Field size for grassland obligate bird species	10-20 ha	4.9-10 ha[1]	< 4.9 ha	Calculated as contiguous habitat.
Perimeter to Area (P:A) ratio	> 66	33 - 66	< 33	Calculated as the ratio of (Reference[2] P:A /Actual P:A)*100. Greater P:A ratio indicates less edge and is therefore more suitable habitat.
Mow plans	Mow in Sept/Oct	Mow before July 4 & in Sept/Oct	Mow before June 19, July 17, Aug 21, & Sept 18 Or No mow plans	Rated as percentage of potential grassland habitats in each of these categories.
Floristic Quality Index (FQI)	35 - 52	18 - 34	0 - 17	Calculated as: $I' = \left(\frac{\bar{C} \times \sqrt{N}}{10 \times \sqrt{N + A}} \right) \times 100$ Where $\bar{C}$ is the average coefficient of conservatism for native species, *N* is native species richness and *A* is the number of non-native species (after Miller and Wardrop 2006).

[1] In landscapes with large tracks of grasslands.

[2] The reference P:A is calculated as the perimeter to area ratio of a circle the same area of the field's polygon.

Gettysburg National Military Park

Using the metrics put forth by Yetter et al. (2013) the condition of the grassland/meadows at GETT (137 parcels totaling ~653.3 ha) were assessed as significant concern for field size (too small for grassland obligate birds) and good condition for P:A ratio (Table 38). Although the park has mow plans in place, only two parcels (refer to Table 39) at GETT that scored as good for both size and P:A had a mow plan that was conducive to grassland birds. The mow plans for other parcels that scored good for these metrics were unknown as indicated by in-house GIS data (GIS data layers: agfield2013 and mowplan2015). Therefore, mow plans were evaluated as moderate concern. Floristic index was evaluated as unknown (there were no data on the vegetation communities of the grasslands). Trends were not assessed for these metrics as the battlefield rehabilitation maintenance (e.g., mowing, thinning of thickets, prescribed burns) continues and the in-house GIS data were in draft form.

Table 39. Condition assessment for agricultural fields and grasslands at GETT and EISE. Number of individual parcels is indicated in parentheses.

Metric	Good Condition	Moderate Concern	Significant Concern	Condition[1]
GETT				
Field size for grassland obligate birds (percent of all fields and number of fields)	9% (12)	28% (38)	64% (87)	(score=23)
Perimeter to Area (P:A) ratio (percent of all fields and number of fields)	91% (125)	9% (12)	%0 (0)	(score=95)
Mow plans	Mow plans are in place, but not all fields have a mow plan			
Floristic Quality Index	No data available			
EISE				
Field size for grassland obligate birds (percent of all grassland/meadow areas)	14% (4)	54% (15)	32% (9)	(score=41)
Perimeter to Area (P:A) ratio (percent of all grassland/meadow areas)	89% (25)	11% (3)	0% (0)	(score=94)
Mow plans	Mow plans are in place, but not all fields have a mow plan			
Floristic Quality Index	Not evalauated/No data available			

[1] Average score condition based on NRCA guidelines for multiple metrics, refer to Table 7.

Table 40. Grassland and meadow parcels at GETT and EISE that had "good" condition for size and perimeter to area ratio (P:A) for grassland bird habitat. Mow plan, if known, is also indicated.

FID[1]	Permitee	Field Name	Size (ha)	P:A ratio[2]	Mow plan[3]
GETT Parcels					
14	L. Wilkinson	McClean Farm6	10.5	70.6	unknown
16	L. Wilkinson	McClean Farm5	10.2	90.1	unknown
70	None	Bliss Farm1	10.4	83.8	unknown
71	None	Bliss Farm5	10.5	87.6	unknown
91	J. Wolf	Spangler/Sherfy2	15.4	76.0	unknown
93	J. Wolf	Spangler/Sherfy8	11.3	67.8	unknown
106	J. Sanders	E. Cavalry Field W.7	11.6	83.9	unknown
107	J. Sanders	E. Cavalry Field W.2	17.8	88.5	unknown
111	J. Sanders	E. Cavalry Field W.1	15.2	87.3	unknown
136	G. Trostle	Codori-Trostle4	13.8	73.3	Mowed every 1 to 2 years
137	G. Trostle	Codori-Trostle3	15.0	87.5	Mowed every 1 to 2 years
EISE Parcels					
140	J. Wolf	Smith-Rhinehart Farm5	11.7	85.4	unknown
154	J. Wolf	Bushman/Rose/Snyder/Warfield7	11.9	80.8	unknown
175	W. Martin	Eisenhower 1 & 23	10.1	85.1	unknown
195	R. Rohrbaugh	Eisenhower Farm4	25.8	68.3	unknown/ partial do not mow (8.5 ha)

[1] FID: unique feature identifier for in-house GIS data file "agfield2013". The "agfield2013" and "mowplan2015" data layers were cross referenced to develop this table. Data courtesy of C. Musselman.

[2] Refer to Table 26 for P:A calculation methods.

[3] "unknown" indicates a mow plan "type" was not indicated in the draft GIS in-house data layer.

Eisenhower National Historic Site

The condition of the grassland/meadows (28 parcels totaling ~200ha) at EISE was assessed as moderate concern for field size (too small for grassland obligate birds) and good condition for P:A ratio (Table 38). Similar to GETT, only a portion one parcel at EISE that scored good for both area and P:A ratio had a mow plan (refer to Table 39). Other parcels that scored as good for these metrics had unknown mowing regimes as indicated by in-house GIS data (GIS data layers: agfield2013 and mowplan2015). Therefore, mow plans were evaluated as moderate concern. Floristic index was evaluated as unknown (there were no data on the vegetation communities of the grasslands). Trends were not assessed for these metrics as the battlefield rehabilitation maintenance (e.g., mowing, thinning of thickets, prescribed burns) continues and the in-house GIS data were in draft form.

4.3.3.4Confidence in Assessment

The confidence in the assessment for field size, perimeter to area ratio, and mow plans was medium as these values were calculated from draft in-house GIS data and recent rehabilitation efforts (e.g., prescribed burns) have yet to be incorporated into the database.

4.3.3.5 Data Gaps

The NVC mapping data were out of date due to landscape rehabilitation; however, the park is maintaining an in-house GIS data, but these data layers have not yet been merged or cross-referenced with the NVC data. A current vegetation map of the parks would be beneficial. Even though the perimeter to area ratio scored as good for both GETT and EISE, the majority of the grassland/meadow parcels were too small to provide suitable habitat for grassland birds. Focusing management on parcels (refer to Table 39) that scored good for both parcel size and P:A ratio may be beneficial to encourage grassland bird abundance. Updating and merging the in-house GIS data files (agfield2013 and mowplan2015) and developing FGDC compliant metadata would be beneficial to develop a mow plan strategy that would benefit grassland birds. Conducting a grassland vegetation survey to estimate Floristic Quality Index for grasslands would be beneficial, even if only done on a few selected fields such as those indicated in Table 39.

4.3.3.6 Threats

Threats to agricultural fields and grassland include invasive and exotic vegetation, and successional change to woody vegetation. Park management activities, such as rotational mowing, re-establishment of native grasses, selective tree removal, and prescribed burns will assist with the management and maintenance of open grassland habitat (NPS 2014). However, there were several grassland/meadows that had good area and P:A ratios that did not have a mow plan associated with them (refer to Table 39) and developing appropriate mow plans for these parcels could be a management priority.

4.4 Biological Integrity- Focal Terrestrial Animal Communities

4.4.1 Avian Community

4.4.1.1 Relevance and Context

Birds are an important component of park ecosystems and their prominent position in most food webs make them a good sentinel of local and regional ecosystem change. As high profile taxa, many parks provide information on the status and trends of the park's avian community through their interpretive materials and programs (O'Connell et al. 2003, Faccio et al. 2010). In 2009, the MIDN began a volunteer pilot bird monitoring program at three network parks and later expanded to include six network parks (Appomattox Court House National Historic Park, Booker T. Washington National Monument, Fredericksburg and Spotsylvania National Military Park, Petersburg National Battlefield, Richmond National Battlefield Park, and Valley Forge National Historic Park) (Johnson 2014), but bird monitoring is not currently planned for implementation at GETT or EISE (Comiskey and Callahan 2008).

Continental and local declines in bird populations have led to concern for the future of migratory and resident landbirds (Kearney 2003). The causes of population declines are numerous and complex, and include but are not limited to, habitat loss, degradation, and fragmentation of breeding and wintering grounds, and along migratory routes. Additional factors include predation, nest predation, and brood parasitism (Kearney 2003). In 1990, various government agencies, academic institutions, conservation groups, private industry, and citizens worked together to form Partners in Flight (PIF). This voluntary, international coalition is dedicated to "keeping common birds common" (Pashley et al. 2000). PIF helps direct resources for the conservation of landbirds and their habitats with a foundation of scientifically-based Bird Conservation Plans focused on physiographic areas. GETT and EISE are located in the Mid-Atlantic Piedmont, Bird Conservation Region (BCR) 10, PIF physiographic area (Kearney 2003). There are six entry levels for the priority PIF designations (after Kearney 2003):

- Tier I: High Continental Priority: species which are typically of conservation concern throughout their range where a high level of conservation attention warranted.
  - Tier IA. *High Continental Concern + High Regional Responsibility*. Species for which this region shares in major conservation responsibility; i.e., conservation in this region is critical to the overall health of this species. These species are on
  - Tier IB. *High Continental Concern + Low Regional Responsibility*. Species for which this region can contribute to rangewide conservation objectives where the species occurs.
- Tier II. *High Regional Priority*. Species that are of moderate continental priority but are important to consider for conservation within a region.
  - Tier IIA. *High Regional Concern*. Species that are experiencing declines in the core of their range and that require immediate conservation action to reverse or stabilize trends.
  - Tier IIB. *High Regional Responsibility*. Species for which this region shares in the responsibility for long-term conservation, even if they are not currently declining or threatened.

- Tier IIC. *High Regional Threats*. Species of moderate overall priority that are uncommon in a region and whose remaining populations are threatened, usually because of extreme threats to sensitive habitats

- Tier III. *Additional Federally Listed*. Species protected under federal endangered species laws receive conservation attention wherever they occur.

Grassland obligate birds require large, open, unfragmented sections of grassland field habitats. During the twentieth century, grassland birds have exhibited the most consistent population declines of any group of North American birds (Peterjohn and Sauer 1999). While the widespread conversion of grasslands into other habitats contributed to these population declines, other factors, such as habitat fragmentation and unfavorable mowing regimes, were also implicated (Vickery et al. 1999). The PIF conservation plan for Mid-Atlantic Piedmont area has specific management objectives for grassland birds. Grassland species such as the upland sandpiper (*Bartramia longicauda*), horned lark (*Eremophila alpestris*), vesper sparrow (*Pooecetes gramineus*), grasshopper sparrow (*Ammodramus savannarum*), and Eastern meadowlark (*Sturnella magna*) have decreased by an average of 10% per year and are among the most steeply declining birds in this area. This continues a trend noted throughout the eastern United States (Askins 2000). A lack of Breeding Bird Survey data prevents a definitive assessment of population trends for the savannah sparrow (*Passerculus sandwichensis*), bobolink (*Dolichonyx oryzivorus*), and dickcissel (*Spiza americana*) in the Piedmont; however, these birds are known to be declining elsewhere in their ranges (Rosenberg and Wells 1999). The PIF conservation plan suggests the identification and acquisition, management, and/or restoration of grassland habitats > 50 ha with the potential to support Henslow's sparrow (*Ammodramus henslowii*), or that support significant populations of upland sandpiper, vesper sparrow, or grasshopper sparrow (Kearney 2003).

GETT and EISE maintain a combined area of approximately 1,000 ha of grasslands and 18 ha of thicket within the parks (C. Musselman, personal communication, in-house GIS data). The grasslands are hayfields managed through agricultural leases and fields maintained by the NPS. The parks discourage hay harvesting before July in all fields in an effort to improve the reproductive success of grassland birds. Most grasslands in the parks are composed of introduced cool-season grasses, but GETT maintains a few fields dominated by switchgrass (*Panicum virgatum*) and is creating additional warm-season grasslands (Peterjohn 2007). Other management activities, such as the removal of trees from specific sites to produce open landscapes that existed at the time of the battle or prescribed burns to reduce invasive vegetation, may produce additional grassland or shrubland habitats in the future (NPS 2014). Shrublands are scarce in the parks, with no shrublands present at EISE, and limited narrow corridors (<10 m) bordering fields and drainages at GETT (Peterjohn 2007).

<u>4.4.1.2 Data and Methods</u>

The avian communities at GETT and EISE have been surveyed twice in the past 15 years. Yahner et al. (2001b) conducted surveys in 1999 to 2001, which included a focal survey for loggerhead shrikes (*Lanius ludovicianus*) at EISE. A focal study on grassland and shrubland birds was conducted in the parks in 2005 (Peterjohn 2007). Yahner et al. (2001b) used fixed and unlimited distance point counts, vehicular-road surveys (for diurnal raptors and vultures), nocturnal surveys (for owls), and targeted surveys for loggerhead shrikes (at EISE only). Point count surveys were stratified by major habitat type (e.g., deciduous forest, perennial herbaceous), spatial location (e.g., road edge, interior forest), and elevation (e.g., plateau, high, low), with 15 points in EISE and 75 points in GETT. Point-count stations were visited during each of the four seasons (spring-migratory: 15 April-25 May, breeding-summer: 25 May-15 July, fall-migratory: 25 August-10 October, and winter: 1 December-15 March). During point-count surveys all birds heard or seen during a 10-min period were recorded. Owls were surveyed at the vehicular-road stations using owl call-back recordings (Yahner et al. 2001b). Yahner et al. (2001b) did not provide estimates of breeding bird populations in grasslands or shrubland habitats.

Yahner et al. (2001b) also conducted a focal survey for loggerhead shrikes at EISE. The 13.7-km survey route contained 17 stations and encompassed secondary roads traversing the four farms at EISE and areas proximal to the park that recently contained nesting shrikes. Stations were located adjacent to pasture and/or barbed-wire fencing, and the distance between stations was greater than 0.36-km (0.2 miles). Loggerhead shrike surveys were monitored for two years (May 1999-June 2001) (Yahner et al. 2001b).

A Bird Community Index (BCI) for songbirds developed for the Mid-Atlantic Piedmont and Coastal Plain (O'Connell et al. 2003) was used to evaluate the condition of the avian community at GETT and EISE. This is the same BCI that is used by the MIDN in their pilot volunteer bird monitoring program within six network parks (e.g., Johnson 2014). The BCI incorporates the percent of songbird species in nine bird guilds in three biotic elements (structural, functional, and compositional, three guilds per biotic element) to rank the avian community during the breeding season (Table 40). The nine guilds included both specialists and generalist species. Specialist guilds (bark probers, ground gleaners, interior forest, pine associated species, single brooders, and upper canopy foragers) contained species with a narrow range of habitat tolerances or that exhibited low intrinsic rates of population increase. Therefore, these guilds were thought of as indicative of a high-integrity ecological condition while generalist guilds (exotics, nest disrupters, urban/suburban species) were considered indicative of a low-integrity ecological condition (O'Connell et al. 2003). The percent of species in the nine guilds were scored from 1 (bad) to 4 (good) for each guild and then the average rank for each biotic element was calculated. The BCI was calculated by summing the average ranks of the biotic elements and dividing by the number of guilds (9). O'Connell et al. (2003) suggested the following ranking criteria (see below) to evaluate the condition of the breeding avian community based on the nine guild system BCI score. This BCI was applied to the data collected by Yahner et al (2001b) during the breeding season. In this NRCA, based on best professional judgement, the condition of the avian community was assessed.

BCI score and assessed condition (refer to Table 40):

- Humanistic: 0.250-.0460 (Significant Concern)
- Moderately disturbed: 0.461-0.600 (Moderate Concern)
- Largely intact: 0.610-0.730 (Good)

- Naturalistic: 0.731-1.000 (Good)

Table 41. Ranks for specific avian guild percentages for nine guilds in the Piedmont/Coastal Plain Bird Community Index (table from O'Connell et al. 2003).

	Bad →			Good
Biotic Element and Guild	**Rank 1**	**Rank 2**	**Rank 3**	**Rank 4**
Structural				
Forest Interior (specialist)	0-10.0	10.1-20.0	20.1-28.0	28.0-100
Pine associated (specialist)	0	0.1-2.0	2.1-5.0	5.1-100
Urban/suburban (generalist)	60.1-100	47.1-60.0	20.1-47.0	0-20.0
Functional				
Bark prober (specialist)	0-9.0	9.1-16.0	16.1-20.0	20.1-100
Upper canopy gleaner (specialist)	0-4.0	4.1-12.0	12.1-18.0	18.1-100
Ground gleaner (specialist)	0	0.1-3.0	3.1-7.0	7.1-100
Compositional				
Single brooder (specialist)	0-16.0	16.1-34.0	34.1-46.0	46.1-100
Nest disrupter (generalist)	23.1-100	16.1-23.0	0.1-16.0	0
Exotic (generalist)	11.1-100	1.1-11.0	0.1-1.0	0

Peterjohn (2007) surveyed grassland and shrubland birds at GETT and EISE during the breeding season (19 May – 1 July) in 2005. Fields in both parks were surveyed using an area search method, with survey paths along the field perimeter and 50 m inside and parallel to the perimeter. The number of survey paths was dependent on field size with larger fields having more survey paths. Grassland surveys focused only on obligate grassland birds: bobolink, Eastern meadowlark, grasshopper sparrow, Henslow's sparrow, Savannah sparrow, and vesper sparrow.

The MIDN is still exploring metrics to evaluate the condition of grassland birds within network parks (Johnson 2014). However, the Northeast Temperate Network (NETN) Breeding Landbird protocol has guidelines for evaluating the integrity of grassland bird communities (Faccio et al. 2010). Similar to the O'Connell et al. (2003) BCI, the NETN protocol uses the presence of certain guilds (e.g., edge generalist, shrub-dependent, grassland obligate, and exotic species) to assess the condition of the grassland bird community (Table 41). Unfortunately, this assessment could not be applied to the data collected by Peterjohn (2007) as several metrics were not available from his data (e.g., point-counts of abundance, observations of exotic species, and edge-dependent species). The NETN criteria are presented herein as an example of metrics that could be used to assess grassland bird communities.

Table 42. Potential metrics that could be used to assess the condition of grassland bird community at GETT and EISE (based on the NETN Breeding Landbird protocol, Faccio et al. 2010).

Metric	Good	Moderate Concern	Significant Concern
Abundance (birds/point)			
Edge generalist species	< 6.0	6.0-10.0	> 10.0
Shrub-dependent species	< 1.0	1.0-5.0	> 5.0
Grassland obligate species	> 4.0	1.5-4.0	< 1.5
Exotic species	0.0	0.1-1.0	> 1.0
Proportional Species Richness (%)			
Edge generalist species	< 20%	20-50%	> 50%
Shrub-dependent species	< 10%	10-25%	> 25%
Grassland obligate species	> 10%	5-10%	< 5%
Exotic species	0%	0.1-3%	> 3%
Abundance (birds/point)			
Proportion of PIF Priority Grassland Species for BCR 10[1] (# detected/1)	> 80%	50-80%	< 50%
Proportion of PIF Priority Shrubland Species for BCR 10[1] (# detected/5)	< 50%	50-75%	> 75%

[1] The NETN assessment used BCR 13 (Lower Great Lakes/St. Lawrence Plain) as their assessment was developed for Saratoga National Historic Park. GETT and EISE are located in BCR 10 (Mid-Atlantic Piedmont).

4.4.1.3 Reference Condition and Status of the Resource (current condition and trends)

Gettysburg National Military Park

At GETT, Yahner et al. (2001b) documented 151 species including four state-endangered birds: blackpoll warbler (*Dendroica striata*), short-eared owl, upland sandpiper (*Bartramia longicauda*), and yellow-crowned night-heron (*Nyctanassa violacea*). Yahner et al. (2001b) also observed Henslow's sparrow (*Ammodramus henslowii*, state listed rare) and barn owl (*Tyto alba*, state listed candidate at risk) at GETT. Only the blackpoll warbler was observed during the breeding season. Historical records indicated that the great egret (*Ardea alba*, state endangered) and bald eagle (*Haliaeetus leucocephalus*, state threatened) had also been observed at GETT prior to the 2001 survey (Tables 42 and 43, Appendix Table 60) (Pennsylvania T and E Species 2015).

Additionally, 25 species of birds observed by Yahner et al. (2001b) at GETT were listed as priority species by PIF for the Mid-Atlantic Piedmont Physiographic Area (Kearney 2003). Three of these: prairie warbler (*Dendroica discolor*), wood thrush (*Hylocichla mustelina*), and American woodcock (*Scolopax minor*) had a PIF status of IA: High Continental Priority-High Regional Responsibility. The prairie warbler and wood thrush were observed during the breeding season at GETT (Yahner et al. 2001b).

Table 43. State-listed and PIF bird species that have been recorded at GETT and EISE during various surveys (Yahner et al. 2001b, Peterjohn 2007).

Scientific Name	Common Name	State/PIF Status[1]	Park (B: indicates observed during the breeding season)
Ammodramus henslowii	Henslow's sparrow	IB, PA-CR	GETT
Anas rubripes	American black duck	I	GETT[2]
Ardea alba	Great egret	PA-PE	GETT[2]
Asio flammeus	Short-eared owl	PA-PE	GETT, EISE
Bartramia longicauda	Upland sandpiper	IB, PA-PE	GETT
Butorides virescens	Green heron	IIA	GETT (B), EISE (B)
Chaetura pelagica	Chimney swift	IIA	GETT (B), EISE (B)
Colinus virginianus	Northern bobwhite	IIA	GETT[2]
Dendroica cerulean	Cerulean warbler	IB	GETT
Dendroica discolor	Prairie warbler	IA	GETT (B), EISE (B)
Dendroica striata	Blackpoll warbler	PA-PE	GETT (B)
Empidonax traillii	Willow flycatcher	IB	GETT (B), EISE (B)
Empidonax virescens	Acadian flycatcher	IIB	GETT (B), EISE (B)
Euphagus carolinus	Rusty blackbird	IIA	GETT
Haliaeetus leucocephalus	Bald eagle	PA-PT	GETT[2]
Helmitheros vermivorum	Worm-eating warbler	IB	GETT, EISE (B)
Hylocichla mustelina	Wood thrush	IA	GETT (B), EISE (B)
Lanius ludovicianus	Loggerhead shrike	IIC, PA-PE	EISE (B)
Megascops asio	Eastern screech-owl	IIA	GETT
Melanerpes erythrocephalus	Red-headed woodpecker	IB	GETT (B), EISE (B)
Nyctanassa violacea	Yellow-crowned night heron	PA-PE	GETT
Oporornis formosus	Kentucky Warbler	IB	GETT (B), EISE
Pipilo erythrophthalmus	Eastern towhee	IIA	GETT (B), EISE (B)
Piranga olivacea	Scarlet tanager	IIB	GETT (B), EISE
Scolopax minor	American woodcock	IA	GETT, EISE
Seiurus motacilla	Louisiana waterthrush	IIB	GETT, EISE

[1] PA State status codes: PA-CA; Candidate at risk, PA-CR; Candidate rare, PA-PE: state endangered, PA-PT: state threatened; PIF status: I: High Continental Priority; IA: High Continental Priority, High Regional Responsibility; IB: High Continental Priority, Low Regional Responsibility; IIA: High Regional Concern; IIB: High Regional Responsibly; IIC: High Regional Threats; IV: Additional State Listed (Kearney 2003)

[2] Historical record.

Table 42 (continued). State-listed and PIF bird species that have been recorded at GETT and EISE during various surveys (Yahner et al. 2001b, Peterjohn 2007).

Scientific Name	Common Name	State/PIF Status[1]	Park (B: indicates observed during the breeding season)
Spizella pusilla	Field sparrow	IIA	GETT (B), EISE (B)
Tyto alba	Barn owl	PA-CA	GETT
Vermivora pinus	Blue-winged warbler	IB	GETT
Wilsonia canadensis	Canada warbler	IB	GETT

[1] PA State status codes: PA-CA; Candidate at risk, PA-CR; Candidate rare, PA-PE: state endangered, PA-PT: state threatened; PIF status: I: High Continental Priority; IA: High Continental Priority, High Regional Responsibility; IB: High Continental Priority, Low Regional Responsibility; IIA: High Regional Concern; IIB: High Regional Responsibly; IIC: High Regional Threats; IV: Additional State Listed (Kearney 2003)

[2] Historical record.

Table 44. Bird species observed during the breeding season at GETT and EISE in 2001 (Yahner et al. 2001b). Guild type and specific guilds are after O'Connell et al. (2003) for forest breeding birds and Faccio et al. (2010) for grassland obligate birds.

Scientific Name	Common Name	Guild Type	Guild1	GETT 2001	EISE 2001
Accipiter cooperii	Cooper's hawk	n/a	n/a	X	
Accipiter striatus	Sharp-shinned hawk	n/a	n/a	X	
Agelaius phoeniceus	Red-winged blackbird	grassland	SD	X	X
Aix sponsa	Wood duck	n/a	n/a	X	
Ammodramus savannarum	Grasshopper sparrow	grassland	GO	X	X
Anas platyrhynchos	Mallard	n/a	n/a		X
Archilochus colubris	Ruby-throated hummingbird	forest	U	X	
Ardea herodias	Great blue heron	n/a	n/a	X	X
Baeolophus bicolor	Tufted titmouse	forest	BP	X	X
Bombycilla cedrorum	Cedar waxwing	forest/grassland	U, EG	X	X
Branta canadensis	Canada goose	n/a	n/a	X	X
Bubo virginianus	Great horned owl	n/a	n/a	X	
Buteo jamaicensis	Red-tailed hawk	n/a	n/a	X	X
Buteo lineatus	Red-shouldered Hawk	n/a	n/a	X	X
Buteo platypterus	Broad-winged hawk	n/a	n/a	X	
Butorides virescens	Green heron	n/a	n/a	X	X
Cardinalis cardinalis	Northern cardinal	forest/grassland	U, SD		X
Carduelis tristis	American goldfinch	forest/grassland	U, EG	X	X

[1] Guilds used to assess the forest breeding bird community condition (after O'Connell et al. 2003) BP: bark prober forager, E: exotic, GG: ground gleaner forager, IF: interior forest, ND: nest disrupter, P: Pine associated, UC: high canopy forager, S: single brooded, U: urban/suburban. NETN Grassland guilds that could be used to assess condition: E: exotic, EG: edge generalist, GO: grassland obligate, SD: shrub-dependent (after Faccio et al. 2010). n/a: not assigned to a guild.

Table 43 (continued). Bird species observed during the breeding season at GETT and EISE in 2001 (Yahner et al. 2001b). Guild type and specific guilds are after O'Connell et al. (2003) for forest breeding birds and Faccio et al. (2010) for grassland obligate birds.

Scientific Name	Common Name	Guild Type	Guild1	GETT 2001	EISE 2001
Carpodacus mexicanus	House finch	forest/grassland	E, U, EG	X	X
Cathartes aura	Turkey vulture	n/a	n/a	X	X
Catharus fuscescens	Veery	forest	BP, IF, S	X	
Certhia americana	Brown creeper	n/a	n/a	X	
Chaetura pelagica	Chimney swift	forest	S, U	X	X
Charadrius vociferus	Killdeer	n/a	n/a	X	X
Coccyzus americanus	Yellow-billed cuckoo	forest	S, UC	X	X
Coccyzus erythropthalmus	Black-billed cuckoo	forest	S	X	
Colaptes auratus	Northern flicker/yellow shafted flicker	forest	GG, S	X	X
Columba livia	Rock Dove	forest/grassland	U, E, EG	X	X
Contopus virens	Eastern wood-pewee	forest	IF, S	X	X
Coragyps atratus	Black vulture	n/a	n/a	X	X
Corvus brachyrhynchos	American crow	forest/grassland	ND, U, EG	X	X
Corvus ossifragus	Fish crow	forest/grassland	ND, S, EG	X	X
Cyanocitta cristata	Blue jay	forest	ND, U	X	X
Dendroica discolor	Prairie warbler	forest/grassland	S, SD	X	X
Dendroica petechia	Yellow warbler	forest	S	X	X
Dendroica striata	Blackpoll warbler	n/a	n/a	X	

[1] Guilds used to assess the forest breeding bird community condition (after O'Connell et al. 2003) BP: bark prober forager, E: exotic, GG: ground gleaner forager, IF: interior forest, ND: nest disrupter, P: Pine associated, UC: high canopy forager, S: single brooded, U: urban/suburban. NETN Grassland guilds that could be used to assess condition: E: exotic, EG: edge generalist, GO: grassland obligate, SD: shrub-dependent (after Faccio et al. 2010). n/a: not assigned to a guild.

Table 43 (continued). Bird species observed during the breeding season at GETT and EISE in 2001 (Yahner et al. 2001b). Guild type and specific guilds are after O'Connell et al. (2003) for forest breeding birds and Faccio et al. (2010) for grassland obligate birds.

Scientific Name	Common Name	Guild Type	Guild1	GETT 2001	EISE 2001
Dolichonyx oryzivorus	Bobolink	forest/grassland	S, GO	X	X
Dryocopus pileatus	Pileated woodpecker	forest	BP, IF, S	X	
Dumetella carolinensis	Gray catbird	forest/grassland	U, SD	X	X
Empidonax minimus	Least flycatcher	forest/grassland	EG	X	
Empidonax traillii	Willow flycatcher	forest/grassland	S, SD	X	X
Empidonax virescens	Acadian flycatcher	forest	IF, S	X	X
Falco sparverius	American kestrel	n/a	n/a	X	X
Geothlypis trichas	Common yellowthroat	forest/grassland	SD	X	X
Helmitheros vermivorum	Worm-eating warbler	forest	IF, S		X
Hirundo rustica	Barn swallow	forest/grassland	EG	X	X
Hylocichla mustelina	Wood thrush	forest	IF, S	X	X
Icterus galbula	Baltimore oriole	forest/grassland	S, UC, EG	X	X
Icterus spurius	Orchard oriole	forest/grassland	S, EG	X	X
Lanius ludovicianus	Loggerhead shrike	forest	ND		X
Megaceryle alcyon	Belted kingfisher	n/a	n/a	X	X
Melanerpes carolinus	Red-bellied woodpecker	forest	ND, U	X	X
Melanerpes erythrocephalus	Red-headed woodpecker	forest	ND	X	X
Melospiza georgiana	Swamp sparrow	n/a	n/a	X	

[1] Guilds used to assess the forest breeding bird community condition (after O'Connell et al. 2003) BP: bark prober forager, E: exotic, GG: ground gleaner forager, IF: interior forest, ND: nest disrupter, P: Pine associated, UC: high canopy forager, S: single brooded, U: urban/suburban. NETN Grassland guilds that could be used to assess condition: E: exotic, EG: edge generalist, GO: grassland obligate, SD: shrub-dependent (after Faccio et al. 2010). n/a: not assigned to a guild.

Table 43 (continued). Bird species observed during the breeding season at GETT and EISE in 2001 (Yahner et al. 2001b). Guild type and specific guilds are after O'Connell et al. (2003) for forest breeding birds and Faccio et al. (2010) for grassland obligate birds.

Scientific Name	Common Name	Guild Type	Guild1	GETT 2001	EISE 2001
Melospiza melodia	Song sparrow	forest/grassland	U, EG, SD	X	X
Mimus polyglottos	Northern mockingbird	forest/grassland	U, EG, SD	X	X
Mniotilta varia	Black-and-white warbler	forest	BP, IF, S	X	
Molothrus ater	Brown-headed cowbird	grassland	EG	X	X
Myiarchus crinitus	Great crested flycatcher	forest	S	X	X
Oporornis formosus	Kentucky warbler	forest	IF, S, GG	X	
Parula americana	Northern parula	forest	IF, S, UC	X	
Passer domesticus	House sparrow	forest/grassland	E, ND, U, EG	X	X
Passerculus sandwichensis	Savannah sparrow	grassland	GO	X	X
Passerina cyanea	Indigo bunting	grassland	SD	X	X
Phasianus colchicus	Ring-necked pheasant	n/a	n/a	X	
Pheucticus ludovicianus	Rose-breasted grosbeak	forest	IF, UC	X	
Picoides pubescens	Downy woodpecker	forest	BP, U	X	X
Picoides villosus	Hairy woodpecker	forest	BP, IF, S	X	X
Pipilo erythrophthalmus	Eastern towhee	forest/grassland	IF, SD	X	X
Piranga olivacea	Scarlet tanager	forest	IF, S, UC	X	
Poecile atricapilla	Black-capped chickadee	forest	BP, S	X	
Poecile carolinensis	Carolina chickadee	forest	BP, S	X	X

[1] Guilds used to assess the forest breeding bird community condition (after O'Connell et al. 2003) BP: bark prober forager, E: exotic, GG: ground gleaner forager, IF: interior forest, ND: nest disrupter, P: Pine associated, UC: high canopy forager, S: single brooded, U: urban/suburban. NETN Grassland guilds that could be used to assess condition: E: exotic, EG: edge generalist, GO: grassland obligate, SD: shrub-dependent (after Faccio et al. 2010). n/a: not assigned to a guild.

Table 43 (continued). Bird species observed during the breeding season at GETT and EISE in 2001 (Yahner et al. 2001b). Guild type and specific guilds are after O'Connell et al. (2003) for forest breeding birds and Faccio et al. (2010) for grassland obligate birds.

Scientific Name	Common Name	Guild Type	Guild1	GETT 2001	EISE 2001
Polioptila caerulea	Blue-gray gnatcatcher	forest	UC	X	X
Pooecetes gramineus	Vesper sparrow	grassland	GO	X	X
Quiscalus quiscula	Common grackle	forest	ND, S, U	X	X
Sayornis phoebe	Eastern phoebe	n/a	n/a	X	X
Seiurus aurocapilla	Ovenbird	forest	GG, IF, S	X	
Setophaga ruticilla	American redstart	forest	IF, S	X	X
Sialia sialis	Eastern bluebird	grassland	EG	X	X
Sitta carolinensis	White-breasted nuthatch	forest	BP, IF, S	X	X
Spizella passerina	Chipping sparrow	forest/grassland	U, EG	X	X
Spizella pusilla	Field sparrow	grassland	SD	X	X
Stelgidopteryx serripennis	Northern rough-winged swallow	forest/grassland	S, EG	X	
Strix varia	Barred owl	n/a	n/a	X	
Sturnella magna	Eastern meadowlark	grassland	GO	X	X
Sturnus vulgaris	European starling	forest/grassland	E, ND, U, EG	X	X
Tachycineta bicolor	Tree swallow	forest/grassland	S, EG	X	X
Thryothorus ludovicianus	Carolina wren	forest	U	X	X
Toxostoma rufum	Brown thrasher	forest/grassland	S, SD	X	X
Troglodytes aedon	House wren	grassland	EG	X	X

[1] Guilds used to assess the forest breeding bird community condition (after O'Connell et al. 2003) BP: bark prober forager, E: exotic, GG: ground gleaner forager, IF: interior forest, ND: nest disrupter, P: Pine associated, UC: high canopy forager, S: single brooded, U: urban/suburban. NETN Grassland guilds that could be used to assess condition: E: exotic, EG: edge generalist, GO: grassland obligate, SD: shrub-dependent (after Faccio et al. 2010). n/a: not assigned to a guild.

Table 43 (continued). Bird species observed during the breeding season at GETT and EISE in 2001 (Yahner et al. 2001b). Guild type and specific guilds are after O'Connell et al. (2003) for forest breeding birds and Faccio et al. (2010) for grassland obligate birds.

Scientific Name	Common Name	Guild Type	Guild1	GETT 2001	EISE 2001
Turdus migratorius	American robin	forest/grassland	U, EG	X	X
Tyrannus tyrannus	Eastern kingbird	forest/grassland	S, EG	X	X
Vireo flavifrons	Yellow-throated vireo	forest	IF, S, UC	X	
Vireo griseus	White-eyed vireo	n/a	n/a	X	
Vireo olivaceus	Red-eyed vireo	forest	S, UC	X	X
Vireo gilvus	Warbling vireo	forest/grassland	UC, EG	X	X
Wilsonia citrina	Hooded warbler	forest	IF	X	
Zenaida macroura	Mourning dove	forest/grassland	ND, U, EG	X	X
Total breeding bird species observed				95	72

[1] Guilds used to assess the forest breeding bird community condition (after O'Connell et al. 2003) BP: bark prober forager, E: exotic, GG: ground gleaner forager, IF: interior forest, ND: nest disrupter, P: Pine associated, UC: high canopy forager, S: single brooded, U: urban/suburban. NETN Grassland guilds that could be used to assess condition: E: exotic, EG: edge generalist, GO: grassland obligate, SD: shrub-dependent (after Faccio et al. 2010). n/a: not assigned to a guild.

Seven species, Henslow's sparrow, cerulean warbler (*Dendroica cerulean*), willow flycatcher (*Empidona traillii*), worm-eating warbler, red-headed woodpecker, Kentucky warbler, blue-winged warbler (*Vermivora pinus*), and Canada warbler (*Wilsonia canadensis*) had a PIF status of IB: High Continental Priority-Low Regional Responsibility. Only three of these: willow flycatcher, red-headed woodpecker, and Kentucky warbler were observed during the breeding season at GETT (Yahner et al. 2001b).

Six species observed by Yahner et al. (2001b) had a PIF status of IIA: High Regional Priority-High Regional Concern. These species were green heron, chimney swift, rusty blackbird (*Euphagus carolinus*), Eastern screech owl (*Megascops asio*), Eastern towhee, and field sparrow. Four of these species: green heron, chimney swift, Eastern towhee, and field sparrow were observed during the breeding season at GETT. The Northern bobwhite (*Colinus virginianus*) was listed in historical records for GETT, but was not observed by Yahner et al. (2001b).

Three species observed at GETT (Acadian flycatcher, Louisiana waterthrush, and scarlet tanager) had a PIF status of IIB: High Regional Priority-High Regional Responsibility. Acadian flycatcher and scarlet tanager were observed during the breeding season (Yahner et al. 2001b).

Yahner et al. (2001b) observed 95 species of birds breeding within GETT; of these, O'Connell et al. (2003) used 61 species in their guild based system to estimate a BCI for the avian breeding bird community during the breeding season (Table 43). The condition of the breeding bird community was assessed at GETT as "largely intact" (Table 44). Guilds that ranked as "humanistic" (rank 1) or "moderately disturbed" (rank 2) at GETT were the specialist guilds of pine associated and bark probers (a lower than desired species richness was observed for these guilds). The generalist guilds of exotics had higher than the desired number of species. Overall, the avian community for 2001 survey data was evaluated as good condition with confidence in the assessment rated as medium. The confidence was medium because even though the data were of good quality, the data were over ten years old and may not be reflective of the current avian community at GETT. A trend was not evaluated due to the lack of long term data.

Peterjohn (2007) observed four species of obligate grassland birds during the breeding season at GETT in 2005: bobolink, Eastern meadowlark, grasshopper sparrow, and Savannah sparrow (Table 43). These grassland species were not uniformly distributed across GETT grasslands but had specific habitat preferences. For example, bobolinks (the most numerous grassland species) and Eastern meadowlarks were concentrated in grasslands managed by the NPS, where the fields were larger (generally >40 ha) and were dominated by cool season grasses (Peterjohn 2007). Contrary to this, grasshopper sparrows were absent from fields preferred by bobolinks and Eastern meadowlarks, and occupied grasslands with more open vegetation and a less-well developed litter layer. Savannah sparrows prefer early successional grassland habitats, which were very scarce at GETT, and therefore the abundance of this species was the lowest of the four grassland obligate species (Peterjohn 2007). Unfortunately, Peterjohn's (2007) data lacked several metrics and could not be used to assess the condition of grassland communities, and therefore the condition was assessed as unknown (Table 44).

Table 45. MIDN avian guild percentages and condition ranks for the Piedmont/Coastal Plain Bird Community Index applied to breeding birds at GETT and EISE observed in 2001 (refer to Table 38 for rank ranges). Guild abbreviations are also given. Arrows after guilds indicate the desired direction of species richness to improve condition.

Biotic Element and Guild	GETT		EISE	
	MIDN Guild %	MIDN Rank	MIDN Guild %	MIDN Rank
Structural				
Forest Interior, IF (specialist) ↑	27.9	3	17.0%	2
Pine associated, P (specialist) ↑	0%	1	0%	1
Urban/suburban, U (generalist) ↓	34.3%	3	42.3%	3
Functional				
Bark prober, BP (specialist) ↑	14.8%	2	10.6%	2
Upper canopy gleaner, UC (specialist) ↑	14.8%	3	10.6%	2
Ground gleaner, GG (specialist) ↑	4.9%	3	2.1%	2
Compositional				
Single brooder, S (specialist) ↑	57.4%	4	53.2%	4
Nest disrupter, ND(generalist) ↓	13.1%	3	17.0%	2
Exotic, E (generalist) ↓	6.6%	2	8.5%	2
Structural Average rank (∑ ranks/4)		1.5		1.5
Functional average rank (∑ ranks/4)		1.5		1.5
Compositional average rank (∑ ranks/4)		2.0		2.0
BCI Score and rating (range) (∑ average ranks/9)		0.67 Largely Intact (0.61-0.73)		0.56 Moderately Disturbed (0.46-0.60)
Avian Community Condition (Songbirds)		Good		Moderate Concern
Avian Community Condition (Grassland)		Unknown		Unknown

Eisenhower National Historic Park

At EISE Yahner et al. (2001b) documented 111 species including two state-endangered birds: loggerhead shrike and short-eared owl (Pennsylvania T and E Species 2015) Tables 42 and 43, Appendix Table 60). The loggerhead shrike was observed during the breeding season at EISE.

Additionally, 15 species of birds observed by Yahner et al. (2001b) at EISE were listed as priority species by PIF for the Mid-Atlantic Piedmont Physiographic Area (Kearney 2003). Three of these: prairie warbler (*Dendroica discolor*), wood thrush (*Hylocichla mustelina*), and American woodcock (*Scolopax minor*) had a PIF status of IA: High Continental Priority-High Regional Responsibility. The prairie warbler and wood thrush were observed during the breeding season.

Four species, willow flycatcher (*Empidona traillii*), worm-eating warbler (*Helmitheros vermivorum*), red-headed woodpecker (*Melanerpes erythrocephalus*), and Kentucky warbler (*Oporornis formosus*) had a PIF status of IB: High Continental Priority-Low Regional Responsibility. Only the Kentucky warbler was not observed during the breeding season (Yahner et al. 2001b).

Four species, the green heron (*Butorides virescens*), chimney swift (*Chaetura pelagica*), Eastern towhee (*Pipilo erythrophthalmus*), and field sparrow (*Spizella pusilla*) had a PIF status of IIA: High Regional Priority-High Regional Concern. All four species were observed at EISE during the breeding season (Yahner et al. 2001b).

Three species: Acadian flycatcher (*Empidonax virescens*), scarlet tanager (*Piranga olivacea*), and Louisiana waterthrush (*Seiurus motacilla*), and had a PIF status of IIB: High Regional Priority-High Regional Responsibility. Only the Acadian flycatcher was observed during the breeding season at EISE (Yahner et al. 2001b).

One species, the loggerhead shrike (*Lanius ludovicianus*) was listed as IIC: High Regional Priority, High Regional Threats. The loggerhead shrike was observed during the breeding at EISE (Yahner et al. 2001b).

Yahner et al. (2001b) observed 72 species of birds breeding within EISE; of these, O’Connell et al. (2003) used 47 species in their guild based system to estimate a BCI for the avian breeding bird community during the breeding season (Table 43). The condition of the breeding bird community was assessed at EISE as “moderately disturbed” (Table 44). Guilds that ranked as “humanistic” (rank 1) or “moderately disturbed” (rank 2) at EISE were the specialist guilds of forest interior, pine associated, upper canopy foragers, bark probers, upper canopy foragers, and ground gleaners (a lower than desired species richness was observed for these guilds). The generalist guilds of exotics and nest disrupters had higher than the desired number of species. Overall, the avian community for 2001 survey data was evaluated as moderate concern with confidence in the assessment rated as medium. The confidence was medium because even though the data were of good quality, the data were over ten years old and may not be reflective of the current avian community at EISE. Additionally, EISE has limited forested habitat which could also influence the BCI score. A trend was not evaluated due to the lack of long term data.

At EISE, grasslands were restricted to one field (all others were cultivated crops) which supported bobolinks and Eastern meadowlarks; only a few individuals of grasshopper and Savannah sparrows were detected due to the limited abundance of suitable breeding habitat (Peterjohn 2007). Peterjohn (2007) also noted that while loggerhead shrikes were likely permanent breeding residents at EISE until 2001 (the date of last published sighting); the lack of recent sightings and the absence of observations during the 2005 survey was likely an indicator that this species was extirpated from the park. Unfortunately, Peterjohn's (2007) data lacked several metrics and could not be used to assess the condition of grassland communities, and therefore the condition of the grassland bird community was assessed as unknown (Table 44).

4.4.1.4 Confidence in Assessment

Confidence in the assessment of the bird community was medium as there has only been only one inventory effort for birds in all habitats (e.g., Yahner et al. 2001b) at GETT and EISE and it was done over 10 years ago. The confidence in the assessment of grassland bird communities was low as there has only been one focal study for these species and there were insufficient data to assess condition. Another avian inventory or yearly avian monitoring would be beneficial, especially one that included metrics to assess grassland bird species. It should be noted that BCI scores and ratings are based on ecological criteria. However, parks such as GETT and EISE are managed based on cultural landscape objectives and these cultural parks may not ever attain "high ecological integrity". But, shifts in ecological condition over time may be detected through the use of such BCIs and be important in interpreting changes in ecological condition (Johnson 2014).

4.4.1.5 Data Gaps

A current survey of GETT and EISE bird communities (including grassland communities) would be beneficial as the previous inventories were conducted over 10 years ago. Avian monitoring is a lower priority for the entire MIDN Network, but has been implemented in some MIDN parks where there is a high interest by park natural resource management. While GETT and EISE have shown some interest, avian monitoring at this time has not been implemented (Comiskey and Callahan 2008). Monitoring breeding birds in the parks, both forest and grassland birds would be beneficial if park resources permit. Another data gap is specific information on the presence of the loggerhead shrike, a state-endangered species, at EISE. The fields at EISE had supported a breeding population prior to 2001, but this species may now be locally extirpated from the park. Yahner et al. (2001b) recommended surveying loggerhead shrikes at EISE at least four times every year between May and early July.

4.4.1.6 Threats

A primary threat to landbird populations is habitat loss due to development; however, Neotropical migrants (birds that breed in the US and Canada during the summer, but migrate to Mexico, Central America, South America, or the Caribbean Islands during the winter such as flycatchers, warblers, orioles, and vireos) are particularly vulnerable to habitat fragmentation (Robinson and Wilcove 1994, Faaborg et al. 1995). Forest fragmentation leads to increases in edge habitat, an ideal habitat for non-migratory resident species, and results in higher rates of brood parasitism and nest predation in the remaining forest habitat (Faccio et al. 2010). Battlefield rehabilitation could improve forest breeding bird habitat by removing invasive plant species; however, an avian survey would be required to determine the impact of the rehabilitation on the avian community. Threats to grassland birds include the loss of grassland habitats through conversion to agricultural use, unfavorable mowing regimes (e.g., mowing before nestlings have fledged causing mowing mortality, and successional change to shrublands and woodlands. Mowing regimes are in place for many grassland parcels within the parks, but there are still some fields that are suitable habitat for grassland birds that do not have mow plans (refer to Agricultural Fields and Grasslands section). Other global threats to landbird populations include, but are not limited to, predation by feral cats and climate change.

4.4.2 Herpetofauna- amphibian and reptile communities

4.4.2.1 Relevance and Context

As tracts of natural land become developed and fragmented, National Parks and protected areas provide increasingly important habitat refugia for herpetofauna (amphibians and reptiles). Amphibians and reptiles are sensitive to environmental degradation (e.g., wetland alteration, degraded water quality, habitat loss and alteration). Declines in herpetofauna have been documented on a regional and global scale (Bailey et al. 2007). Habitats for herpetofauna at GETT and EISE include forest, grasslands, wetlands, and riparian areas (Yahner et al. 2001a).

4.4.2.2 Data and Methods

Amphibians and reptiles were surveyed in GETT and EISE in 1999-2000 (Yahner et al. 1999a, Yahner et al. 2001a, Derge et al. 2001: Note: all three reports presented the same data). Forest, grassland (not grazed by cattle and mowed only once per year), wetland, and riparian areas were surveyed for the presence of amphibians and reptiles. These studies used eight methods of sampling: general searches, visual-encounter surveys, anuran-calling surveys, coverboards, funnel traps, turtle traps, drift-fences, and leaf bags. The selection of primary sampling points was based on a stratified random design with the number of sampling points being proportional to the area of each habitat within the parks (Figures 49 to 51) (Yahner et al. 2001a).

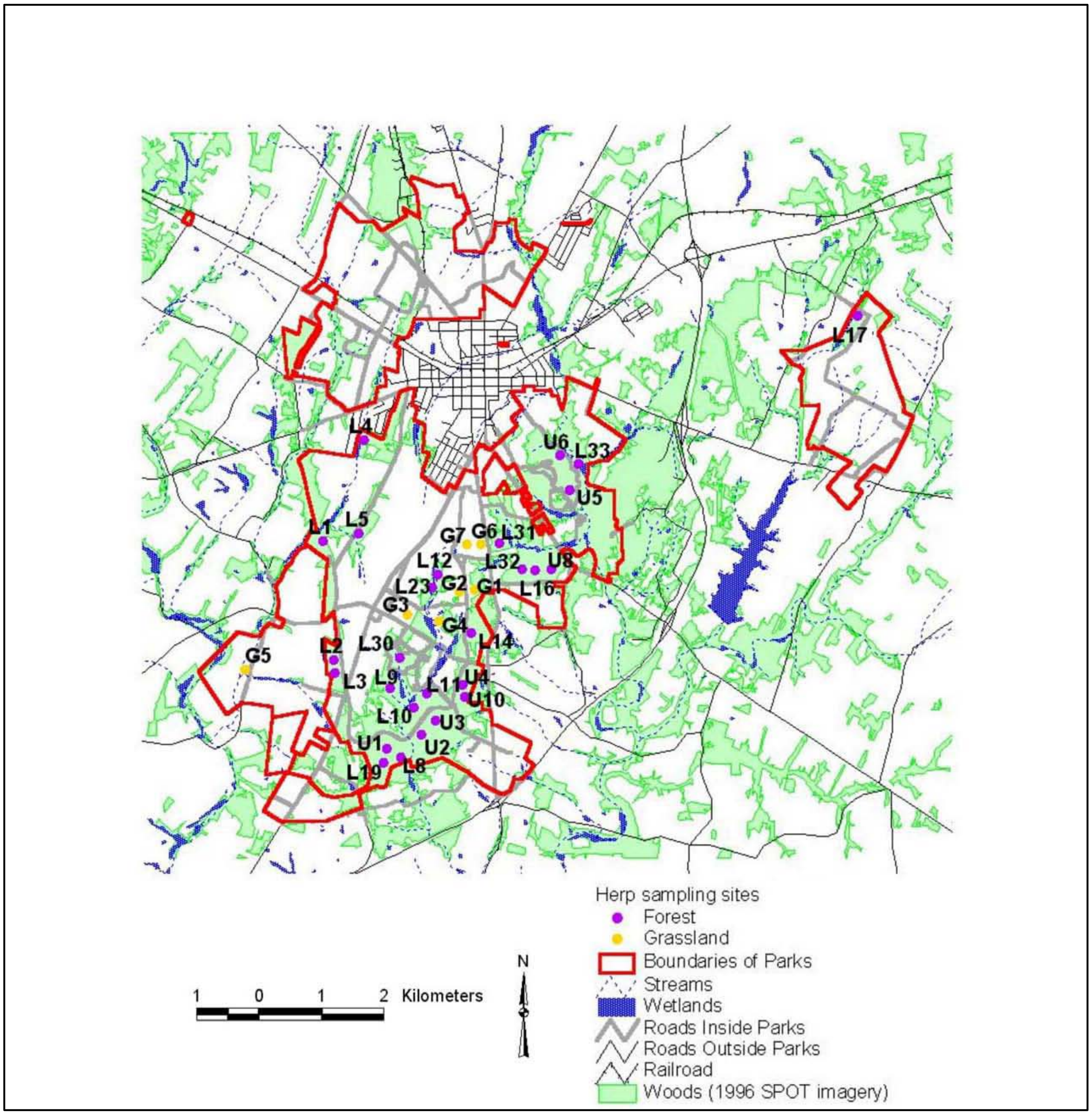


Figure 49. Map of GETT and EISE, which was used for the selection of sampling points in forest and grassland in the amphibian and reptile inventory project (1999-2000). The locations of sampling points for visual encounter surveys and coverboard surveys are given, using a G to depict a grassland point (n = 7), a U for an upland forested point (n = 8), and an L for a lowland forested point (n = 18) (map and legend excerpted from Yahner et al. 2001a).

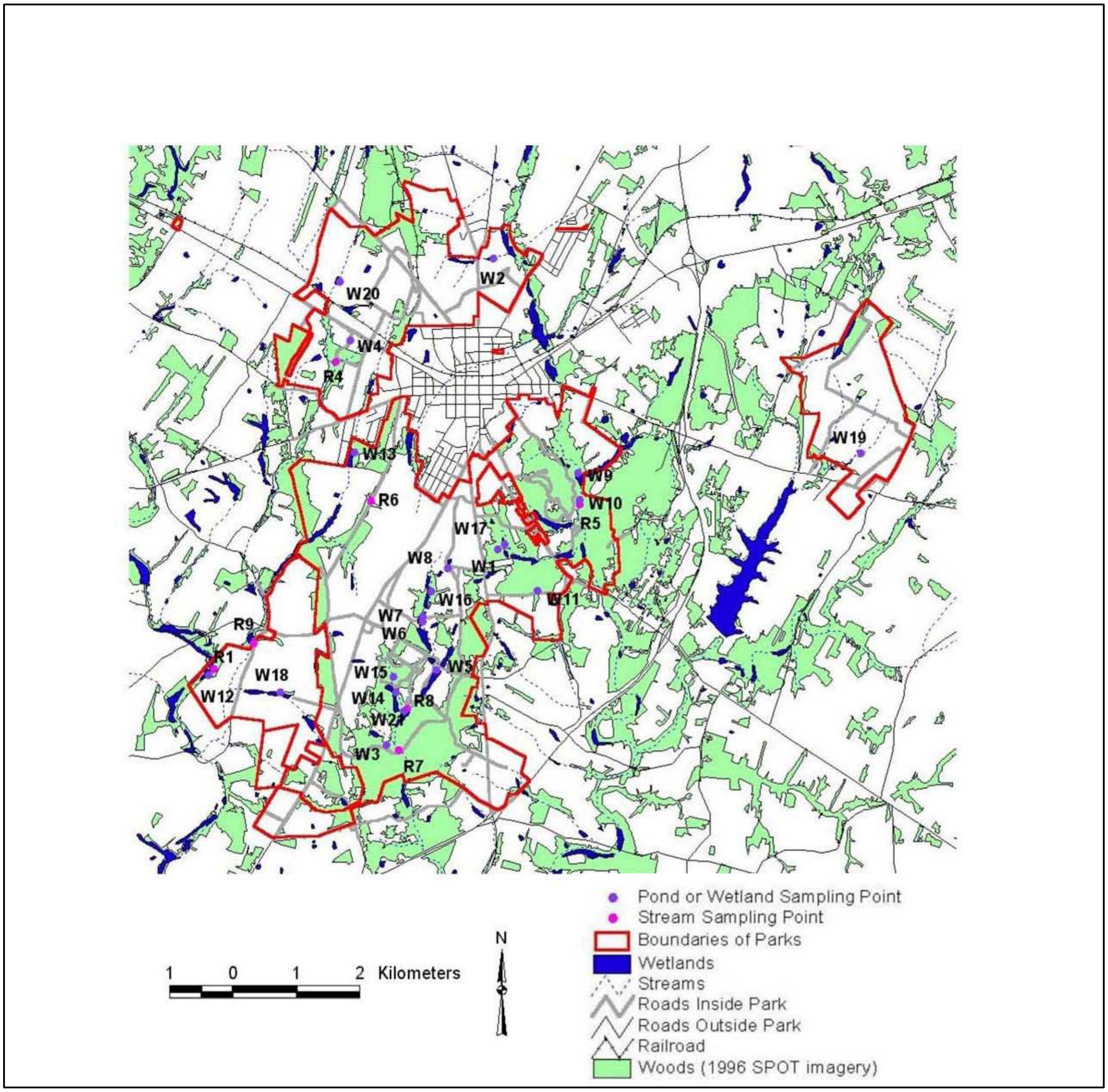


Figure 50. Map of GETT and EISE, showing the location of wetlands and waterbodies surveyed for amphibians and reptiles (1999-2000). The locations of sampling points for visual encounter surveys and general searches are given, using a W to depict wetland points (n = 21) and an R for forested riparian points (n = 7) (map and legend excerpted from Yahner et al. 2001a).

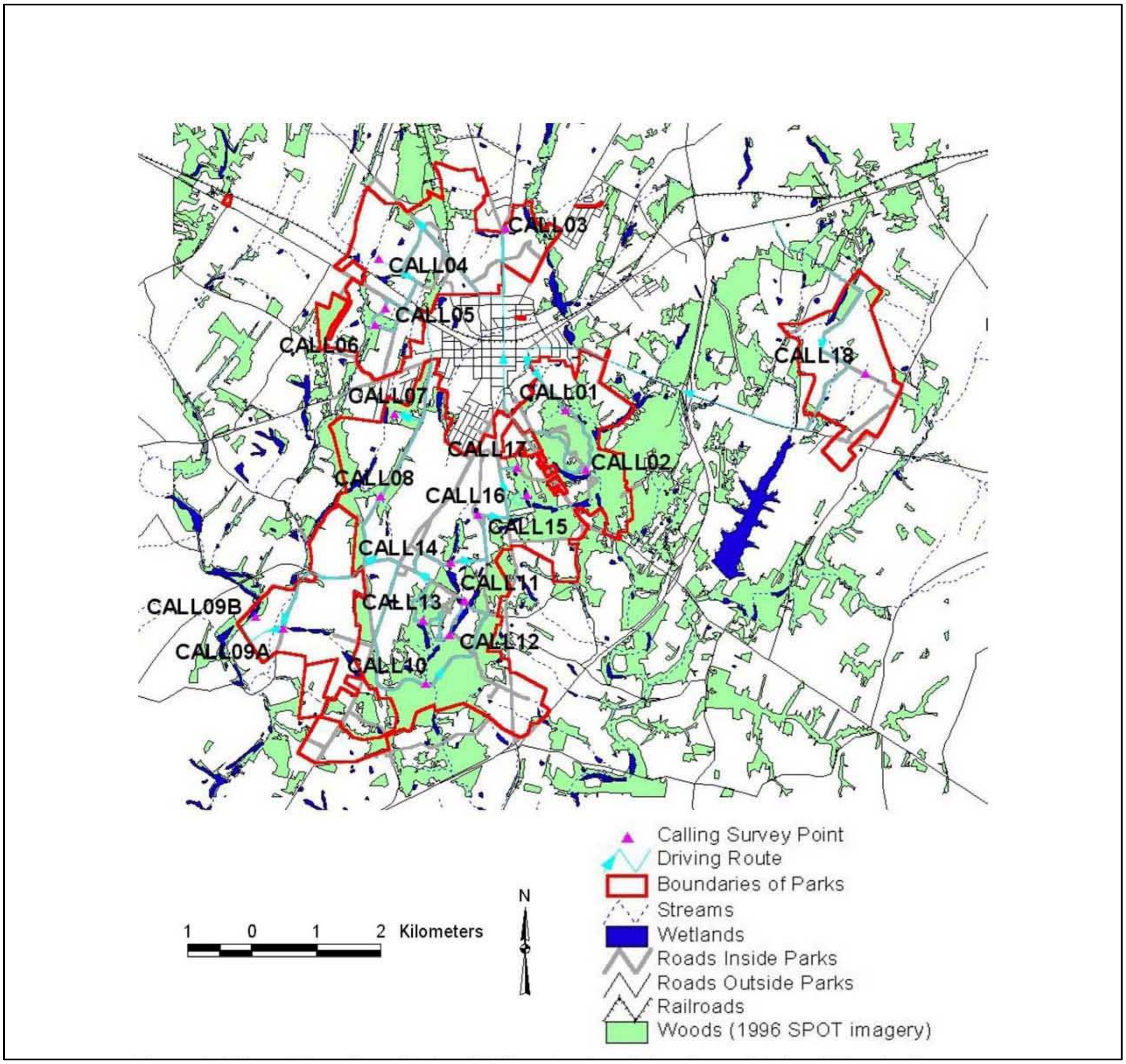


Figure 51. Map of GETT and EISE, showing the travel route for vehicular surveys for pond-breeding amphibians (1999-2000). Arrows indicate direction of travel, and survey stops (n = 19) are marked (map and legend excerpted from Yahner et al. 2001a).

Staff at GETT conducted informal surveys for Eastern box turtle (*Terrapene c. carolina*) from 2006 to 2008. Box turtles that were observed were marked by notching the carapace, measured, weighed, and location recorded. As of this NRCA these data have not been formally analyzed or interpreted (Z. Bolitho, Chief, Resource Management, Gettysburg National Military Park, email communication, 2 February 2016).

The Pennsylvania Amphibian and Reptile Survey or PARS (2015) is a state-sponsored atlas project that was initiated in 2013 to determine the distribution of herpetofauna throughout the state. PARS is a joint venture between the PA Fish and Boat Commission and the Mid-Atlantic Center for Herpetology and Conservation. PARS (2015) supports an online database where herpetofauna sightings can be reported by anyone from the skilled professional scientist to the most amateur naturalist. The PARS databased was used to compile a herpetofauna species lists for Adams County and this was used as a baseline list of what herpetofauna might be present in the park. The PARS (2015) database listed 20 species of amphibians and 25 species of reptiles (45 species) that have been recorded in Adams County (Table 45). There were a few species that Yahner et al. (1999a, 2001a) observed that were not in the PARS database for Adams County. These were one amphibian (Fowler's toad, *Anaxyrus fowleri*) and two reptiles (ringneck snake [*Diadophis punctatus edwardsii*], and Eastern hognose snake [*Heterodon platirhinos*]). Including these species the expected number of amphibians that could be present at GETT and EISE would be 48 species (21 amphibians and 27 reptiles) (Table 45).

Table 46. Amphibian and reptile species that have been documented at GETT and EISE, and those known in Adams County, PA (PARS 2015). Bold type indicates Federally Listed threatened (LT), State Listed Endangered (PE), State listed Threatened (PT), State Listed Uncommon (PC).

Scientific Name	Common Name	GETT[1]	EISE[1]	PARS[2]
Amphibians				
Ambystoma jeffersonianum	Jefferson salamander			X
Ambystoma maculatum	Spotted salamander	X		X
Anaxyrus americanus americanus	Eastern American toad	X	X	X
Anaxyrus fowleri	Fowler's toad	X	X	
Desmognathus fuscus	Northern dusky salamander			X
Eurycea bislineata	Northern two-lined salamander	X	X	X
Eurycea longicauda	Longtail salamander			X
Gyrinophilus p. porphyriticus	Northern spring salamander			X
Hemidactylium scutatum	Four-toed salamander			X
Hyla versicolor	Gray treefrog	X	X	X
Lithobates catesbeianus	Bullfrog	X	X	X
Lithobates clamitans melanota	Green frog	X	X	X
Lithobates palustris	Pickerel frog	X		X
Lithobates pipiens	Northern leopard frog	X		X
Lithobates sylvaticus	Wood frog	X		X
Notophthalmus v. viridescens	Red-spotted newt	X		X
Plethodon cinereus	Redback salamander	X		X
Plethodon glutinosus	Slimy salamander	X		X

[1] GETT and EISE observations from Yahner et al. 1999a, 2001a (Note: These reports list the same species as NPSpecies 2015).

[2] Species observed in Adams County as recorded in the PARS (2015) database.

Table 45 (continued). Amphibian and reptile species that have been documented at GETT and EISE, and those known in Adams County, PA (PARS 2015). Bold type indicates Federally Listed threatened (LT), State Listed Endangered (PE), State listed Threatened (PT), State Listed Uncommon (PC).

Scientific Name	Common Name	GETT[1]	EISE[1]	PARS[2]
Amphibians (continued)				
Pseudacris c. crucifer	Northern spring peeper	X	X	X
Pseudacris feriarum	Upland chorus frog	X		X
Pseudotriton r. ruber	Northern red salamander			X
Reptiles				
Agkistrodon contortrix mokasen	Northern copperhead	X		X
Chelydra s. serpentina	Common snapping turtle	X	X	X
Chrysemys p. picta	Eastern painted turtle	X		X
Chrysemys picta marginata	Midland painted turtle			X
Clemmys guttata	Spotted turtle	X		X
Coluber c. constrictor	Northern black racer	X		X
Crotalus horridus (PC)	Timber rattlesnake	X		X
Diadophis punctus (edwardsii)	Northern ringed snake	X		X
Elaphe alleghaniensis	Eastern ratsnake	X		X
Glyptemys insculpta	Wood turtle			X
Glyptemys muhlenbergii (LT, PE)	Bog turtle			X
Graptemys geographica	Northern map turtle			X
Heterodon platirhinos	Eastern hognose snake	X		
Lampropeltis t. triangulum	Eastern milk snake	X		X
Nerodia s. sipedon	Northern water snake	X		X
Plestiodon fasciatus	Common five-lined skink			X
Pseudemys rubiventris (PT)	Red-bellied cooter			X
Regina septemvittata	Queen snake			X
Sternotherus odoratus	Common musk turtle	X	X	X
Storeria d. dekayi	Northern brown snake			X
Storeria occipitmaculata	Northern red-bellied snake			X
Terrapene c. carolina	Eastern box turtle	X		X
Thamnophis sirtalis	Eastern gartersnake	X		X

[1] GETT and EISE observations from Yahner et al. 1999a, 2001a (Note: These reports list the same species as NPSpecies 2015).

[2] Species observed in Adams County as recorded in the PARS (2015) database.

Table 45 (continued). Amphibian and reptile species that have been documented at GETT and EISE, and those known in Adams County, PA (PARS 2015). Bold type indicates Federally Listed threatened (LT), State Listed Endangered (PE), State listed Threatened (PT), State Listed Uncommon (PC).

Scientific Name	Common Name	GETT[1]	EISE[1]	PARS[2]
Reptiles (continued)				
Trachemys scripta elegans (invasive)	Red-eared slider			X
Trachemys scripta	Pond slider			X
Virginia v. valeriae	Eastern smooth snake			X
Total species recorded		**29**	**9**	**46**

[1] GETT and EISE observations from Yahner et al. 1999a, 2001a (Note: These reports list the same species as NPSpecies 2015).

[2] Species observed in Adams County as recorded in the PARS (2015) database.

4.4.2.3 Reference Condition and Status of the Resource (current condition and trends)

The number of amphibians and reptiles expected to occur at GETT and EISE were determined by those previously observed within the parks (Yahner et al. 1999a, 2001a) and those known to be present in Adams County (PARS 2015). This yielded at total of 48 species (21 amphibians and 27 reptiles) that could be expected to occur in GETT and EISE (Table 45).

Herpetofauna species richness, expressed as the percent of species observed at GETT and EISE as compared to species recorded in Adams County (PARS 2015, Yahner et al. 1999a, 2001a) was used as a metric to evaluate condition. Threshold values (percent of species observed) for good, moderate concern, significant concern were based on best professional judgment (Table 46).

Table 47. Reference condition thresholds and current status of herpetofauna community at GETT and EISE.

Metric	Good Condition	Moderate Concern	Significant Concern	GETT Condition	EISE Condition
Amphibian species richness (21 expected)[1]	>80% of species expected (>16 species detected)	50-80% of species expected (10-15 species detected)	<50% of species expected (<10 species detected)	71% of species expected (15 species detected)	33% of species expected (7 species detected)
Reptile species richness (27 expected)[1]	>80% of species expected (>22 species detected)	50-80% of species expected (14-22 species detected)	<50% of species expected (<14 species detected)	52% of species expected (14 species detected)	7% of species expected (2 species detected)

[1] Expected and observed number of species was based on those recorded during park surveys and listed in the PARS database for Adams County.

Gettysburg National Military Park

Yahner et al. (1999a, 2001a) observed 15 species of amphibians (71% of expected species) and 14 species of reptiles (50% of expected species) during the 1999-2001 surveys at GETT (Table 45). These included ten species of frogs and toads, five salamanders, five turtles, and nine snakes (no lizards were observed) (Figure 52). The timber rattlesnake (*Crotalus horridus*), a Pennsylvania state listed species of concern/uncommon, was recorded on a Wildlife Observation Card at GETT in 1993. The timber rattlesnake is often found in rocky outcrops in forested areas, away from disturbance (Behler and King 1995). Another timber rattlesnake specimen, vouchered at the Shippensburg Museum, was collected 5 km east of GETT in 1972 (Yahner et al. 2001a). If rattlesnakes den or overwinter in the parks, it is likely that they would have been documented in the summer, when they are active. Yahner et al. (2001a) concluded that the rattlesnake does not occur as a resident species in GETT or EISE, but may be observed on occasion. The condition of the herpetofauna community was evaluated as moderate concern for both amphibians and reptiles for GETT (Table 46). Since there has only been one survey, the trend was assessed as unknown.

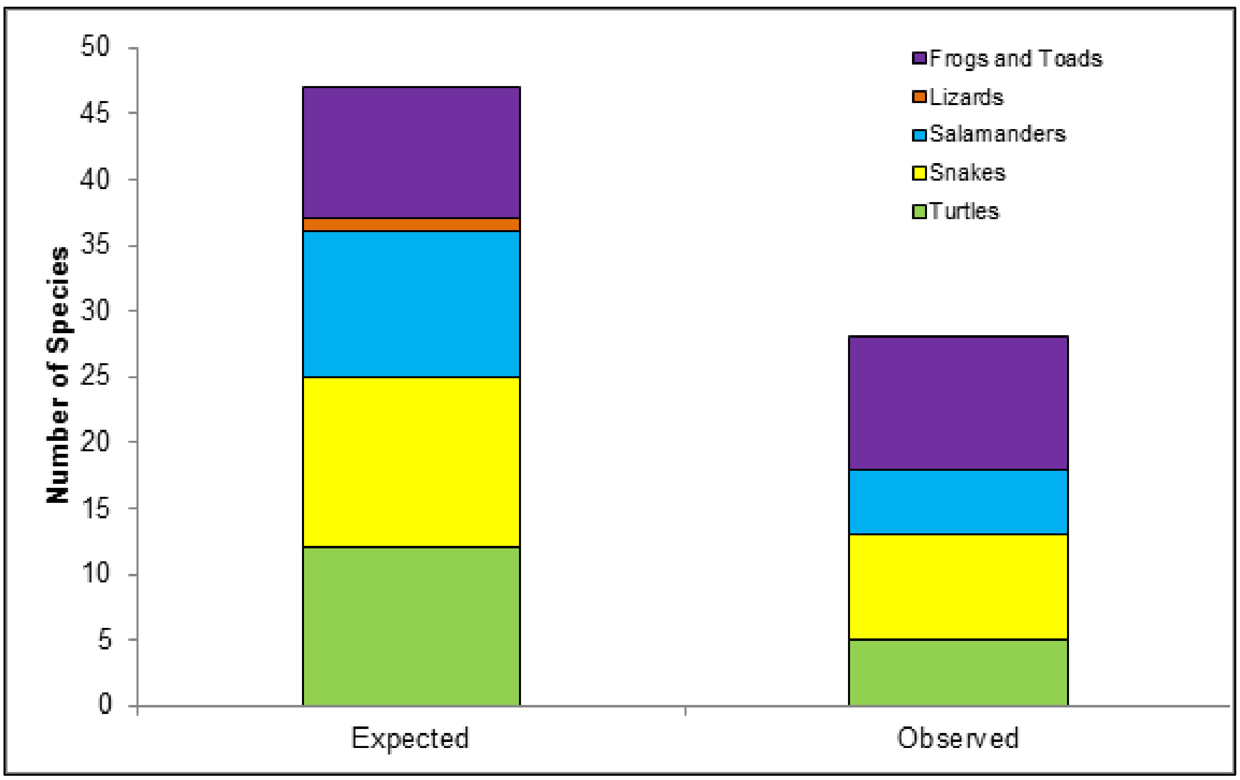


Figure 52. Number of herpetofauna species expected and observed at GETT and EISE (based on park surveys and species listed in the PARS database for Adams County).

Eisenhower National Historic Park

Yahner et al. (1999a, 2001a) observed seven species of amphibians (33% of expected species) and two species of reptiles (7% of expected species) during the 1999-2001 surveys at EISE (Table 45). These included six species of frogs and toads, one salamander, and two turtles (no lizards or snakes were observed) (Figure 52). No state or federally listed species were observed at EISE. The condition of the herpetofauna community was evaluated as significant concern for both amphibians and reptiles for EISE (Table 46). Since there has only been one survey, the trend was assessed as unknown.

Other state listed species that have been observed in Adams County, but not documented at GETT or EISE, were the Pennsylvania state threatened Northern red-bellied cooter (*Pseudemys rubriventris*) and the federally threatened and state endangered bog turtle (*Glyptemys muhlenbergii*) (Pennsylvania T and E species 2015). It is unlikely that the bog turtle is present in the parks as there is a lack of suitable habitat (Z. Bolitho, Chief, Resource Management, Gettysburg National Military Park, personal communication, 27 July 2015).

4.4.2.4 Confidence in Assessment

Confidence in assessment was medium because the herpetofauna inventory data was 15 years old and there has only been one survey. Species richness was used as an indicator of condition; however, the use of this metric alone does have its shortcomings. For example, the abundance and distribution of species are important components of an assessment; diversity in some habitat types can be expected to be low, regardless of condition; parks may not have appropriate habitat for some species; and survey methods/effort will determine number of species detected as present (S. Colwell, personal communication, 22 August 2016).

4.4.2.5 Data Gaps

The only data gap was the herpetofauna were inventoried 15 years ago. Additionally, a single herpetological inventory may not be sufficient to document these species as they are cryptic by nature. A current survey of GETT and EISE amphibians and reptiles would be beneficial.

4.4.2.6 Threats

Wetland areas at both GETT and EISE are generally small (refer to Wetlands, Vernal Pools, and Ponds Section) and suitable habitat for herpetofauna communities may be limited within the parks. Based on land use analyses, these small wetlands are surrounded by a high proportion of anthropogenic lands that could negatively impact the fauna and flora of the wetlands. However, focal wetland surveys have not been conducted so it is difficult to evaluate direct impacts to the wetlands and any associated faunal communities at the parks. Threats to herpetofauna communities include indirect effects due to development, including habitat loss, degradation, and fragmentation, degraded water quality, and altered wetland hydrology and habitat degradation due to natural succession and encroachment by invasive exotic plant species. Direct effects include vehicular road kill during migration periods and increased predation on nests and juveniles by unnaturally high raccoon populations (PNHP 2015b). In addition, herpetofauna that reside or use managed agricultural fields may be threatened by livestock trampling and mowing of fields for agriculture.

4.4.3 Terrestrial Arthropod and Lepidoptera

4.4.3.1 Relevance and Context

As a group, terrestrial arthropods are important to monitor, given the diversity of the ecosystem services they offer, including pollination, decomposition, and biological pest control of crops by natural enemies. For example, Lepidoptera (butterflies) taxa are sensitive to land-use changes mainly as a result of their multiple life stages and their specialized habitat requirements. Resource requirements can change at each life-stage. For instance, for many Lepidoptera the larval stage requires different and separate host-plant(s) than the adult's required nectar source. Thus most butterfly species, though often trophic specialists, require multiple kinds of habitat types (e.g., forests and grasslands). These multiple resource requirements make the butterflies a difficult group to manage, particularly in highly fragmented areas where habitats are fragmented by multiple land-use types (Kim and Piechnick 2009).

4.4.3.2 Data and Methods

In 1999 and 2000, a terrestrial arthropod survey was conducted at GETT and EISE. The objective was to provide an invertebrate inventory of forest, grassland, wetland, and riparian habitats, to collect baseline information for management, and to develop a monitoring plan (Kim et al. 2001, Kim and Piechnik 2009). The goal of the study was to identify potential surrogate groups for monitoring which best represented overall arthropod diversity and to establish the most efficient sampling methods to monitor these groups. Diversity measures used to assess arthropod diversity were family richness, evenness, log abundance, and H' (Shannon Diversity Index) (Kim and Piechnik 2009).

Collections were made at interior forest stands (GETT, Big Round Top and Plum Run), grazed woodlot (GETT, Codori-Trostle Thicket), riparian forest (EISE, Marsh Creek), open wetland/grassland (GETT, Valley of Death), old field/forest edge (GETT, east of Pennsylvania Monument), and an open riparian grassland (GETT, Willoughby Run/Will's Farm) (Figure 53). Lepidoptera were also surveyed at 36 randomly selected sites in GETT (33 sites) and EISE (six sites) (Figure 54). Land-use evaluation with respect to Lepidoptera richness and abundance was used to determine target types of land uses that would affect Lepidoptera the most should they be altered (e.g., cutting or mowing) (Kim and Piechnik 2009). Gross trophic structure was determined using guild designations using a dataset of 206 arthropod families. The guild designations were detritivore (consume dead and decaying plant and animal matter), zoophage (consume living animals), phytophage (consume living plant material), mycetophage (consume fungi), and omnivore (Kim and Piechnik 2009).

4.4.3.3 Reference Condition and Status of the Resource (current condition and trends)

On average, the Big Round Top sampling stations had greater arthropod family richness and abundance when compared to the other sites. The intensely sampled station at Big Round Top had higher family richness but lower total abundance than the intensely sampled station at Codori-Trostle Thicket (Figure 55). Further analyses suggested that the Big Round Top sample site might be a better estimator for the overall park diversity during this particular sampling period (1999-2000). However, spatial and temporal changes such as removal or addition of vegetation within the park could change the predictability of the overall GETT and EISE park diversity by using the Big Round Top as a sentinel site (Kim and Piechnik 2009).

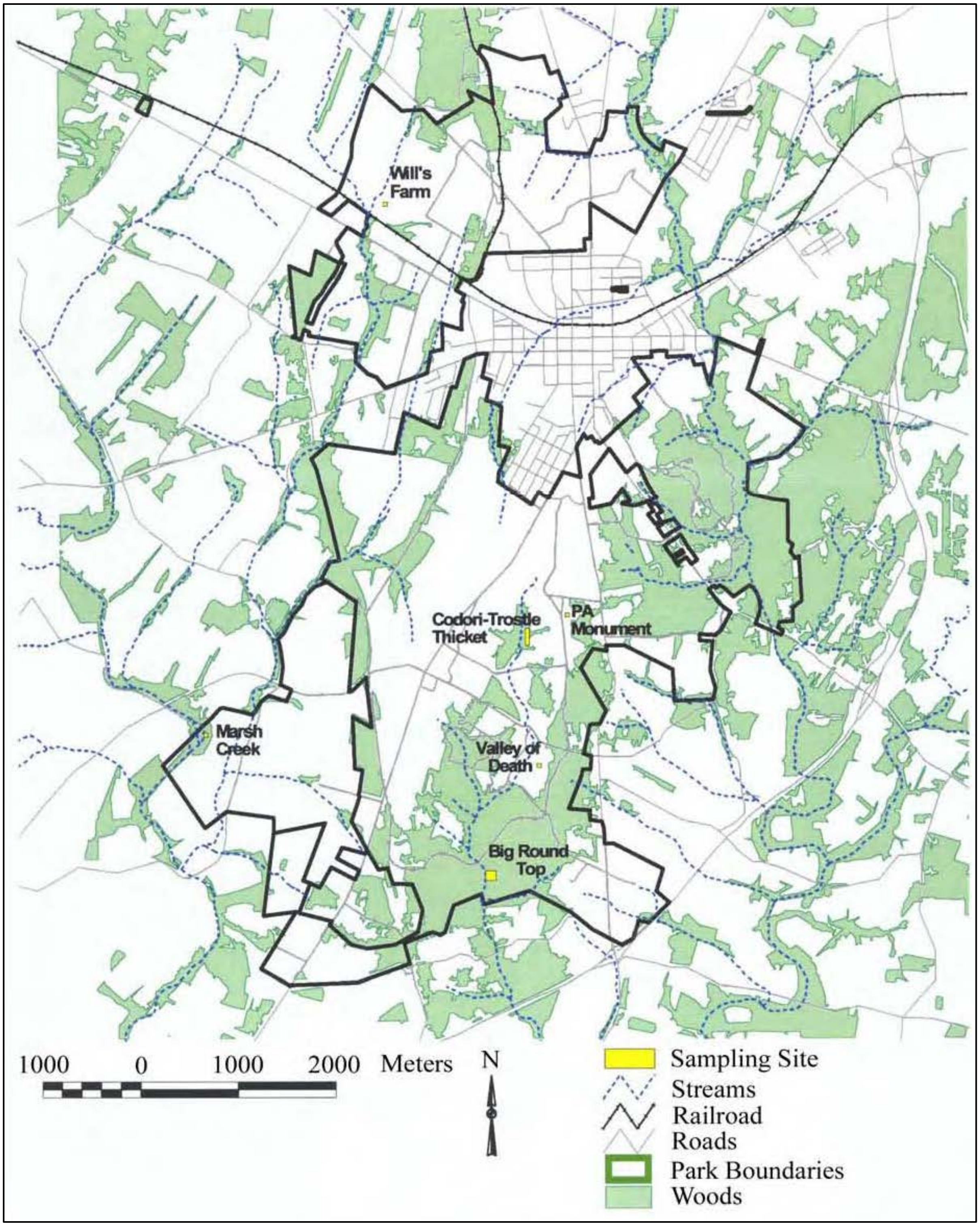


Figure 53. Location of terrestrial arthropod sampling sites conducted in 1999-2000 at GETT and EISE (map excerpted from Kim and Piechnik 2009).

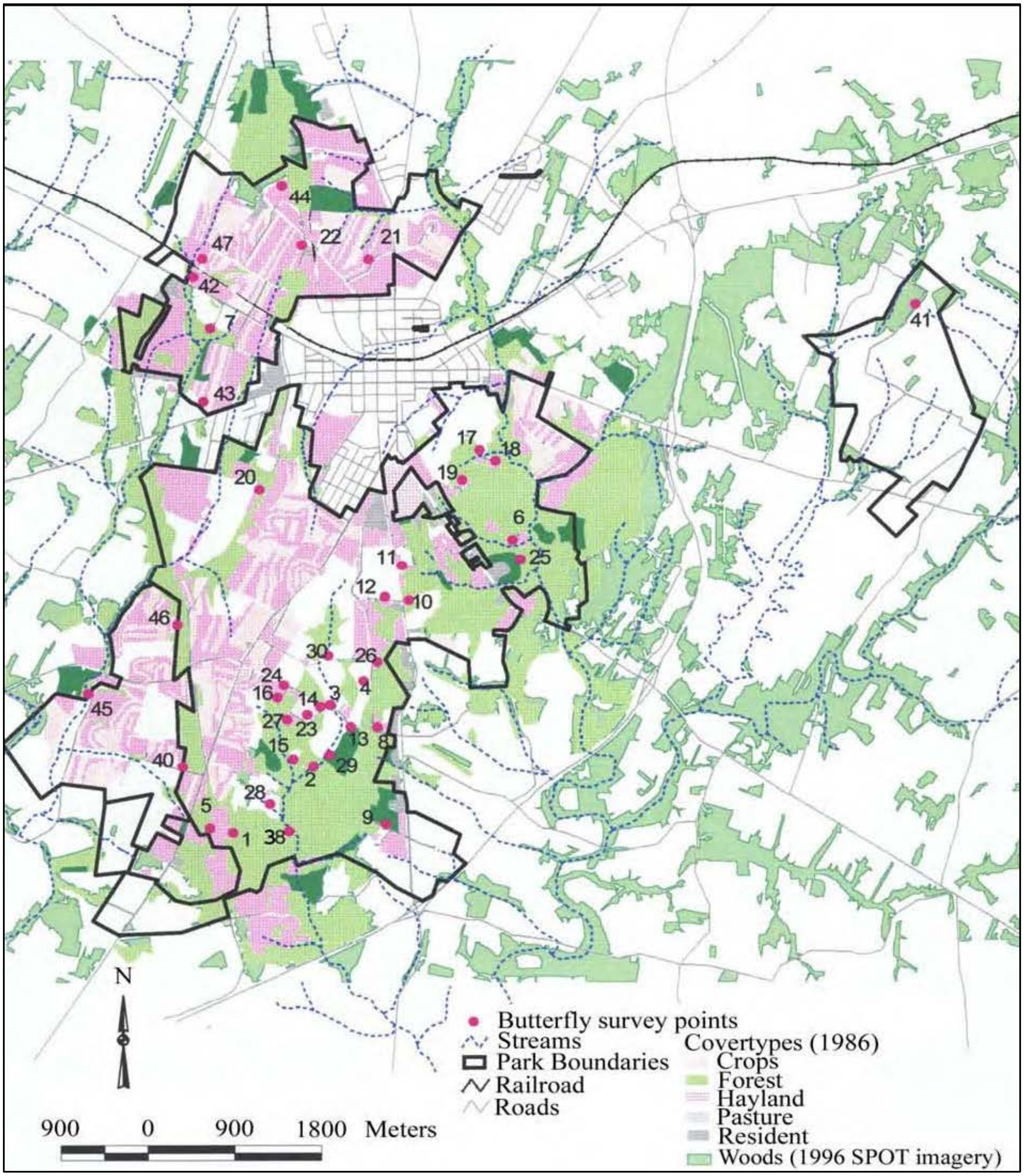


Figure 54. Location of butterfly sampling sites conducted in 1999-2000 at GETT and EISE (map excerpted from Kim and Piechnik 2009).

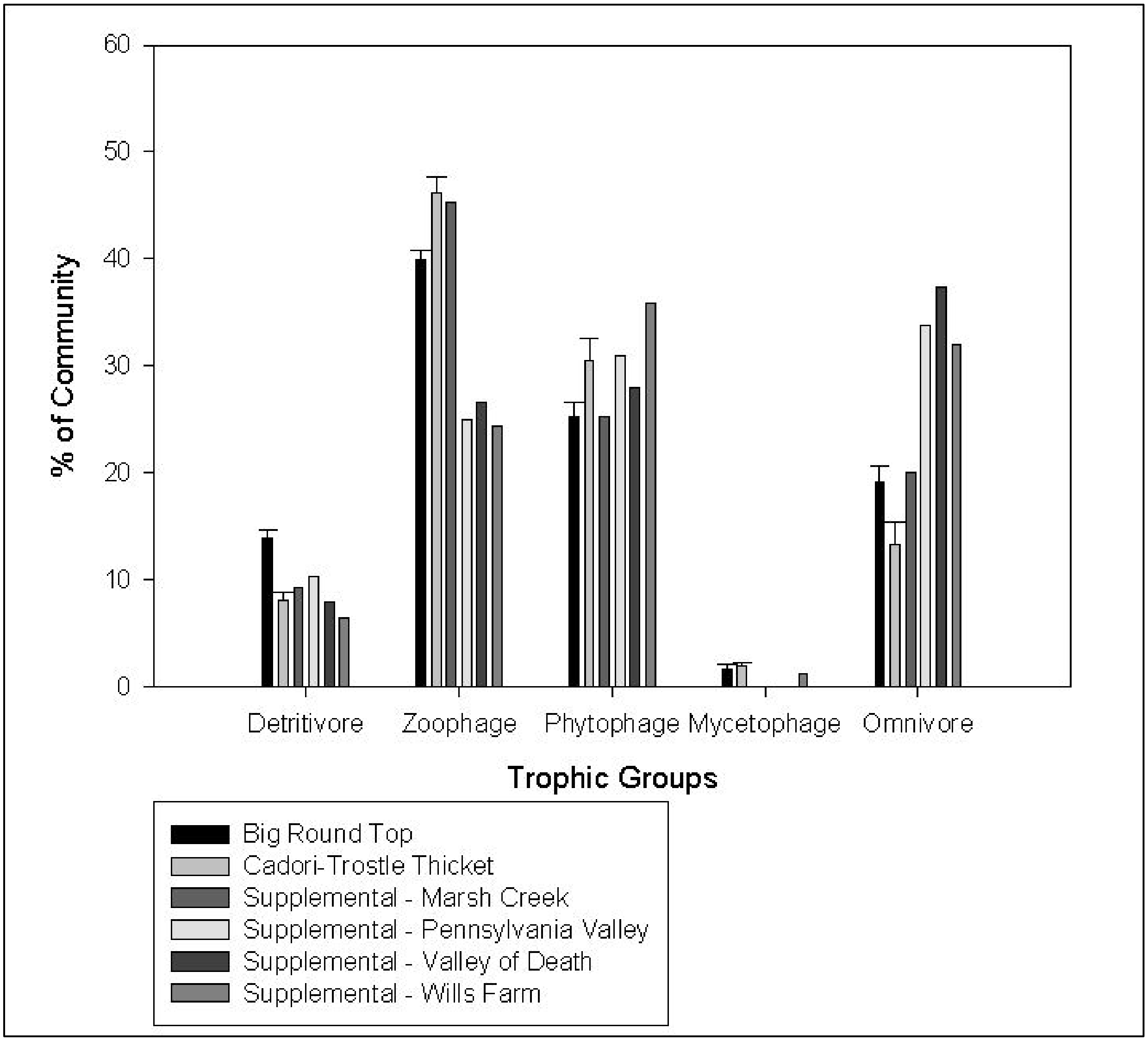


Figure 55. Relative proportions (mean ± SD) of arthropod trophic groups across sampling sites. It is important to note that sampling effort differed between sites (Figure excerpted from Kim and Piechnik 2009).

Kim and Piechnik (2009) suggested a group of 16 arthropod species for monitoring that were a fair cross-section of trophic structure (Table 47). This list was somewhat biased toward predators since they have been determined to be more sensitive to decreases in habitat size and habitat fragmentation than other trophic groups (Srivastava et al. 2008).

Thirty-two Lepidoptera species were observed and identified from 36 sites, with an average site species richness of 7.41. This species collection required a mix of habitat types, including wooded, grassland, and edge habitats (Table 48). The European Skipper (*Thymelicus lineola*) was the most commonly observed species in terms of number of specimens collected/observed and the number of sites where observed. The Little Glassy Wing (*Pompeius verna*) was the second most collected species, while the Little Wood Satyr (*Megisto cymela*) was the second highest in incidence. There were multiple species with single occurrences; however, more long-term monitoring data would be required to discern the cause. For instance, these single occurrences could represent the end of a flight display period for a species, the species could be rare or uncommon, or the local population could be declining. More information is needed about the butterfly species and their life histories within GETT and EISE (Kim and Piechnik 2009).

Table 48. Suggested list of common and easily identified arthropods for monitoring purposes at GETT and EISE (after Kim and Piechnik 2009) and locations where they were observed.

Species	Family	Common Name[1]	Trophic Level	Location
Agelinopsis pennsylvanica	Agelinidae	Spider	predator	Codori-Trostle Thicket
Leptogaster flavipes	Ascilidae	Robber flies	predator	Big Roundtop
Parcoblatta virginica	Blatellidae	Wood cockroach	omnivore	Big Roundtop
Philaenus spumarius	Cercopidae	Meadow spittlebug	phytophagous	Big Roundtop, Codori-Trostle Thicket
Oscinella frit	Chloropidae	Frit flies	phytophagous	Big Roundtop, Codori-Trostle Thicket
Metriona sp.	Chrysomelidae	Leaf beetles	phytophagous	Wills Farm
Systena hudsonias	Chrysomelidae	Leaf beetles	phytophagous	Big Roundtop
Agallia constricta	Cicaedellidae	Constricted Leaf hopper	phytophagous	Big Roundtop, Codori-Trostle Thicket
Cicindela sexguttata	Cicindellidae	Six-spotted tiger beetle	predator	Big Roundtop
Chrysotus obliquus comples	Dolichopodidae	Longlegged flies	predator	Big Roundtop, Codori-Trostle Thicket
Camponotus sp. 1	Formicidae	Carpenter ants	omnivore	Big Roundtop, Codori-Trostle Thicket
Ophion sp.	Ichneumonidae	Short-tailed Ichneumonidae wasps	predator/parasite	Marsh Creek
Oxyopes	Oxyopidae	Lynx spiders	predator	Marsh Creek, Pennsylvania Monument, Valley of Death
Odontotaenius disjunctus	Passalidae	Horned Passalus bass beetle	detritivore	Codori-Trostle Thicket
Pipunculus (Eudorylas) sp.	Pipunculidae	Big-headed flies	predator/parasite	Big Roundtop, Codori-Trostle Thicket
Oecanthus sp.	Grylidae	Crickets	phytophagous	Big Roundtop

[1] Common names after BugGuide.net

Table 49. Lepidoptera collected at GETT and EISE (April-September 1999), and typical habitat preferences of each species (after Kim and Piechnik 2009).

Family & Scientific Name	Common Name	Habitat	Nectar Source	Larval Host Plant
Hesperiidae (Skippers)				
Ancyloxypha numitor	Least skipper	moist pastures and grasslands	small flowers	grasses
Atalopedes campestris	Sachem	open areas	variety	grasses
Epargyreus clarus silver-	Silver spotted skipper	disturbed forest	variety	locust and other legumes
Erynnis brizo (Boisduval & LeConte 1834)	Sleepy dusky wing	woodland margins	damp soil and flowers	scrub oaks
Erynnis juvenalis (Fabricius 1793)	Juvenal's dusky wing	oak woodlands	variety	oaks
Euphys dion (Edwards 1879)	Dion skipper	wetlands - bogs	n/a	calcareous ferns
Poanes hobomok (Horris 1862)	Hobomok skipper	woodland margins	variety	grasses
Polites mystic (Edwards 1863)	Peck's skipper	open areas	variety, esp. red clover	grasses
Pompeius verna (Edwards 1862)	Little glassy wing	forest openings	variety	purpletop grass
Thorybes pylades (Scudder 1870)	Northern cloudy wing	open or scrubby woodlands	variety	legumes and clovers
Thymelicus lineola (Ochsenheimer 1808)	European skipper	open grassy fields	variety, esp. red clover	grasses
Lycaenidae (Gossamer-wing butterflies)				
Celastrina ladon (Linnaeus 1758)	Spring azure	woodland margins and wetlands	trees, shrubs, herbs	perennials
Everes comyntas (Eodt 1824)	Eastern tailed blue	open areas and fields	short flowers	herbaceous legumes
Satyrium calanus (Hubner 1808)	Banded hairstreak	mixed deciduous forest	variety	oak, walnut, and hickory
Strymon melinus (Hubner 1818)	Gray hairstreak	hilltops	variety	variety

Table 48 (continued). Lepidoptera collected at GETT and EISE (April-September 1999), and typical habitat preferences of each species (after Kim and Piechnik 2009).

Family & Scientific Name	Common Name	Habitat	Nectar Source	Larval Host Plant
Nymphalidae (Brush-fotted butterflies)				
Coenonympha tullia inornata	Common wood nymph	tall grass and open wood margins	sap, dung, and flowers	grasses
Euphydryas phaeton (Drury 1773)	Baltimore	bogs, marshes, wet meadows	variety	turtlehead and other perennials
Megisto cymela (Cramer 1777)	Little wood satyr	tall grass and wood margins grasses	sap, exudates flowers	grasses
Phyciodes tharos (Drury 1773)	Pearl crescent	open areas	variety	asters
Polygonia comma (Harris 1842)	Comma	woodlands	sap, exudates	nettle, elms
Polygonia interrogationis (Fabricius 1798)	Question mark	woodland openings	sap, exudates	elms, hackberry, nettle
Speyeria cybele (Fabricius 1775)	Great spangled fritillary	woodland margins	variety	violets
Vanessa virginiensis (Drury 1773)	American painted lady	open areas	variety	pussytoes, everlastings
Papilionidae (Swallowtail butterflies)				
Battus philenor	Pipevine swallowtail	deciduous forest	pink and purple flowers	birthworts
Papilio glaucus	Tiger swallowtail	deciduous forest	tree and herb flowers	yellow poplar, cherry, ash, spicebush
Papilio polyxenes (Fabricius 1775)	Black swallowtail	open fields	variety, incl. shrubs	parsleys
Papilio troilus (Linnaeus 1758)	Spicebush swallowtail	semi-open woodlands	variety	sassafras and spicebush
Pieridae (Sulphur butterflies)				
Colias eurytheme (Boisduval 1852)	Orange sulphur	open fields	short flowers	alfalfa, clover, other legumes

Table 48 (continued). Lepidoptera collected at GETT and EISE (April-September 1999), and typical habitat preferences of each species (after Kim and Piechnik 2009).

Family & Scientific Name	Common Name	Habitat	Nectar Source	Larval Host Plant
Pieridae (Sulphur butterflies) (continued)				
Colias philodice (Godart 1819)	Clouded sulphur	open fields	short flowers	clovers
Pieris rapae (Linnaeus 1758)	Cabbage white	open areas	variety	herbaceous perennials

Roughly half (16) of the 34 sites had seven or more Lepidoptera species. Kim and Piechnik (2009) concluded that three land-use types were "good" habitat for Lepidoptera and may deserve further attention in future monitoring efforts of butterflies. These habitats were: Mixed Evergreen-Deciduous Shrubland, Mixed-Evergreen-Deciduous Forest, River, and Deciduous Woodland.

The inventory in 1999-2000 was a first attempt to survey the terrestrial arthropods at GETT and EISE. A potential monitoring plan was outlined but the authors stated that more information, such as temporal and spatial population data were needed and that more species (e.g., Diptera) needed to be identified and described with greater taxonomic resolution (Kim and Piechnik 2009). Therefore, more data were required before attempting to assess the condition of terrestrial arthropod communities at GETT and EISE. Thus, the condition for these communities was assessed as unknown (Table 49). Trends could not be evaluated because these communities have only been inventoried once.

Table 50. Condition assessment for terrestrial arthropods.

Metric	**Good Condition**	**Moderate Concern**	**Significant Concern**	**GETT Condition**	**EISE Condition**
Terrestrial arthropods	Thresholds not available			Unknown	Unknown
Lepidoptera	Thresholds not available			Unknown	Unknown

4.4.3.4 Confidence in Assessment

The confidence in the assessment was low as the data were over 15 years old and battlefield rehabilitation may have altered the habitat used by these species.

4.4.3.5 Data Gaps

Terrestrial arthropods including Lepidoptera were last surveyed in 1999-2000. A focal study on terrestrial arthropods using Kim and Piechnik's (2009) suggested species for monitoring would be beneficial. Lepidoptera could be surveyed in the habitats that ranked as 'good'; however, the quality of those habitats would have to be re-evaluated as battlefield rehabilitation may have altered the habitat quality for this particular taxonomic group.

Kim and Piechnik's (2009) recommended a threefold monitoring plan for terrestrial arthropods:

- surrogate monitoring for overall diversity;
- monitoring at-risk or important taxa such as:
  - Lepidoptera, declining pollinating insects, and all bee taxa; and
- monitoring taxa found in specialized habitats (specialists).

4.4.3.6 Threats

Disturbance or alteration of habitats suitable for terrestrial arthropods could threaten their distribution and abundance. Kim and Piechnik (2009) suggested that best management practices would be to avoid impact on edges of habitats (i.e., junctions of two or more undisturbed land use types) and those areas with the host-plants as listed in Table 48. Early season mowing can negatively impact butterflies by cutting host plants, reducing present and future nectar sources, and harming the early life stages of butterflies (Glassberg 1993). Many land-use categories that ranked as "good" butterfly habitat were within mow plan areas. To minimize impact on butterfly populations, best management practices would be to minimize mowing in these sites, and at minimum, only mow after June 29 (Kim and Piechnik 2009).

4.4.4 Mammal Community – except white-tailed deer

4.4.4.1 Relevance and Context

Mammals contribute to species richness, diversity, and play a major role in ecosystem dynamics as consumers of plant material, invertebrates, and as prey for snakes, raptors, and carnivorous mammals. Small mammals may directly influence population levels of insect pests and disease vectors such as gypsy moths and deer ticks, as well as regionally rare raptorial birds (Cook et al. 2004). The abundance and composition of small mammal communities can also affect the structure, species composition, and successional trends of plant communities (Ostfeld 2002).

The Pennsylvania Important Mammal Areas (IMA) was initiated in 2001 to promote the conservation of mammal species by identifying sites or regions that include habitats critical to their survival, and to educate the public about mammals and their needs. While selection as an Important Mammal Area does not provide legal protection, it focuses public awareness on mammals and provides landowners and governmental agencies with information to compliment land management and land use decisions to better protect mammal species and their habitat (PA Game Commission 2015). In 1999, two specimens of the least shrew (*Cryptotis parva*), a Pennsylvania state endangered species, were collected at EISE by the Pennsylvania Natural Heritage Program (Hart 2006b). Historically, this shrew ranged throughout much of Pennsylvania, but it is currently thought to be restricted to the Piedmont Province of Pennsylvania. Thus, GETT and EISE become very important as a refuge for the least shrew within the state. The presence of the least shrew compelled the Mammal Technical Committee of the Pennsylvania Biological Survey to designate GETT, EISE, and several adjacent properties outside the parks' boundaries as are designated as IMAs (Hart 2006b).

In the Northeastern U.S., cave and mine hibernating bats are dying at an alarming rate due to white-nose syndrome (WNS). WNS first identified in New York in 2006 and has since rapidly spread to multiple sites throughout the eastern United States and into Canada. WNS is caused by a fungus (*Pseudogymnoascus destructans*) that thrives in the cold, humid conditions of caves and mines where some bat species hibernate. White-nose syndrome has been confirmed in several PA counties. It has not yet been confirmed in Adams County (as of 2015) but has been confirmed in adjacent counties (Figure 56) (White-Nose Syndrome.org 2015).

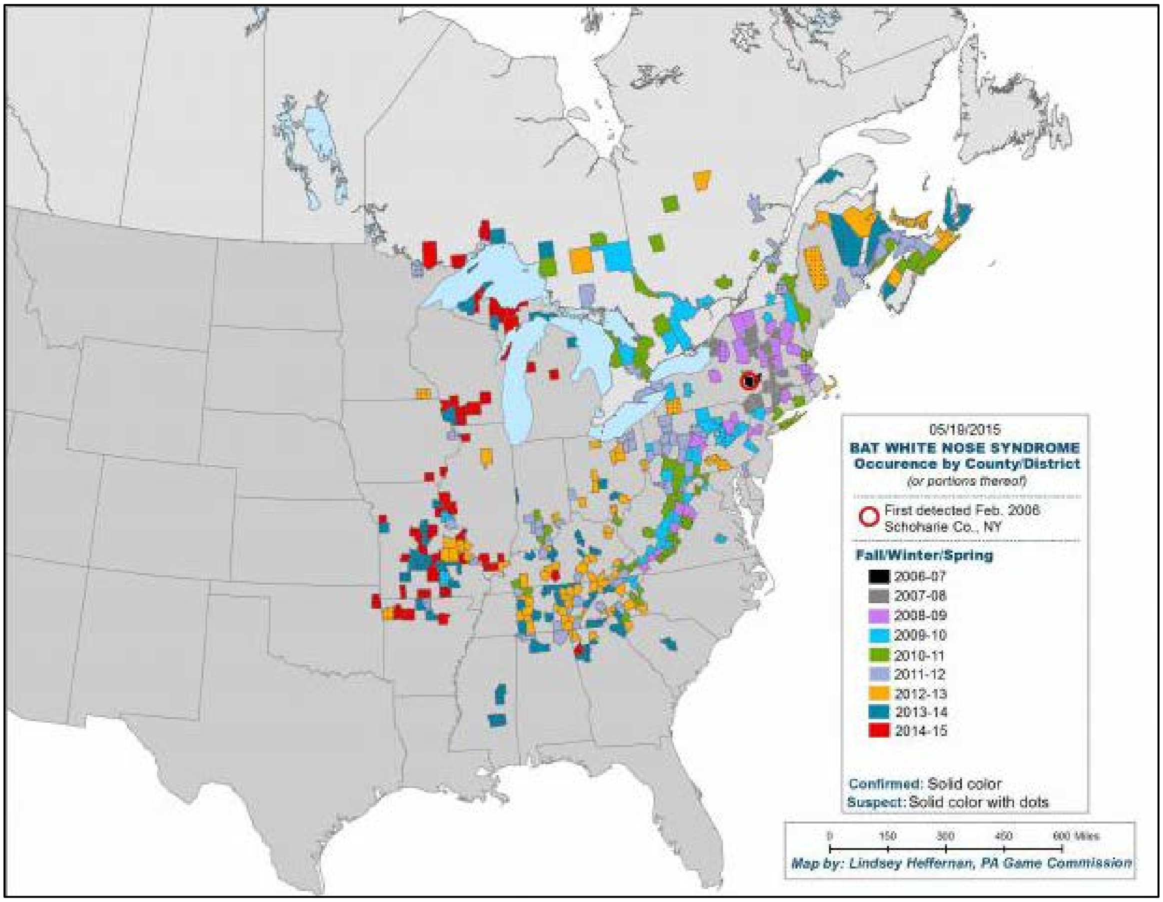


Figure 56. Bat white nose syndrome detection map since first detected in 2006 in NY. Adams County, the location of GETT and EISE, is indicated by black arrow (map excerpted from WhiteNoseSyndrome.org 2015).

The northern long-eared bat (*Myotis septentrionalis*) is one of the species impacted by white-nose syndrome. Due to declines caused by white-nose syndrome as well as continued spread of the disease, the U.S. Fish and Wildlife Service (USFWS) listed the northern long-eared bat as a federally threatened species on May 4, 2015 (USFWS 2015). The northern long-eared bat is also PA state listed as candidate rare indicating that it is a "species which exist only in one of a few restricted geographic areas or habitats within Pennsylvania, or they occur in low numbers over a relatively broad area of the Commonwealth" (Hart 2006a, PNHP 2015b). The northern long-eared bat occurs throughout Pennsylvania, but has been found in relatively low numbers (PNHP 2015b). This bat is associated with boreal forests, hunting at night over small ponds, in forest clearings, at tree top level, and along forest edges for night-flying insects (e.g., caddisflies, moths, beetles, flies). Maternity roosts are located in tree cavities, under exfoliating tree bark, and in buildings (PNHP 2015b).

The high density of white-tailed deer (*Odocoileus virginianus*) at GETT and EISE has been of concern in both parks since the 1980s (Frost et al. 1997, Storm et al. 1989, Stainbrook and Diefenbach 2012). Currently, the NPS is managing the abundance of deer at GETT and EISE through direct reduction by shooting by qualified federal employees (refer to White-tailed Deer Abundance section).

4.4.4.2 Data and Methods

Mammal species were surveyed at GETT and EISE from 1993-1994 in conjunction with the development of an inventory and monitoring protocol for mammal species in Eastern National Parks (excluding white-tailed deer and black bear [*Ursus americanus*]) (Yahner et al. 1997, 1999b). Mammal survey areas at the parks were divided into three habitat types: grassland, old-field, and forest; with surveys occurring at ten randomly selected sites (two grassland, four old-field, two lowland-forest, and two upland-forest areas) (Yahner et al. 1999b). Trapping stations were systematically placed along randomly oriented transects within each habitat. Three methods, pitfall trapping, live-trapping, and vehicular road surveys, were used to evaluate the mammal community.

Hart (2001) conducted a survey of mammal species of special concern for the Wild Resource Conservation Fund in 2000-2001. The study focused on the distribution of the least shrew and bats within GETT and EISE. Surveys for least shrews were conducted at three sites within GETT. Bats surveys were conducted using survey forms, mist netting and harp traps.

Hart (2006b) resurveyed GETT and EISE in 2004-2005 to determine what state or federally threatened or endangered small mammal species may occur within the two park units. Specifically, this study was conducted to gather information to assist defining boundaries for the Least Shrew IMA. Conservation of specific areas within the IMA that encompass GETT and EISE would allow least shrew dispersal within and among populations (providing that corridors are created and maintained) thus promoting stability for shew populations in this portion of the state (Hart 2006b). Although Hart (2006b) focused on threatened and endangered species, other small mammal species that were encountered were also reported. Survey areas within GETT and EISE were selected based on the habitat type (grasslands with little woody vegetation) likely to support least shrew populations, and trapping methods included pitfall traps and snap-traps.

Bats have been surveyed twice at both GETT and EISE. In 1999-2000 park management (former Resource Manager, Dr. Bert Frost, as cited in Hart 2006a) mist-netted seven sites (one in EISE and six in GETT). Hart (2001, 2006a) conducted a focal study on bats at GETT in 2000-2001 and again at GETT and EISE in 2004-2005 when bats were mist-netted at six sites (two in EISE and four in GETT).

Together these studies have observed 27 mammal and six bat species at GETT and seven mammal and five bat species at EISE (Table 50).

Table 51. Mammal species documented to occur at GETT and EISE (NPSpecies 2015). Includes survey area (from Yahner et al. 1997, 1999b and Hart 2006b) if known, incidental observations during inventory effort, and NPS wildlife observation cards. A: indicates observed by Yahner et al. (1997, 1999b); B: indicates observed by Hart (2001, 2006a, 2006b); C: indicates listed as present in NPSpecies (2015). D: Information from Stainbrook et al. 2006, E: Wildlife observation card. Bold text indicates state-listed species (refer to Appendix Table 61 for list of expected mammal species).

Scientific Name	Common Name	Habitat	EISE	GETT
Blarina brevicauda	Northern short-tailed shrew	Old field, Forest, Rock wall	B, C	A, B, C
Cryptotis parva (PE)[2]	Least shrew	Grassland, Old field	B, C	B
Didelphis virginiana[2]	Virginia opossum	Pasture		E
Eptesicus fuscus[1]	Big brown bat	Forested riparian, Barn	B, C	B, C
Glaucomys volans	Southern flying squirrel	Not available		A, C, E
Lasiurus borealis[1]	Red bat	Forested riparian	B, C	B, C
Lasiurus cinereus[1]	Hoary bat	Forested riparian		B, C
Lontra canadensis	River otter	Road kill		C
Marmota monax	Woodchuck	Vehicular survey		A, C
Mephitis mephitis	Striped skunk	Not available		A, C
Microtus pennsylvanicus	Meadow vole	Grassland, Old field, Forest	A, B, C	A, B, C
Microtus pinetorum	Woodland vole	Forested riparian		B, C
Mus musculus	House mouse	Not available	C	
Mustela frenata	Long-tailed weasel	Not available		A, C, E
Mustela vison	American mink	Not available		A, C, E
Myotis lucifugus[1]	Little brown myotis	Forested stream	B, C	A, B, C
Myotis septentrionalis[1, 3] (LT, CR)	Northern long-eared bat	Forested riparian	B, C	B, C

[1] Bats were specifically surveyed in 1999-2000 and in 2004-2005 (Hart 2006a).

[2] Species not listed in NPSpecies (2015) but were observed or reported by park staff, Hart (2001, 2006b) or Yahner et al. (1997, 1999b).

[3] Federal listed codes: LE: Listed endangered, LT: Listed threatened EP: Proposed endangered; State listed status codes: CA: Candidate at risk, CU: Condition undetermined, CR: Candidate rare, PE: Pennsylvania endangered, PT: Pennsylvania threatened, PX: Pennsylvania extirpated

Table 50 (continued). Mammal species documented to occur at GETT and EISE (NPSpecies 2015). Includes survey area (from Yahner et al. 1997, 1999b and Hart 2006b) if known, incidental observations during inventory effort, and NPS wildlife observation cards. A: indicates observed by Yahner et al. (1997, 1999b); B: indicates observed by Hart (2001, 2006a, 2006b); C: indicates listed as present in NPSpecies (2015). D: Information from Stainbrook et al. 2006, E: Wildlife observation card. Bold text indicates state-listed species (refer to Appendix Table 61 for list of expected mammal species).

Scientific Name	Common Name	Habitat	EISE	GETT
Odocoileus virginianus[2]	White-tailed deer	Not available	D	C, D
Ondatra zibethicus	Muskrat	Not available		A, C
Peromyscus leucopus	White-footed mouse	Grassland, Old field, Forest, Rock wall	B, C	A, B, C
Peromyscus maniculatus	Deer mouse	Grassland, Rock wall		A, C
Peromyscus maniculatus bairdii[2]	Prairie deer mouse	Rock wall		A, B
Pipistrellus subflavus[1]	Eastern pipistrelle	Forested riparian	B, C	B
Procyon lotor	Raccoon	Not available		A, C, E
Rattus norvegicus[2]	Norway rat	Grassland, Old field		B
Sciurus carolinensis	Eastern gray squirrel	Vehicular survey		A, C
Sorax cinereus[2]	Masked shrew	Not available		A, B, E
Sorax hoyi[2]	Pygmy shrew	Grassland		B
Sorex cinereus fontinalis	Maryland shrew	Old field, Forest	C	A, B, C
Sylvilagus floridanus	Eastern cottontail	Vehicular survey		A, C
Tamias striatus	Eastern chipmunk	Old field, Forest, Vehicular survey		A, C
Urocyon cinereoargenteus	Gray fox	Not available		A, C, E
Vulpes vulpes	Red fox	Not available		A, C, E
Zapus hudsonius	Meadow jumping mouse	Grassland, Forest	B	A, B, C

[1] Bats were specifically surveyed in 1999-2000 and in 2004-2005 (Hart 2006a).

[2] Species not listed in NPSpecies (2015) but were observed or reported by park staff, Hart (2001, 2006b) or Yahner et al. (1997, 1999b).

[3] Federal listed codes: LE: Listed endangered, LT: Listed threatened EP: Proposed endangered; State listed status codes: CA: Candidate at risk, CU: Condition undetermined, CR: Candidate rare, PE: Pennsylvania endangered, PT: Pennsylvania threatened, PX: Pennsylvania extirpated

4.4.4.3 Reference Condition and Status of the Resource (current condition and trends)

The number of mammal species and bats expected to occur at GETT and EISE were determined by those previously observed within the parks (Yahner et al. 1997, 1999b, Hart 2001, 2006a, 2006b) and those known to be present in Adams County or listed as having a range in the region of GETT and EISE (PNHP 2015b). This yielded a total of 41 mammal species and 12 bat species that could be expected to occur in GETT and EISE (Appendix Table 61).

Mammal inventories conducted in other NPS Networks (e.g., Northeast Coastal and Barrier Network [NCBN]) established a goal of detecting 90% of the terrestrial mammal species expected to occur within the park (Gilbert et al. 2008). Using best professional judgment, the condition of the mammal community and the bat community at GETT and EISE was evaluated based on the percent of species expected to be detected (Table 51).

Table 52. Reference condition and current status of the mammal community at GETT and EISE.

Metric	Good Condition (green)	Moderate Concern (yellow)	Significant Concern (red)	EISE Condition	GETT Condition
Mammal Species Richness (41 expected species)	>80% of species (>32 detected)	50-85% of species (32-20 species detected)	<50% species (<20 species detected)	(red) 20% observed, No trend estimated	(yellow) 68% observed, No trend estimated
Bat Species Richness (12 expected species)	>80% of species (>9 species detected)	50-85% of species (8-6 species detected)	<50% of species (<6 species detected)	(red) 42% observed, No trend estimated	(yellow) 50% observed, No trend estimated

Gettysburg National Military Park

Combining information from park staff, Yahner et al. (1997, 1999b) and Hart (2001, 2006a), 28 mammal species (other than bats) (68% of the expected species, falling within the moderate concern range) have been observed at GETT (Table 51). Since these surveys used slightly different methods and sites, trends in mammal abundance could not be determined. The least shrew, a state endangered species, has been captured at GETT (Hart 2006b).

Combining information from both the 1999-2000 and 2004-2005 bats surveys (Hart 2006a), a total of six bat species (55% of expected species, falling in the moderate concern range) have been documented at GETT (Table 51, Figure 57). Trends in bat abundance could not be determined using the available data. During the 1999-2000 survey five northern long-eared bat (or northern myotis, *Myotis septentrionalis*), a state listed candidate rare species and federally listed threatened species (USFWS 2015), were captured at two GETT sites (Hart 2006b). Hart (2006a) also visually inspected six barns (Codori, Klingel, Sherfy, Spangle, Trostle, and Weikert Barns) at GETT to determine the presence of possible maternity colonies. Although every site checked showed some sign of bat presence, only the Sherfy Barn had bats (big brown bat, *Eptesicus fuscus*) using this site. It was likely that historic renovation had altered the temperature and humidity in the buildings such that they were unusable by bats (Hart 2006a).

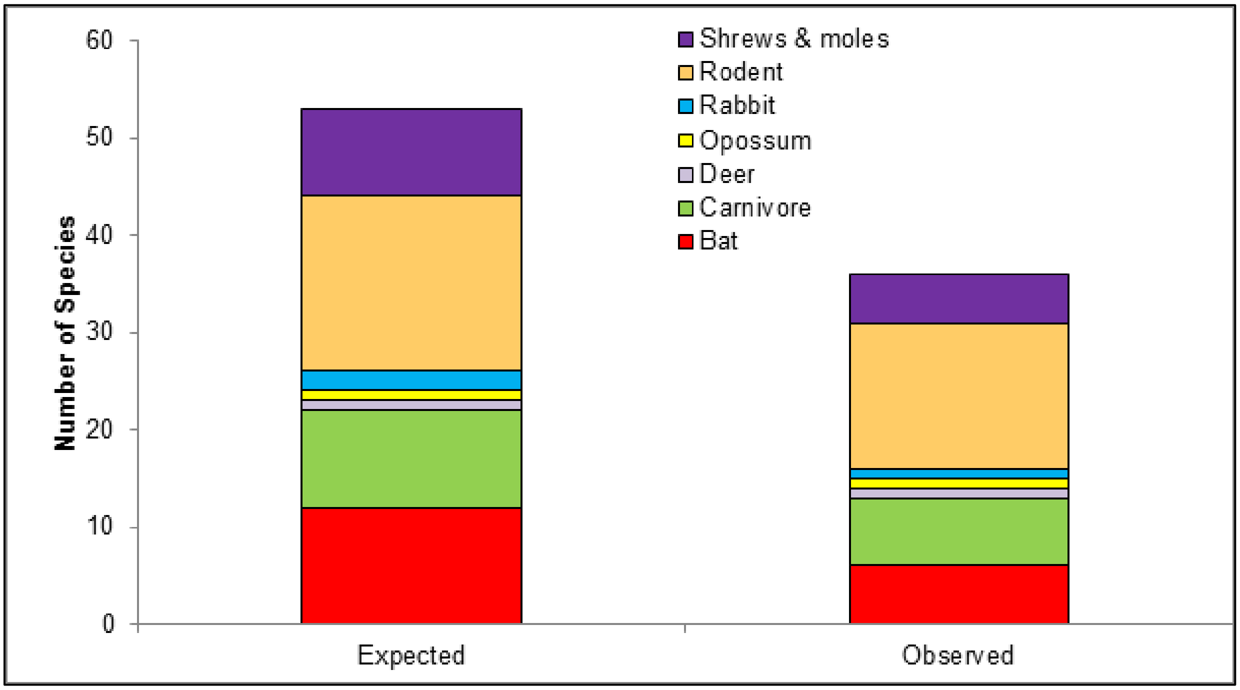


Figure 57. Number of mammal species expected and observed at GETT and EISE (refer to Appendix Table 61).

Eisenhower National Historic Site

Combining information from park staff, Yahner et al. (1997, 1999b) and Hart (2006b) eight mammal species (other than bats) (20% of the expected species) have been observed. This falls within the significant concern range. Since these surveys used slightly different methods and sites, trends in mammal abundance could not be determined (Table 51). The least shrew, a state endangered species, has been captured at EISE (Hart 2006b).

Combining information from both the 1999-2000 and 2004-2005 bats surveys (Hart 2001, 2006a) five bat species (42% of expected species, falling in the significant concern range) have been documented at EISE (Table 51, Figure 57). Trends in bat abundance could not be determined using the available data. During the 1999-2000 survey one northern long-eared bat (or northern myotis, *Myotis septentrionalis*), a state listed candidate rare species and federally listed threatened species, was captured EISE (Hart 2006b).

4.4.4.4 Confidence in Assessment

The confidence in the assessment of mammal species and bats at GETT and EISE was medium as the surveys were somewhat dated (~10 years ago). Species richness was used as an indicator of condition; however, the use of this metric alone does have its shortcomings. For example, the abundance and distribution of species are important components of an assessment; diversity in some habitat types can be expected to be low, regardless of condition; parks may not have appropriate habitat for some species; and survey methods/effort will determine number of species detected as present. Additionally with bats, different capture techniques have their own capture biases and alone may not representative of the complete bat community (S. Colwell, personal communication, 22 August 2016).

4.4.4.5 Data Gaps

The mammal inventory data were dated and a current survey of GETT and EISE mammal species, including another focal bat survey, would be beneficial to adequately document species within the park. The NPSpecies (2015) database was missing some species (refer to Table 50) that have been documented within the park units, and therefore should be updated.

4.4.4.6 Threats

Threats to mammal communities include habitat fragmentation, vehicle mortality, and predation by domestic and feral cats (e.g., Gilbert et al. 2008). Standardized mammal surveys conducted at regular intervals would provide better information on the status of mammal species in the park.

More than 50% of American bat species are rapidly declining or are already listed as endangered. The two most common species, the little and big brown bats, have altered their primary mode of roosting in cavities to take advantage of old structures such as barns and outbuildings as well as portions of structures such as attics in dwellings (Hart 2006b). This has led to conflicts between humans and bats and has been one of the problems in bat conservation in general. At GETT and EISE, although there are no reports of large maternity colonies of bats using the many residences across the landscape, there are several barns that either have recent colonies or have been reported to contain such colonies in the past. Renovation of these sites has reduced the functionality of these as maternity roost sites. Only one barn, the Sherfy Barn, still contains what appears to be a fairly significant population of big brown bats (Hart 2006b). Additionally, WNS could also be a threat to bat populations at GETT and EISE.

The only two known resident Pennsylvania bat species that remain unreported from GETT or EISE were the Indiana bat (*Myotis sodalis*) and eastern small footed bat (*Myotis leibii*) (Hart 2006b) two species that are predominantly associated with large tracts of mature forest (Barbour and Davis 1969), a primary habitat type lacking within the confines of both park units. Although it was noteworthy that two female radio-tagged Indiana bats were tracked to sites in Maryland just south of GETT and they most likely flew over the park (Hart 2006b). Mist-netting was conducted in the vicinity of Devil's Den (Hart 2006b), an area of GETT that approximates likely eastern small-footed bat summer roosting habitat (Veilleux 2005) without any captures of that species. It is highly likely that the high volume of tourist traffic to one of the park's more well-known and appealing sites prevents the use of crevices in the large outcrops by the small-footed bat (Hart 2006b).

4.4.5 White-tailed Deer Abundance

4.4.5.1 Relevance and Context

An important purpose for managing the deer population at GETT and EISE is to preserve the historic character of the parks. Management objectives include maintaining the landscape as it existed during the historic 1863 Civil War battle (e.g., dense understory in woodlots) in GETT and as it existed during Eisenhower's occupancy (e.g., patchwork of crop fields) in EISE. In the 1980s, resource managers at GETT and EISE were concerned that the overabundance of white-tailed deer (*Odocoileus virginianus*) were adversely affecting the cultural integrity of both parks by negatively impacting forest regeneration, reducing growth of crops, causing increased deer-vehicle collisions in and around the park, and altering the presence and appearance of understory vegetation thereby making preservation of historic woodlots and interpretation of the battle events difficult for NPS staff (Storm et al. 1989, Vecellio et al. 1994, Frost et al. 1997, Niewinski et al. 2006, Stainbrook and Diefenbach 2012). In 1992, deer abundance was estimated at GETT and EISE at approximately 136 deer km^{-2} of forested land, which was greater than 10 times the recommended density by the Pennsylvania Game Commission for Adams County at that time (Frost et al. 1997). Thus to increase forest regeneration, restore a dense understory in the woodlots, and reduce crop damage the NPS began culling deer in 1995 to reach a density goal of 10 deer km^{-2} of forest (Stainbrook and Diefenbach et al. 2012). Currently, the parks' management deer program sets goals for deer density, provides for the long-term protection, conservation and restoration of native species and cultural landscapes (NPS 2015c).

4.4.5.2 Data and Methods

The most recent published assessment of deer abundance in GETT and EISE was conducted in 2010 by Stainbrook and Diefenbach (2012). This study used mark-resight, change-in-ratio, catch-per-unit-effort, and distance sampling methods to estimate deer abundance.

Currently, the NPS is continuing to manage the abundance of deer at GETT and EISE through direct reduction by shooting by qualified federal employees (hunting of deer by the public is not permitted within the parks' boundaries) (NPS 2015c). All deer taken through this program are tested for Chronic Wasting Disease (CWD), and as of 2012 all deer taken within GETT and EISE tested negative for CWD (although CWD was detected on deer farm in Adams County in 2012, S. Colwell personal communication, 22 August 2016). Deer management is conducted October through March and will continue each year as necessary (NPS 2015c). Additionally, the parks monitor the deer population each spring and also long-term forest monitoring is conducted by the MIDN in conjunction with park staff (refer to Forest Communities, Woodlots, and Vegetation Associations section) to help assess the program and set deer management goals (NPS 2015c). Deer monitoring follows the methods of Stainbrook and Diefenbach (2012) using mark-resight, change-in-ratio estimator based on data collected during culling operations, catch per-unit-effort, and distance sampling methods to estimate deer abundance.

4.4.5.3 Reference Condition and Status

In 1992 the abundance of deer in the parks was estimated at 136 deer km^{-2} of forest (Frost 1997). Stainbrook and Diefenbach (2012) estimated that the density in 2010 ranged from 43-71 deer km^{-2} of forest. In 2016, park staff estimated that deer density was 33-93 deer km^{-2} of forest (D. Reiner, personal communication, 12 October 2016). Thus, since the initiation of culling the deer density has decreased, an average, approximately 50%. Although the 2010 and 2016 estimates were still much higher than the desired goal of 10 deer km^{-2} of forest, NPS staff have observed increased tree regeneration and reduced crop damage on NPS-owned property since culling was initiated. However, with increasing forest regeneration, the visibility of deer would decline and therefore actual deer density could be higher (J. Comiskey, personal communication, 18 March, 2016).

Stainbrook and Diefenbach (2012) observed more deer on private lands and fewer deer on NPS lands in their 2010 study and suggested that the NPS may want to consider re-evaluating the deer density goal if landscape objectives (e.g., a dense understory in woodlots as existed during the Battle of Gettysburg) were being met. Based on best professional judgement the condition of deer abundance, as it pertains to management goals, was assessed as moderate concern (since the density goal has not been maintained), with an improving trend (since management actions are succeeding in reducing deer density towards the management goal) (Table 52).

Table 53. Condition assessment of deer abundance.

Target Goal	1992 abundance	2010 abundance	2016 abundance	GETT and EISE Condition
10 deer km^{-2} forest	136 deer km^{-2} of forest	43-71 deer km^{-2} of forest	33-93 deer km^{-2} of forest	

4.4.5.4 Confidence in Assessment
The confidence in the assessment was high as deer abundance is currently monitored every spring and the parks continue to a practice deer reduction program and continually re-evaluate the program to set deer management goals.

4.4.5.5 Data Gaps
There are no data gaps as the parks continue to monitor deer abundance, have a deer management plan in place, and have long-term forest monitoring to assess the impact of deer browsing on vegetation.

4.4.5.6 Threats
The deer population is currently under a strong management program. Chronic wasting disease could also be an emerging threat as it was detected in Adams County in a captive deer farm in 2012.

Chapter 5. Discussion

5.1 NRCA Background

Natural resources for Gettysburg National Military Park and Eisenhower National Historic Site were divided into four general areas: physical resources, water-related resources, ecosystem integrity, and focal animal communities. Within each of these categories specific natural resource issues were discussed (Table 53).

Table 54. Natural resource areas for GETT and EISE.

	Natural Resource Areas			
	Physical Resources	**Water-Related Resources**	**Ecosystem Integrity**	**Focal Terrestrial Animal Communities**
Issues Discussed	Air quality - ozone	Stream water quality	Forest communities, woodlots, and vegetation associations	Avian community
	Air quality - wet deposition	Wetlands, vernal pools, and ponds	Plant species of interest	Herpetofaunal community
	Air quality - visibility	Aquatic macroinvertebrates	Agricultural fields and grasslands	Terrestrial Arthropod & Lepidoptera communities
	Night sky resources	Fish community		Mammal community
	Acoustic environment			White-tailed deer abundance

The approach of this Natural Resource Condition Assessment was to use existing data to evaluate the condition of natural resources at GETT and EISE. Thresholds for condition (good, moderate concern, and significant concern) were obtained from a variety of resources such as federal and or state regulations (e.g., water quality criteria), peer-reviewed literature, study reports, and in some cases when threshold values were not available, best professional judgment. If possible, trends in the condition (improving, deteriorating, or unchanging) were noted. And finally, an estimate of the confidence in the assessment based on the quality and quantity of available information (high, medium, low confidence) was also provided. The assessment of condition used standardized symbology provided by NRCA guidelines (Table 54).

Table 55. Natural resource condition assessment symbology.

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

5.2 Natural Resource Overview and Condition Assessment

Gettysburg National Military Park and Eisenhower National Historic Site are located in the south central portion of Pennsylvania in Adams County. The parks are adjacent to each other and share a common boundary on the western side of GETT. GETT preserves the site of the American Civil War battle of Gettysburg, the Soldiers' National Cemetery, and the commemoration of the great battle by Civil War veterans. The landscape is a mosaic of mature and maturing woodlands and woodlots, agricultural fields, pastures, small wetlands, and streams which provide habitat for flora and fauna. The park’s enabling legislation was to protect lands occupied by the military during the battle and to preserve important topographical features of the battlefield. EISE preserves the presidential and retirement home and farm of General and President Dwight D. Eisenhower, 34th President of the United States. During his presidency the farm sported a putting green, a skeet range, and a prized herd of Angus cattle. The farm was used as a weekend retreat, temporary White House, and meeting place for world leaders. EISE contains flat open fields and pastures dissected by rolling hills, forested areas, meadows, wetlands, riparian zones, and local stream valleys.

5.2.1 Physical Resources

Metrics used by the NPS ARD to assess air quality were ozone, total nitrogen (N) wet deposition, total sulfur (S) wet deposition, and mercury deposition. Ozone concentration was measured using three specific metrics: the 4th-highest daily maximum 8-hour average ozone concentration (the human health standard), and W126 and SUM06 metrics (both ecological standards that measure exposure to ozone sensitive vegetation). All three ozone metrics were rated as moderate concern for both GETT and EISE. While trends in these metrics were not specifically evaluated for these parks, the NPS ARD regional trend maps for these metrics showed an improving trend in the regional area of the park. The confidence in the assessment was high as ozone was routinely measured and interpreted by the NPS ARD. Both total N and total S wet deposition were rated as significant concern with improving trends for both GETT and EISE. Threshold standards for air quality related to mercury deposition have not yet been established; however, the trend in mercury deposition was evaluated as improving. The confidence in the assessment was high as wet deposition was routinely measured and interpreted by the NPS ARD (Table 55).

Air pollution causes haze and reduces visibility. Visibility was estimated using a Haze Index based on the haze levels on the clearest and haziest days. As the Haze Index increases, visibility worsens. The US EPA’s Regional Haze Program protects visibility in Class I areas. Class I areas include national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres that were in existence when the Clean Air Act was amended in 1977. Class I areas receive the highest degree of air quality protection under the Clean Air Act and have specific national regional haze goals. Generally, all other parks that do not meet the criteria for Class I are considered Class II areas. GETT and EISE are considered Class II areas. The visibility at both parks was evaluated as significant concern. Although the NPS ARD did not estimate trends in visibility, NPS ARD regional haze maps indicated no change on the 20% clearest days and a possible improving trend in visibility on the 20% haziest days in this region. The confidence in the assessment was high as visibility was routinely measured and interpreted by the NPS ARD (Table 55).

The night sky as we see it is a combination of both natural and human-caused sources of light. Natural light sources include moonlight, starlight from individual stars and planets, and other celestial bodies. The NPS uses the term "natural lightscape" to describe resources and values that exist in the absence of human-caused light at night. Natural lightscapes are important for nighttime scenery, such as viewing a starry sky, but are also critical for maintaining nocturnal habitat for a variety of species. Alteration of night sky resources can be in the form of astronomical light pollution, where stars and other celestial bodies are obscured from view or in the form of ecological light pollution where lighting can disrupt natural ecosystem processes and wildlife behavior. The NPS NSNSD measures the quality of the photic environment by measuring total sky brightness averaged across the entire sky and comparing that value to natural nighttime light levels. This measure, called the ALR, can be directly measured or modeled when observational data are unavailable. An ALR of 0.0 would indicate pristine natural conditions, while a ratio of 1.0 would indicate that anthropogenic light was 100% brighter than the average natural light from the night sky. The modeled median ALR value at GETT was 7.15 and was 7.06 at EISE. At these light levels the Milky Way may be only visible when it is directly overhead, the landscape is clearly shadowed or illuminated and the horizon may appear aglow with anthropogenic light. The condition of the night sky for both parks was evaluated as moderate concern by the NPS NSNSD and trend was not estimated as night sky resources were only recently (2013) modeled. The confidence in the assessment was medium because it was based on modeled data (Table 55).

In the National Park setting, the total acoustic environment of the park may include natural, cultural, and historic sounds depending on the purpose and values of the park. The acoustic environment, like water, scenery, or wildlife, is a valuable resource that can easily be degraded by inappropriate sounds or sound levels and as a result, the acoustic environment requires careful management just as any other park resource. At GETT and EISE, acoustic noise resource protection and noise reduction are related to: the ability to enhance the visitor experience, the rural, historical, and commemorative settings throughout the park, interpretative programs, living history exhibitions, and preserving quality wildlife habitat. NPS NSNSD measures the acoustic environment and assists park managers with specialized resource management, policy expertise, and technical expertise in the form of acoustical monitoring, data collection and analysis, and all aspects of park planning and compliance. At GETT and EISE, ambient natural and existing sound pressure levels were modeled, and the mean L_{50} dBA impact metric was calculated. This metric indicates how much anthropogenic noise raises the existing sound pressure levels in a given location. The L_{50} dBA impact between natural and existing acoustic conditions was 9.5 dBA at GETT and 6.6 dBA at EISE. Both values were within the significant concern range, based on NPS NSNSD thresholds, for non-urban parks. Trend was not estimated and the confidence in the assessment was medium since the L_{50} dBA was based on modeled data as opposed to field data (Table 55).

5.2.2 Water Related Resources

Water quality is ecologically significant as it affects aquatic communities and ecosystems. Surface water resources at GETT and EISE are streams and ponds. The major streams at GETT are Rock Creek, Willoughby Run, Stevens Run, and Plum Run. Willoughby Run drains into Marsh Creek at EISE. US EPA indicated that the water quality of Stevens Run and Rock Creek were impaired and both streams needed TMDLs based on 2002 and 2004 assessments. Impairments listed as needing a TMDL were siltation and nutrients (excess nitrogen and phosphorus) for Rock Creek; while Stevens Run was listed as needing a TMDL for siltation, nutrients (excess nitrogen and phosphorus), and toxic chemicals. As of 2016, the TMDLs have not yet been developed. The MIDN along with park staff has conducted monthly water quality sampling since 2010 at GETT and EISE, but has not yet analyzed these data; however, an assessment of condition was estimated based on PA state water quality standards using these data (continuous water quality monitoring was recently initiated at Plum Run but these data were not yet available for interpretation). Dissolved oxygen, pH, and specific conductance at both GETT and EISE were evaluated as good condition. Water temperature was evaluated as good condition for GETT and good to moderate condition at EISE. Siltation was evaluated as moderate concern for both parks, while nutrients and toxics were assessed as moderate concern for GETT and unknown for EISE. Trends were not evaluated as the MIDN has not yet analyzed these data. The confidence in the assessment of the MIDN water quality parameters (dissolved oxygen, pH, specific conductance, and temperature) was medium because the water quality data were recent but have not been completely analyzed by the MIDN. The confidence in other water quality parameters (nutrients, siltation, and toxics) was low as these were not sampled by the MIDN and the last assessment by the state and/or US EPA was over ten years ago (Table 55).

Wetlands are important habitats that can support a diverse array of flora and fauna. The wetlands within GETT and EISE were small (< 5ha in size) and were associated with streams and included floodplain forests, forested swamps, shrub swamps, and graminoid marshes. These wetlands have been altered by subsequent generations of landowners and farmers that drained historic wetlands. Two obligate vernal pool amphibians, the wood frog and spotted salamander, have been recorded at GETT (none have been reported at EISE); however, the presence of vernal pools within the parks has not been verified. Additionally, there were several plants that are known to be found in association with vernal pool habitats that have been recorded in both parks. GIS landscape level data (2011 NLCD data) and in-house park GIS data were used to evaluate the condition of the wetlands based on wetland patch size and surrounding land use (e.g., anthropogenic land use versus natural lands). The condition of the wetlands at GETT scored as significant concern for wetland patch size (too small) and moderate concern based on the low percent of natural lands in three buffer zones (0-100 m, 100-250 m, and 250-500 m buffer zones) around the wetlands. At EISE, wetland patch size also scored as significant concern (too small). The immediate buffer zone (0-100 m) scored as moderate concern while the other two zones (100-250 m and 250-500 m) scored as significant concern due to the low percent of natural lands in the vicinity of the wetlands. The confidence in the assessment was medium and trend was not evaluated as this was a first attempt to assess wetlands using these metrics. Additionally, battlefield rehabilitation may have changed the land use adjacent to the parks' wetlands since the NLCD 2011 data were developed (Table 55).

Aquatic macroinvertebrates perform essential roles in stream ecosystem function and are often used by regulatory agencies to document stream condition under the Clean Water Act. Aquatic macroinvertebrate sampling was initiated by the MIDN at GETT and EISE in 2009 and continues to the present. The MIDN uses a multi-metric IBI to measure relevant aspects of benthic macroinvertebrate community composition. Based on the MIDN calculated IBI the condition of the aquatic macroinvertebrate community at both GETT and EISE was evaluated as significant concern, with an unchanging trend. The confidence in the assessment was high since the data were recent and the MIDN plans to continue aquatic macroinvertebrate sampling at GETT and EISE. Additionally, a focal survey for crayfish was conducted in 2005 at both parks. The condition of the crayfish community was evaluated as significant concern for both parks due to the abundance of invasive crayfish species. The trend was unknown and the confidence was medium due to the age of the data (Table 55).

Freshwater fish communities are useful indicators of environmental condition and fish community structure is often used as an index of condition. Fish assemblages generally include a range of species that represent a variety of trophic levels and the structure of fish assemblages tends to be reflective of environmental health. The fish community at GETT and EISE has only been surveyed once in 2004. An IBI developed for New Jersey streams and based on the US EPA rapid bioassessment was used to evaluate the fish community. Metrics used in the IBI included species richness, trophic composition, and abundance. The condition of the fish community at GETT was evaluated as good (Rock Creek community). The fish community at EISE was evaluated as good (Marsh Creek community) to moderate concern (Willoughby Run community). Trends could not be estimated as there has only been one survey. The confidence in the condition for the survey efforts was rated as medium due to the age of the data (Table 55).

5.2.3 Ecosystem Integrity

Vegetation at GETT and EISE has been monitored at various times over the past several decades, and has ranged from flora inventories, focal studies of woodlot plant communities, vegetation association mapping (conducted in 2003), and long-term forest monitoring by the MIDN and park staff. The

National Vegetation Classification mapping effort in 2003 identified 15 vegetation associations: Chestnut Oak Forest, Dry Oak – Mixed Hardwood Forest, Tuliptree Forest, Modified Successional Forest, Conifer Plantation, Virginia Pine Successional Forest, Sycamore – Mixed Hardwood Floodplain Forest, Bottomland Mixed Hardwood Forest, Palustrine Shrub Thicket, Successional Old Field, Agricultural Field, Pasture, Orchard, Wet Meadow, and Reed Canary Grass Riverine Grassland. However, battlefield rehabilitation at GETT has significantly altered the vegetation in many sections of the park; so much so, that the 2003 vegetation map was significantly out of date even before it was published. However, the park does maintain draft internal GIS database to track the progress of the battlefield rehabilitation that is updated continuously.

Since 2007, the MIDN and park staff have monitored forest plots at GETT to assess forest ecosystem integrity; forest cover is low at EISE and thus is not monitored. Metrics used to evaluate forest health include forest community structure, density and composition of tree seedlings and saplings, monitoring selected herbaceous species as indicators of deer browsing, detection of forest pests and diseases, detection of invasive plants, status of coarse woody debris and snags, and measures of soil chemistry. The most current and comprehensive data for forest integrity at GETT were from 2007 to 2010, and indicated that overall the condition of forest health at GETT was good. Five metrics: forest structural stage, forest tree canopy cover, snags, coarse woody debris, and Ca:Al soil chemistry were evaluated as good condition. Forest regeneration was assessed as moderate concern; while C:N soil chemistry was evaluated as significant concern. The trend in structural stage was unchanging from 2007-2009 (census 1) to 2011-2013 (census 2). Forest regeneration from census 1 to census 2 for tree seedlings was improving but was deteriorating for invasive plants. The trend for soil chemistry was unchanging based on 8 plots (sampled in 2010 and 2013).Trends were not evaluated for canopy tree condition, snags, or coarse wood debris from census 1 to census 2. The confidence in the assessment was high (Table 55).

Park management to maintain the historic and cultural landscape at GETT and EISE strongly influences vegetation within the parks. At GETT and EISE agricultural fields and grasslands are abundant. These large expanses of grasslands are primarily managed as a cultural resource to restore and perpetuate the battlefield as it appeared at the time of the Battle of Gettysburg, but they also provide critical habitat for a variety of flora and fauna, such as grassland obligate bird species, turtles and snakes, small mammals, and rare plant species. The fields at GETT and EISE have not been specifically surveyed except in the context as a habitat for focal surveys of other species such as mammals and grassland birds. The metrics used to assess the condition of these areas as related to grassland bird habitat were: field patch size, perimeter to area (P:A) ratio of the fields, mow plans, and Floristic Quality Index. The condition of the fields at GETT and EISE were assessed as significant concern for field size (too small for grassland obligate birds), good condition for P:A ratio, moderate concern for mow plans, and unknown for Floristic Quality Index (there were no data on the vegetation communities of the grasslands). Trends were not evaluated as the battlefield rehabilitation continues to alter the parks' landscape (Table 55).

Vegetation management is an important part of the natural resource goals for GETT and EISE. The parks' primary goals regarding vegetation are to restore and perpetuate the battlefield as it appeared at the time of the Battle of Gettysburg. This includes preserving and protecting threatened and endangered plants as well as documenting and managing non-native invasive plants. Field surveys were conducted in 2004-2005 to document the presence of federally-listed and state-listed plant species of special concern in GETT and EISE. Invasive plant species have not specifically been mapped at GETT and EISE, but have been noted during various vegetation surveys. Thirty-five state-listed plant species (3.8% of all species) were recorded at GETT. Three state-listed plants (1% of all species) have been recorded at EISE. Forty-five invasive plants or potentially invasive plants (5% of all species) were recorded at GETT, and 19 invasive plants or potentially invasive plants (7% of all species). The condition for plant species of concern was evaluated as unknown for both GETT and EISE since there were no thresholds available to assess condition; however, the last survey for plant species of concern was done over ten years ago and may not be representative of the current species in the parks. Neither GETT nor EISE have been mapped for the areal extent of invasive plants; however, the MIDN forest vegetation monitoring indicated that exotic plant species at GETT were prevalent in the park and therefore invasive vegetation was evaluated as significant concern based on best professional judgement. The condition of invasive plants at EISE was evaluated as unknown since invasives have not been surveyed at EISE. The confidence in the assessment for both species of interest and invasive vegetation was low (Table 55).

5.2.4 Focal Animal Communities

Birds are an important component of park ecosystems and their prominent position in most food webs make them good sentinels of local and regional ecosystem change. The avian community at GETT and EISE has been surveyed once in 1999 to 2001, that also included a focal survey for loggerhead shrikes at EISE. A focal study on grassland and shrubland birds was conducted in the parks in 2005. One hundred and fifty-one (151) bird species have been observed at GETT and 111 observed at EISE; of these, 95 species breed in GETT and 72 in EISE. Six state-listed species were observed at GETT: barn owl, blackpoll warbler, Henslow's sparrow, short-eared owl, upland sandpiper, and yellow-crowned night-heron. Two state listed species were observed at EISE: loggerhead shrike and short-eared owl. The condition of the avian songbird community was evaluated using a guild based BCI developed for the Mid-Atlantic Piedmont and Coastal Plain region. The BCI, based on birds observed during the breeding season, incorporated the percent of species in nine bird guilds from three biotic elements (structural, functional, and compositional) with three guilds per biotic element. The guilds were broadly categorized as specialist or generalist. Specialist guilds contained species with a narrow range of habitat tolerances or that exhibit low intrinsic rates of population increase. Therefore, these guilds were thought of as indicative of a high-integrity ecological condition while generalist guilds were considered indicative of a low-integrity ecological condition. The condition of the breeding bird community was assessed at GETT as "largely intact" and overall was evaluated as good condition. The condition of the breeding bird community was assessed at EISE as "moderately disturbed" and the condition was assessed as moderate concern. Guilds that ranked as "humanistic" or "moderately disturbed" at EISE were the specialist guilds of forest interior, pine associated, upper canopy foragers, bark probers, upper canopy foragers, and ground gleaners (a lower than desired species richness was observed for these guilds). The generalist guilds of exotics and nest disrupters had higher than the desired number of species. However, this assessment should be interpreted with caution due to the scarce amount of forest habitat at EISE. Confidence in the assessment for both parks was rated as medium due to the age of the data. Trends were not evaluated due to the lack of long term data (Table 55).

Obligate grassland birds have been observed during the breeding season at both GETT and EISE: bobolink, Eastern meadowlark, grasshopper sparrow, and Savannah sparrow. The NETN Breeding Landbird protocol has guidelines for evaluating the integrity of grassland bird communities. Similar to the Mid-Atlantic Piedmont BCI, the grassland bird community can be assessed using the presence of certain guilds (e.g., edge generalist, shrub-dependent, and grassland obligate and exotic species). Unfortunately, this assessment could not be applied to the grassland bird data as several metrics were missing. Therefore the grassland bird community for both GETT and EISE was evaluated as unknown. The confidence in the assessment was low (Table 55).

Amphibians and reptiles are sensitive to environmental degradation. Habitats for herpetofauna (amphibians and reptiles) at GETT and EISE include forest, grassland (not grazed by cattle and mowed only once per year), wetland, and riparian areas. Amphibian and reptile communities have been surveyed once in 1999 to 2000. At GETT, 29 species were observed (15 amphibians and 14 reptiles) and at EISE, nine species were observed (seven amphibians and two reptiles). No state or federally listed species were observed at either GETT or EISE. The metric used to evaluate the condition of the herpetofaunal community was species richness, expressed as a percent of observed amphibian and reptile species at GETT and EISE as compared to species observed in Adams County, and the thresholds were based on best professional judgment. At GETT, 71% of the expected amphibian and 50% of expected reptile species were observed, and the condition for these communities was assessed as moderate concern. At EISE, 33% of amphibian and 7% of reptile species were observed and the communities were evaluated as significant concern. Since there has only been one monitoring effort the trend was unknown, and the confidence in the assessment was medium due to the age of the data (Table 55).

Terrestrial arthropods, including Lepidoptera (butterflies and moths), provide a diverse array of ecosystem services, including pollination, decomposition, and biological pest control of crops by natural enemies. For example, butterfly taxa are sensitive to land-use changes mainly as a result of their multiple life stages and their specialized habitat requirements. Terrestrial arthropods including Lepidoptera were inventoried once (in 1999-2000) at GETT and EISE. This inventory was a first attempt to develop a monitoring plan for these species. Although, this study suggested potential taxa that could be used as sentinel groups to monitor, there was a lack of spatial and temporal population data and a need for greater taxonomic resolution, both of which hindered the development of a robust monitoring protocol. Therefore, more data were required before the condition of terrestrial arthropod communities at GETT and EISE could be evaluated and the condition of the community was assessed as unknown and the confidence in the assessment was low. Trends could not be evaluated because these communities have only been inventoried once (Table 55).

Mammals contribute to species richness and diversity and play a major role in ecosystem dynamics as consumers of plant material and invertebrates and as prey for snakes, raptors, and carnivorous mammals. Small mammals can affect the structure, species composition, and successional trends of plant communities, and may directly influence population levels of insect pests and disease vectors such as gypsy moths and deer ticks, as well as regionally rare raptorial birds. Pennsylvania Biological Survey has designated GETT, EISE, and several adjacent properties outside the parks' boundaries as an IMA for the least shrew, a Pennsylvania state endangered species. The northern long-eared bat (or northern myotis) a state listed candidate rare species and federally listed threatened species has also been captured at both GETT and EISE. Mammals have been surveyed several times over the past 20 years at GETT and EISE. The most recent surveys occurred in 2004-2005 and included focal surveys for least shrews and bats. Twenty-seven and six mammals (other than bats) have been recorded at GETT and EISE, respectively. Mammal inventories conducted in other NPS Networks (e.g., NCBN) established a goal of detecting 90% of the terrestrial mammal species expected to occur within the park. Using best professional judgment, the condition of the mammal communities at GETT and EISE was evaluated based on the percent of species expected to be detected. The condition of the mammal community (excluding bats) at GETT was moderate concern (66% of expected species) and significant concern for EISE (17% of expected species). Trends could not be evaluated due to different methodology of the surveys. Confidence in the assessment was medium due to the age of the data. Six bat species (55% of expected) have been documented at GETT and five bat species (42% of expected species) have been recorded at EISE. The condition of the bat community was evaluated as moderate concern for GETT and significant concern for EISE. Since these surveys used slightly different methods and sites, trends in bat abundance could not be determined. During the 1999-2000 survey five northern long-eared bat (or northern myotis, a state listed candidate rare species and federally listed threatened species) was observed at both GETT and EISE. When sites were re-surveyed in 2004-2005, only big brown bats appeared to have active colonies. It was likely that historic renovation of the buildings used by bats had altered the temperature and humidity such that these sites not longer provided suitable habitat. The confidence in the assessment was medium due to the age of the data (Table 55).

White-tailed deer abundance has been a concern at GETT and EISE since 1980s. An important purpose for managing the deer population in the parks is to conserve and protect the historic woodlots that played a role in the Battle of Gettysburg. Thus to increase forest regeneration and reduce crop damage the NPS began culling deer in 1995 to reach a density goal of 10 deer km-2 of forest. In 2016, deer density was ranged from 33-93 deer km-2 of forest. Thus, since the initiation of culling the deer density had decreased, an average, approximately 50%. Although the 2016 density was much higher than the desired goal of 10 deer km-2 of forest, NPS staff have observed increased tree regeneration and reduced crop damage since culling was initiated. Based on best professional judgement the condition of deer abundance, as it pertains to management goals, was assessed as moderate concern (since the density goal has not yet been met), with an improving trend (since management actions are succeeding in reducing deer density towards the management goal) (Table 55).

Table 56. Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Air Quality			
Ozone (human health standard)	moderate concern, trend unknown	moderate concern, trend unknown	Continued monitoring by local, state, and federal agencies (data interpolated by the NPS ARD from stations relatively close to the parks)
Ozone, SUM06 (ecological standard)	moderate concern, trend unknown	moderate concern, trend unknown	
Ozone, W126 (ecological standard)	moderate concern, trend unknown	moderate concern, trend unknown	
Wet N deposition	significant concern, improving trend	significant concern, improving trend	
Wet S deposition	significant concern, improving trend	significant concern, improving trend	
Mercury wet deposition	Condition threshold not established but trend was improving	Condition threshold not established but trend was improving	
Visibility	significant concern, trend unknown	significant concern, trend unknown	
Night sky resources	moderate concern, trend unknown	moderate concern, trend unknown	Based on modeled NSNSD data, field data for both parks would be beneficial
Acoustic resources	significant concern, trend unknown	significant concern, trend unknown	Based on modeled NSNSD data, field data for both parks would be beneficial
Water Resources			
Water quality- dissolved oxygen	good condition, trend unknown	good condition, trend unknown	Continue with MIDN water quality monitoring. Possibly expand continuous water quality monitoring to other locations and include other parameterxs.
Water quality- nutrients	moderate concern, trend unknown	condition and trend were unknown	
Water quality- pH	good condition, trend unknown	good condition, trend unknown	

Table 55 (continued). Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend		EISE Condition/Trend		Recommendation
Water Resources (continued)					
Water quality- siltation		moderate concern, trend unknown		moderate concern, trend unknown	Continue with MIDN water quality monitoring. Possibly expand continuous water quality monitoring to other locations and include other parameterxs.
Water quality- specific conductance		good condition, trend unknown		good condition, trend unknown	
Water quality- temperature		good condition, trend unknown		good to moderate concern, trend unknown	
Water quality- toxic chemicals		moderate concern, trend unknown		condition and trend were unknown	
Wetland patch size		Significant concern, unknown trend		Significant concern, unknown trend	Conduct a wetlands inventory.
Wetlands (0-100m buffer)		moderate concern, trend unknown		moderate concern, trend unknown	
Wetlands (100-250m buffer)		moderate concern, trend unknown		Significant concern, unknown trend	
Wetlands (250-500m buffer)		moderate concern, trend unknown		Significant concern, unknown trend	
Aquatic macroinvertebrates: Crayfish community		Significant concern, unknown trend		Significant concern, unknown trend	Continue monitoring the aquatic macroinvertebrate community using the MIDN protocol. Conduct focal crayfish study
Aquatic macroinvertebrates		Significant concern, unchanging trend		Significant concern, unchanging trend	
Fish community		good condition, trend unknown		good to moderate condition, trend unknown	Conduct fish survey

Table 55 (continued). Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Terrestrial Resources			
Forest Communities - Forest structural stage	good condition, trend unchanging	Not sampled	Continue with MIDN forest monitoring. Data are currently being analyzed by the MIDN with respect to trends. Possibly, re-monitor plots after prescribed burns are conducted.
Forest Communities - Forest canopy tree cover	good condition, trend unknown	Not sampled	
Forest Communities - Forest snags	good condition, trend unknown	Not sampled	
Forest Communities - Forest course woody debris	good condition, trend unknown	Not sampled	
Forest Communities - Forest regeneration (stocking index)	moderate concern, growth rate invasive plants	Not sampled	
Forest Communities - Forest soil chemistry (Ca:Al)	good condition, trend unchanging	Not sampled	
Forest Communities - Forest soil chemistry (C:N)	significant concern, trend unchanging	Not sampled	
Plant Species of Interest – Species of Concern	condition and trend unknown	unknown condition and trend	Conduct surveys for density and areal coverage for plant species of interest.
Plant Species of Interest – Invasive plants	significant concern, trend unknown	condition and trend unknown	
Agricultural fields & grasslands - Field size	significant concern, trend unknown	moderate concern, trend unknown	Develop metadata for current landuse cover related to battlefield rehabilitation. Conduct a grassland vegetation study. Develop mow plans for all fields.
Agricultural fields & grasslands – P:A ratio	good condition concern, trend unknown	good condition concern, trend unknown	
Agricultural fields & grasslands – Mow plans	moderate concern, trend unknown	moderate concern, trend unknown	
Agricultural fields & grasslands – Floristic index	condition and trend unknown	condition and trend unknown	

Table 55 (continued). Summary condition table for natural resources at Gettysburg National Military Park and Eisenhower National Historic Site.

Metric	GETT Condition/Trend	EISE Condition/Trend	Recommendation
Focal Communities			
Avian community - songbird	good condition, trend unknown	moderate concern, trend unknown	Conduct avian monitoring.
Avian community - grassland	condition and trend unknown	condition and trend unknown	Conduct grassland bird study and focal loggerhead shrike study.
Herpetofauna - Amphibians community	moderate concern, trend unknown	significant concern, trend unknown	Conduct herpetofauna monitoring.
Herpetofauna- Reptiles	moderate concern, trend unknown	significant concern, trend unknown	
Terrestrial arthropod & Lepidoptera	condition and trend unknown	condition and trend unknown	Develop monitoring plan and conduct terrestrial arthropod & Lepidoptera monitoring
Mammal community (excluding bats)	moderate concern, trend unknown	significant concern, trend unknown	Conduct a mammal survey, including a focal bat study.
Mammal community (bats)	moderate concern, trend unknown	significant concern, trend unknown	
Deer abundance	moderate concern, improving trend	moderate concern, improving trend	Continue with deer management plan.

5.3 Threats to Natural Resources

The physical resources evaluated were air quality, night sky resources, and the acoustic environment. Air quality (e.g., ozone, wet deposition, visibility) at GETT and EISE is influenced both local (adjacent urban areas such as Baltimore, MD) and regional (Northeast) pollution such as emissions from automobile traffic and industry. Wet deposition can alter the environment where it falls from the atmosphere, which can be long distances from the pollution source. The Susquehanna River Basin, to the east of GETT and EISE, is one of the areas most impacted by atmospheric deposition in the United States. The naturally and culturally appropriate lightscape and night sky at GETT and EISE could be threatened by artificial light from park facilities and operations, artificial light from nearby development, and light domes from bright town/cities. There are wildlife species at both parks that have specific nocturnal behaviors that may be negatively impacted by light pollution (e.g., bats). The acoustic environment can be threatened by intrusive sounds that are not part of the natural or cultural backdrop of the park. Both the visitor experience and wildlife can be impacted by noise from park facilities and operations, noise from nearby development, and vehicular transportation. Park staff have stated the most problematic acoustical issues were related to traffic, loud music, and tour buses.

There are many threats to water quality resources (streams and wetlands) and aquatic communities (aquatic macroinvertebrates and fish) at GETT and EISE. For example, some of the streams within both GETT and EISE were noted as needing a TMDL by the US EPA in 2002 and 2004. The listed impairments were siltation, nutrients, toxic chemicals (for Rock Creek and Stevens Run in GETT) and siltation and low dissolved oxygen for EISE (Willoughby Run). However, as of 2016 the TMDL for these streams has not yet been evaluated and additionally the last US EPA assessment for impairments was in 2004, so there could be other current water quality issues. Threats to water quality include, but are not limited to, agricultural activities such as grazing and farming, and urban runoff that could contribute to siltation and low dissolved oxygen. Urban runoff from storm sewers and residential runoff could contribute to elevated nutrient levels. Variability in water flow could be caused by urban runoff/storm sewers, small residential runoff, surface water withdrawals, and upstream impoundments (as in the case of Marsh Creek). Past industrial use could contribute to toxic chemicals in waterbodies (e.g., the Westinghouse Plant Superfund site).

Although the wetlands at both parks have been recently mapped, they have not been surveyed for water quality, hydroperiod, or flora and fauna. Possible threats to wetlands can be a variety of anthropogenic and natural threats. Cattle grazing in wetland pastures can negatively impact water quality, and cause soil compaction and erosion along stream banks. Groundwater withdrawals can impact the hydroperiods of wetlands and may negatively impact wetland flora and fauna. Invasive and exotic plants and animals also can threaten riparian buffers and wetlands by crowding out native species. Water quality issues may be negatively impacting the aquatic macroinvertebrate community of the streams within the parks. The multimetric aquatic macroinvertebrate IBI for communities at both GETT and EISE was evaluated as impaired since sampling was initiated in 2009. Additionally, exotic crayfish (virile and rusty crayfish) were the dominant species at the majority of the stream sites sampled in 2005, and these invasive species have likely extirpated native crayfish from the streams in the parks. As for the fish communities in the streams (only sampled once in 2004), there were a number of non-native fish species observed (species that were outside of their native ranges); however, they are now considered as naturalized species and generally accepted as components of the native fish fauna. The principal threats and management issues that may negatively impact fish communities at GETT and EISE were related to activities associated with development, agriculture, other disturbances upstream of the park, and water quality issues as previously mentioned.

Non-native invasive vegetation is prevalent at both GETT and EISE, and is likely the biggest threat to the natural resources as well as the cultural resources of the parks. Non-native invasive plants can negatively effect and/or threaten native species diversity and ecosystems, and seriously degrade the cultural landscape. The NPS has actively implemented a series of management actions (e.g., prescribed burns, chemical and mechanical treatment) that are aimed at controlling invasive vegetation. The actions along with woodlot health cuts are integral to the battlefield rehabilitation goals; however, the opening of the tree canopy by woodlot health cuts may also promote invasive vegetation. Damage from white-tailed deer browsing in the forested areas of GETT is significant. Deer over-browsing negatively impacts forest regeneration, reduces crop growth, and causes increased deer-vehicle collisions in and around the park, and alters the presence and appearance of understory vegetation thereby making preservation of historic woodlots and interpretation of the battle events difficult for NPS staff. However, the park has an established deer culling program which has significantly reduced deer density in the park, which in turn has led to positive effects on forest regeneration. Forest pests can also present a threat to woodland areas. While the USDA Forest Risk Service has indicated the area of GETT and EISE are at a low risk for forest pest invasion, the emerald ash borer has been documented at GETT and this pest could potentially infest a large proportion of ash trees in the park.

Both parks contain open areas consisting of landscaped areas, crops, pastures, old fields, and grasslands. Invasive vegetation is also a threat to these open areas, especially in old fields and grasslands which provide habitat for a variety of flora and fauna. Natural succession from grassland towards the establishment woody plants may result in the loss of some species adapted to the previous successional stage. These successional species face a major threat if their required ecological stage is not continually maintained by some form of active management such as the current rotational mowing management plan. Additionally, while grassland birds are present at both GETT and EISE, they have specific habitat requirements that may limit their abundance (e.g., contiguous open areas, vegetation, and temporal requirement for successful fledging of young). Some of these requirements are met (e.g., mowing after nestlings have fledged) or may be met in the future as the battlefield rehabilitation will provide more open areas that are beneficial to these species.

The focal animal communities at GETT and EISE are birds, terrestrial arthropods, mammals, amphibians and reptiles. A primary threat to landbird populations in the Northeast Region is habitat loss due to development, with Neotropical migrants being particularly vulnerable to habitat fragmentation. Forest fragmentation leads to increases in edge habitat, an ideal habitat for non-migratory resident species, and results in higher rates of brood parasitism and nest predation in the remaining forest habitat. Threats to mammal communities include habitat fragmentation, vehicle mortality, and predation by domestic and feral cats. In the Northeastern U.S., bats are dying at an alarming rate due to white-nose syndrome, a fungus that infects that hibernating bats. White-nose syndrome has been confirmed in several PA counties, including some adjacent counties, but has not yet been confirmed in Adams County as of 2015. Additionally, renovation of historic structures (e.g., barns, outbuildings) at GETT and EISE has reduced the suitability of these sites as maternity roost habitats. Threats to herpetofauna communities include altered wetland hydrology, degraded water quality, habitat loss and fragmentation, vehicular road kill during migration periods, and predation.

5.4 Suggested Management Actions and Research Needs

Several of the natural resources at GETT and EISE were surveyed over ten years ago and the parks would benefit by conducting these surveys again. Budgetary constraints must be weighed against the benefit of such surveys and staggering surveys over an extended time period (e.g., five years) may be helpful in terms of scheduling and cost effectiveness. Listed below are suggestions for management plans and research needs. These are listed by higher priority and lower priority, based on best professional judgment.

5.4.1 Higher Priority (based on best profession judgment)

- Conduct loggerhead shrike (state-listed endangered bird) focal survey at EISE.
- Conduct a grassland bird survey at GETT and EISE using the methodology and metrics of the NETN to evaluate the condition of the community.
- Develop mow plans beneficial to grassland birds for grassland/meadow parcels that scored “good” for size and P:A suitability requirements for grassland birds (refer to Table 39).
- Conduct a focal study for crayfish to determine the extent of invasive species.
- Partner with the NPS NSNSD to conduct in field-based acoustic studies within GETT and EISE and reduce noise by:
    - outreach to visitors about reducing noise from sources such as electronics and idling vehicles,
    - communicate with visitors about benefits of noise reduction to park experience,
    - reduce noise from park operations (time activities to preserve quiet times, purchase quieter equipment).
- Protect lightscape and natural night sky by:
    - Establishing park lighting plan(s),
    - retrofitting of light sources in order to reduce glare, reduce overall light output, direct lights downward and install warmer color lamps.
- Incorporate facets of the Piedmont Region Maryland Biological Stream Survey into water quality and aquatic macroinvertebrate sampling (e.g., fish community sampling).
- Conduct a survey (flora and fauna) of wetlands including vernal pools and small ponds.
- Evaluate current status of extreme invasive plants such as mile-a-minute, Oriental bittersweet, garlic mustard, and Japanese stiltgrass. Map the distribution and extent of invasive plant species throughout the park. Continue with invasive plant management with mechanical control, chemical treatment, and prescribed burns.
- Merge in-house draft GIS data layers with NVC vegetation map to update the parks landscape map.
- Develop Federal Geographic Data Committee (FGDC) compliant metadata for in-house draft GIS data (e.g., wetlands, grasslands, mow plans, woodlot health cuts). This could be done in partnership with North Carolina State University or the University of Rhode Island, both of which work with the NPS on GIS-based products.
- Conduct a focal wetland study to assess wetlands condition using the guidelines set forth in Faber-Langendoen et al. (2012).

5.4.2 Lower Priority (based on best profession judgment)

- Complete a new map of the NVC vegetation associations once the battlefield rehabilitation is completed (this is listed as lower priority because park staff do have draft GIS data of on-going rehabilitation areas).
- Conduct another survey for plant species of concern (existing data were more than 10 year old).
- Conduct another amphibian and reptile survey (existing data were more than 10 years old).
- Conduct another mammal survey (existing data were more than 10 years old).
- Conduct another fish survey (existing data were more than 10 years old).
- Conduct another avian survey (existing data were more than 10 years old) using the MIDN bird protocol.
- Improve grassland composition on leased hayfields; increase extent of early successional stages of grasslands; reduce fragmentation of grassland habitats; and improve grassland diversity by creating additional communities of native warm-season grasses to improve grassland bird habitat.
- Survey vegetation composition of grasslands/meadows, perhaps focusing on those areas that score as “good” in size and P:A with the goal of calculating a Floristic Quality Index for grassland bird suitability.
- Explore opportunities for creating shrubby successional habitats in both parks (to improve grassland bird habitat).

Literature Cited

Adams County Conservation District & Adams County Office of Planning and Development (ACCD). 2011. Adams County stormwater management plan. Act 167 County-wide stormwater management plan, Adams County, Pennsylvania.

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

Atkinson, J. B. 2008. Fish Inventories of Mid-Atlantic and Northeast Coastal and Barrier Network Parks with Virginia, Maryland and Pennsylvania. Technical Report NPS/NER/NRTR—2008/113. National Park Service. Philadelphia, Pennsylvania.

Bailey, L. L., E. H. Campbell Grant, S. D. Mattfeldt. 2007. National Capital Region Network. Amphibian monitoring protocol, revision 1.3. USGS Patuxent Wildlife Research Center, Laurel, Maryland.

Barber, J. R., C. L. Burdett, S. E. Reed, K. A. Warner, C. Formichella, K. R. Crooks, D. M. Theobald, and K. M. Fristrup. 2011. Anthropogenic noise exposure in protected natural areas: Estimating the scale of ecological consequences. *Landscape Ecology* 26:1281–1295.

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. *Trends in Ecology and Evolution* 25(3):180–189.

Barbour, M. T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates, and fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water, Washington, D.C. Available at http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm (accessed 19 December 2016).

Barbour, R. W., and W. H. Davis. 1969. Bats of America. The University Press of Kentucky. Lexington, KY. 286 pp.

Behler, J. L. and F. W. King. 1995. The Audubon Society field guide to North American reptiles & amphibians. Alfred A. Knopf, Inc., New York, New York. 743 pp.

Berglund, B., T. Lindvall, and D. H. Schwela (eds.). 1999. WHO. Guidelines for community noise. World Health Organization, Geneva.

Bortle, J. E. 2001. Introducing the Bortle Dark-Sky Scale. Sky and Telescope, February 2001: 126-129. Bortle, J. E. 2006. Sky and Telescope, the essential guide to astronomy. Light pollution and astronomy: The Bortle Dark-Sky Scale. Available at http://www.skyandtelescope.com/resources/darksky/3304011.html (accessed 23 January 2015).

Bowersox, T. W., D. S. Larrick, A. T. Niewinski, G. L. Storm, and W. M. Tzilkowski. 2004. Long term monitoring of woodlot plant communities at Gettysburg National Military Park. National Park Service, Northeast Region. Philadelphia, Pennsylvania. Technical Report NPS/NERCHAL/NRTR-04/092.

Bowersox, T. W., D. S. Larrick, G. L. Storm, and W. M. Tzilkowski. 2002. Regenerating mixed-oak historic woodlots at Gettysburg National Military Park. Philadelphia, Pennsylvania. Technical Report NPS/PHS/NRTR-02/086.

Buda, S. 2010. State of the Susquehanna, Atmospheric Deposition. http://www.srbc.net/stateofsusq2010/documents/AtmosphericDepositionFeatureArticle.PDF (accessed 6 May 2016).

BugGuide. 2016. http://bugguide.net (accessed 6 April 2016).

Carpenter, S., T. Frost, L. Persson, M. Power, and D. Soto. 1996. Freshwater ecosystems: Linkages of complexity and processes. Pages 299-325 *in* H.A. Mooney, editor. Functional roles of biodiversity: A global perspective. John Wiley & Sons, New York, NY.

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

Comiskey, J. A. 2015. Forest Vegetation Resource Brief Mid-Atlantic Network. Gettysburg National Military Park 2013 Status and Trends. National Park Service, Fredricksburg, Virginia.

Comiskey, J. A., and K. K. Callahan. 2008. Mid-Atlantic Network vital signs monitoring plan. Natural Resource Report NPS/MIDN/NRR—2008/071. National Park Service, Fort Collins, Colorado.

Comiskey, J. A., and S. M. Wakamiya. 2011. Mid-Atlantic Network forest vegetation monitoring: 2007 to 2010. Natural Resource Technical Report NPS/MIDN/NRTR—2011/471. National Park Service, Fort Collins, Colorado.

Comiskey, J. A., and S. M. Wakamiya. 2012. Forest vegetation monitoring: Mid-Atlantic Network 2011 summary report. Natural Resource Data Series NPS/MIDN/NRDS—2012/324. National Park Service, Fort Collins, Colorado.

Comiskey, J. A. and J. S. Wheeler. 2015. Forest vegetation monitoring: Mid-Atlantic Network 2013 summary report. Natural Resource Report NPS/MIDN/NRR—2015/1050. National Park Service, Fort Collins, Colorado.

Comiskey, J. A., J. P. Schmit, and G. Tierney. 2009. Mid-Atlantic Network forest vegetation monitoring protocol. Natural Resource Report NPS/MIDN/NRR—2009/119 National Park Service, Fort Collins, Colorado.

Cook, R. P., K. M. Boland, and T. Dolbeare. 2004. Inventory of small mammals at Cape Cod National Seashore with recommendations for long-term monitoring. Long-term Coastal Ecosystem Monitoring Program Cape Cod National Seashore. National Park Service, Wellfleet, Massachusetts.

Davey, C. A., K. T. Redmond, and D. B. Simeral. 2006. Weather and Climate Inventory, National Park Service, Mid-Atlantic Network. Natural Resource Technical Report NPS/MIDN/NRTR—2006/013. National Park Service, Fort Collins, Colorado.

Derge, K. L., R. H. Yahner, and J. Mravintz. 2001. Survey of reptiles and amphibians in Gettysburg National Park with reference to Michaux State Forest. *Journal of the Pennsylvania Academy of Science* 75:43–49.

Dooling, R., and A. Popper. 2007. The effects of highway noise on birds. Rockville, MD: Environmental BioAcoustics LLC.

Faaborg, J., M. Bittingham, T. Donovan, and J. Blake. 1995. Habitat fragmentation in the Temperate Zone. Pages 357-380 *in* T. E. Martin and D. M. Finch, editors. Ecology and Management of Neotropical Migratory Birds. Oxford University Press, Oxford, UK.

Faber-Langendoen, D., J. Rocchio, S. Thomas, M. Kost, C. Hedge, B. Nichols, K. Strakosch Walz, G. Kittel, S. Menard, J. Drake, and E. Muldavin. 2012. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. Part B. Ecological integrity assessment protocols for rapid field methods (L2). EPA/600/R-12/021b.

Faccio, S., B. R. Mitchell, and P. S. Pooler. 2010. Breeding landbird monitoring protocol: Northeast Temperate Network. Natural Resource Report NPS/NETN/NRR—2010/198. National Park Service, Fort Collins, Colorado.

FishBase. 2015. Available at http://fishbase.org/search.php (accessed 20 May 2015).

Frost, H. C., G. L. Storm, M. J. Batcheller, and M. J. Lovallo. 1997. White-tailed deer management at Gettysburg National Military Park and Eisenhower National Historic Site. *Wildlife Society Bulletin* 25:462–469.

Gilbert A. T., A. F. O’Connell, Jr., E. M. Annand, N. W. Talancy, J. R. Sauer, and J. D. Nichols. 2008. An inventory of terrestrial mammals at National Parks in the Northeast Temperate Network and Sagamore Hill National Historic Site. Scientific Investigations Report 2007-5245. US Geological Survey, Reston, Virginia.

Glassberg, J. 1993. Butterflies through binoculars: A field guide to the butterflies in the Boston, New York, Washington region. Oxford University Press. New York. 160pp + 40 plates.

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

Haralabidis A. S., K. Dimakopoulou, F. Vigna-Taglianti, M. Giampaolo, A. Borgini, M. L. Dudley, G. Pershagen, G. Bluhm, D. Houthuijs, W. Babisch,M. Velonakis, K. Katsouyanni, and L. Jarup. 2008. Acute effects of night-time noise exposure on blood pressure in populations living near airports. *European Heart Journal Advance Access*. Published online February 12, 2008.

Haro, A., W. Richkus, K. Whalen, A. Hoar, W. D. Busch S. Lary, T. Brush, and D. Dixon. 2000. Population decline of the American eel: Implications for research and management. *Fisheries* 25(9):7–16.

Harris, C. M. 1998. Handbook of Acoustical Measurements and Noise Control, 3rd ed. McGraw-Hill, New York.

Hart, J. A. 2001. Special concern mammal species research and management, final report to the Wild Resource Conservation Fund. The Nature Conservancy, Middletown, Pennsylvania.

Hart, J. A. 2006a. Inventory of bat community composition at Gettysburg National Military Park and Eisenhower National Historic Site. Technical Report NPS/NER/NRTR--2006/052. National Park Service. Philadelphia, Pennsylvania.

Hart, J. A. 2006b. Survey for E and T Mammals at Gettysburg National Military Park and Eisenhower National Historic Site. Technical Report NPS/NER/NRTR--2006/044. National Park Service. Philadelphia, Pennsylvania.

Homer, C. G., J. A. Dewitz, l. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing* 81(5):345–354. Available at http://www.mrlc.gov/nlcd2011.php (accessed 1 August 2016).

Integrated Taxonomic Information System. Available at http://www.itis.gov/ (accessed 22 October 2015).

Johnson, M. J. 2014. Breeding bird monitoring: Mid-Atlantic Network 2013 summary report. Natural Resource Data Series NPS/MIDN/NRDS—2014/736. National Park Service, Fort Collins, Colorado.

Karr, J. R., K. D. Fausch, P.L. Angermeier, P. R. Yant, and I. S. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey, Special Publication 5. Champaign, Illinois.

Kearney, R. F. 2003. Partners in Flight landbird conservation plan, Physiographic Area 10: Mid-Atlantic Piedmont, Version 1.0. College Park, Maryland.

Kenworthy, J. P., C. C. Visaggi, and V. L. Santucci. 2006. Paleontological Resource Inventory and Monitoring, Mid-Atlantic Network. TIC #D-800, National Park Service.

Kim, K. C., and D. A. Piechnik. 2009. Ecological analysis of arthropod diversity and development of a monitoring plan for Gettysburg National Military Park and Eisenhower National Historic Site. Technical Report NPS/NER/NRTR—2009/143. National Park Service, Philadelphia, Pennsylvania.

Kim, K. C., R. P. Withington III, J. Grehan, and K.L. Derge. 2001. Inventory of invertebrates at Gettysburg National Military Park and Eisenhower National Historic Site with special reference to forest removal. Interim Technical Report. National Park Service, Philadelphia, Pennsylvania.

Knight, P., K. Imhoff, A. Person, and S. Miller. 2014. Weather of Eisenhower National Historic Site and Gettysburg National Military Park: Mid-Atlantic Network summary report for 2013. Natural Resource Data Series NPS/MIDN/NRDS—2014/720. National Park Service, Fort Collins, Colorado.

Kocin, P. J., and L. W. Uccellini. 2004. Northeast Snowstorms Volume 1: Overview. *Meteorological Monographs*. Vol 32. No 54. American Meteorological Society. Boston, Massachusetts.

Kohut, R. 2005. Handbook for assessment of foliar ozone injury on vegetation in the national parks. Boyce Thompson Institute, Cornell University, Ithaca, New York.

Kohut, R. J. 2007. Ozone risk assessment for Vital Signs Monitoring Networks, Appalachian National Scenic Trail, and Natchez Trace National Scenic Trail. NPS/NRPC/ARD/NRTR—2007/001. National Park Service, Fort Collins, Colorado. Available at http://www.nature.nps.gov/air/permits/aris/networks/ozonerisk.cfm.

Kulesza, C., Y. Le, and S. J. Hollenhorst. 2013. National Park Service visitor perceptions & values of clean air, scenic views, & dark night skies; 1988-2011. Natural Resource Report NPS/NRSS/ARD/NRR- 2013/632. National Park Service, Fort Collins, Colorado.

Kunsman, J. 2006. Inventory of plant species of special concern at Gettysburg National Military Park and Eisenhower National Historic Site. Technical Report NPS/NER/NRTR—2006/042, National Park Service, Philadelphia, Pennsylvania.

Lieb, D. A., R. F. Carline, and H. M. Ingram. 2007. Status of native and invasive crayfish in ten National Park Service properties in Pennsylvania. Technical Report NPS/NER/NRTR 2007/085. National Park Service. Philadelphia, Pennsylvania.

Longcore T. and C. Rich. 2004. Ecological light pollution. *Frontiers in Ecology and the Environment* 2:191-198.

Low, D. J., D. J. Goode, and D. W. Risser. 2000. Hydrogeology and simulation of ground-water flow at the Gettysburg Elevator Plant Superfund Site, Adams County, Pennsylvania. Open-File Report 00-185. Reston, VA: U.S. Geological Survey.

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

Mace, B. L., P. A. Bell, and R. J. Loomis. 2004. Visibility and natural quiet in national parks and wilderness areas: Psychological considerations. *Environment and Behavior* 36:5–31.

Maniero, T. 2004. Air quality monitoring considerations for the Mid-Atlantic Network. Available at http://www.nature.nps.gov/air/Permits/aris/networks/docs/midnAirQualitySummary.pdf (accessed 28 April 2016).

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

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

Mid-Atlantic Network (MIDN). 2011. Macroinvertebrate Resource Brief. National Park Service, Northeast Region, Inventory and Monitoring Program, Fredericksburg, Virginia.

Mid-Atlantic Network (MIDN). 2004. Assessing the risk of foliar injury from ozone on vegetation in parks in the Mid-Atlantic Network. Available at http://www.nature.nps.gov/air/Pubs/pdf/03Risk/midnO3RiskOct04.pdf (accessed 7 October 2015).

Miller, S. J. and D. H. Wardrop. 2006. Adapting the floristic quality assessment index to indicate anthropogenic disturbance in central Pennsylvania wetlands. *Ecological Indicators* 6:313–326.

Moltz, H. L. N. and J. B. Palmer. 2012. DRAFT Critical Area Resource Plan Marsh Creek and Rock Creek Watersheds, Adams County, Pennsylvania. Interstate Commission on the Potomac River Basin, Report No. ICPRB-12-2. Rockville, Maryland

Moore, C. 2001. Visual Estimation of Night Sky Brightness. *The George Wright Forum* 18(4):46–55.

Morfey. 2001. Dictionary of Acoustics, Academic Press

National Atmospheric Deposition Program (NADP). 2015. Available at http://nadp.sws.uiuc.edu/ (accessed 16 October 2015).

National Atmospheric Deposition Program (NADP). 2016. Precipitation data for station PA00, Arendtsville, PA. Available at http://nadp.sws.uiuc.edu/data/sites/sitedetails.aspx?id=PA00&net=NTN (accessed 18 May 2016).

National Park Service (NPS). 1994. Report to Congress. Report on effects of aircraft overflights on the National Park System. September 12, 1994.

National Park Service (NPS) 1999a. Final General Management Plan and Environmental Impact Statement. Volume I. Gettysburg National Military Park.

National Park Service (NPS). 1999b. Baseline water quality data inventory and analyses. Gettysburg National Military Park and Eisenhower National Historic Site. Technical Report NPS/NRWRD/NRTR-99/199. Fort Collins, Colorado

National Park Service (NPS). 2000. Strategic Plan. National Park Service. FY 2001-FY 2005. U.S. Department of Interior, National Park Service, Washington, DC.

National Park Service (NPS). 2002. Core water quality monitoring parameters and other key elements of the NPS Vital Signs Program water quality monitoring component. Freshwater workgroup subcommittee. Fort Collins, Colorado. Available at http://www.nature.nps.gov/water/vitalsigns/assets/docs/COREparamFINwSIGpg.pdf (accessed 11 March 2014).

National Park Service (NPS). 2014. Environmental Assessment for a Fire Management Plan Gettysburg National Military Park & Eisenhower National Historic Site Gettysburg, Pennsylvania.

National Park Service (NPS). 2015a. Eisenhower National Historic Site. Available at http://www.nps.gov/gett/index.htm (accessed 29 December 2015).

National Park Service (NPS). 2015b. Gettysburg National Military Park. Available at http://www.nps.gov/gett/index.htm (accessed 29 December 2015).

National Park Service (NPS). 2015c. Park deer management plan will run October through March, 2016. Available at http://www.nps.gov/gett/learn/news/deer-management-2015-16.htm (accessed 28 September 2015).

National Park Service (NPS). 2015d. Visitor Use Statistics. Available at https://irma.nps.gov/Stats/Reports/Park (accessed 29 December 2015).

National Park Service (NPS). 2016a. Endangered Species website. Available at http://www.nature.nps.gov/biology/endangeredspecies/ (accessed 23 February 2016).

National Park Service (NPS). 2016b. Gettysburg National Military Park: Plants website. Available at http://www.nps.gov/gett/learn/nature/plants.htm (accessed 23 February 2016).

National Park Service (NPS). 2016c. Gettysburg National Military Park Website, NPS Fire Managers Plan Prescribed Burn. Available at https://www.nps.gov/gett/learn/news/nps-fire-managers-plan-prescribed-fire.htm (accessed 28 April 2016).

National Park Service, Air Resources Division (NPS ARD). 2006. Ozone sensitive plant species, by park, November 2006. Available at http://www.nature.nps.gov/air/permits/aris/docs/Ozone_Sensitive_ByPark_3600.pdf, and http://www.nature.nps.gov/air/permits/aris/networks/ozonerisk.cfm (accessed 8 October 2015).

National Park Service, Air Resources Division (NPS ARD). 2013a. Air quality in national parks: trends (2000–2009) and conditions (2005–2009). Natural Resource Report NPS/NRSS/ARD/NRR—2013/683. National Park Service, Denver, Colorado.

National Park Service, Air Resources Division (NPS ARD). 2013b. Methods for determining air quality conditions and trends for park planning and assessments. National Park Service, Denver, Colorado.

National Park Service, Air Resources Division (NPS ARD). 2015. Available at https://www.nature.nps.gov/air/permits/aris/networks/midnLG.cfm (accessed 7 October 2015).

National Park Service, Natural Resource Condition Assessment (NPS NRCA). 2013. Updated Guidance, Draft. 25 July 2013.

National Park Service Natural Sounds & Night Skies Division (NPS NSNSD). 2015a. Acoustic and environment and soundscape resource summary for Eisenhower National Historic Park. National Park Service.

National Park Service Natural Sounds & Night Skies Division (NPS NSNSD). 2015b. Acoustic and environment and soundscape resource summary for Gettysburg National Military Park. National Park Service.

National Park Service Natural Sounds & Night Skies Division (NPS NSNSD). 2015c. Attachment 1 Lightscapes and Photic Environment. National Park Service.

National Park Service Natural Sounds & Night Skies Division (NPS NSNSD) 2015d. Natural Sounds & Night Skies website. Available at http://www.nature.nps.gov/night/ (accessed 28 October 2015).

National Park Service Natural Sounds & Night Skies Division (NPS NSNSD). 2015e. Photic Environment and Lightscapes Resource Summary Eisenhower National Historic Site. National Park Service.

National Park Service Natural Sounds & Night Skies Division (NPS NSNSD). 2015f. Photic Environment and Lightscapes Resource Summary Gettysburg National Military Park. National Park Service.

National Park Service, Natural Sounds & Night Skies Division (NPS NSNSD). 2013. Recommended indicators and thresholds of night sky quality for NPS State of the Parks Reports. Interim Guidance July 2013. WASO-Natural Resource Stewardship and Science, National Park Service, Fort Collins, Colorado.

Niewinski, A. T., T. W. Bowersox, and R. L. Laughlin. March 2006. Vegetation Status in Selected Woodlots at Gettysburg National Military Park Pre and Post White-tailed Deer Management. Technical Report NPS/NER/NRTR--2006/037. National Park Service. Philadelphia, Pennsylvania.

NPSpecies 2015. Information on Species in National Parks, NPSpecies database. Available at https://irma.nps.gov/NPSpecies/ (accessed 20 May 2015).

O'Connell, T. J., R. P. Brooks, M. J. Lanzone, and J. A. Bishop. 2003. A Bird community index for the Mid-Atlantic Piedmont and Coastal Plain. Final Report to the USGS – Patuxent Wildlife Research Center. Report No. 2003-02, Penn State Cooperative Wetlands Center, University Park, Pennsylvania.

Ostfeld, R. S. 2002. Little loggers make a big difference. *Natural History* 111:64–71.

Partners In Flight (PIF). Physiographic Areas. Area 10, Mid-Atlantic Piedmont. Available at http://www.partnersinflight.org/bcps/pl_10sum.htm (accessed 29 September 2015).

Pashley, D. N., C. J. Beardmore, J. A. Fitzgerald, R. P. Ford, W. C. Hunter, M. S. Morrison, and K. V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy. The Plains, Virginia.

Payne, R., and Webb, D. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Annals of the New York Academy of Sciences* 188(1):110–141.

Pennsylvania Amphibian and Reptile Survey (PARS). Available at http://paherpsurvey.org/about.php (accessed 5 June 2015).

Pennsylvania Code §93.7. 2016a. Designated Water Uses and Water Quality Criteria. Drainage List O and Z. http://www.pacode.com/secure/data/025/chapter93/s93.9z.html (accessed 13 January 2016).

Pennsylvania Code §93.7. 2016b. Specific Water Quality Criteria. Available at http://www.pacode.com/secure/data/025/chapter93/s93.7.html (accessed 13 January 2016).

Pennsylvania Department of Conservation and Natural Resources (PA DCNR). 2016. Invasive Plants in Pennsylvania. Available at http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_010314.pdf (accessed 26 February 2016).

Pennsylvania Department of Environmental Protection (PA DEP). 2007. Pennsylvania DEP multihabitat stream assessment protocol. Pennsylvania. Pennsylvania Department of Environmental Protection.

Pennsylvania Department of Environmental Protection (PA DEP). 2013. A benthic macroinvertebrate index of biotic integrity for wadeable freestone riffle-run streams in Pennsylvania. Pennsylvania Department of Environmental Protection, Water Quality Standards.

Pennsylvania Department of Environmental Protection (PA DEP). 2016. 2016 Draft Pennsylvania Integrated Water Quality Monitoring and Assessment Report.

Pennsylvania Game Commission. Important Mammal Areas Project. 2015. Available at http://www.portal.state.pa.us/portal/server.pt?open=514&objID=948195&mode=2 (accessed 3 March 2015).

Pennsylvania Natural Heritage Program (PNHP). 2015a. Vernal Pools. Available at http://www.naturalheritage.state.pa.us/VernalPool_Education.aspx (accessed 9 June 2015).

Pennsylvania Natural Heritage Program (PNHP). 2015b. Species lists and Fact Sheets. Available at http://www.naturalheritage.state.pa.us/Species.aspx (accessed 5 June 2015).

Pennsylvania Spatial Data Access (PASDA). 2016. Impaired waters data. Available at http://www.pasda.psu.edu/ (accessed 22 January 2016).

Pennsylvania T and E Species. Available at

http://www.portal.state.pa.us/portal/server.pt?open=514&objID=621014&mode=2 (accessed 24 September 2015).

Perles, S. J., G. S. Podniesinski, W. A. Millinor, and L. A. Sneddon. 2006. Vegetation Classification and Mapping at Gettysburg National Military Park and Eisenhower National Historic Park. Technical Report NPS/NER/NRTR—2006/058. National Park Service. Philadelphia, Pennsylvania.

Peterjohn, B. 2006. Conceptual Ecological Model for Management of Breeding Grassland Birds in the Mid-Atlantic Region. Technical Report NPS/NER/NRTR--2006/005. National Park Service. Philadelphia, Pennsylvania.

Peterjohn, B. 2007. Grassland and Shrubland Birds of Gettysburg National Military Park and Eisenhower National Historic Site: Current Status and Management Recommendations. Technical Report NPS/NER/NRTR—2007/102. National Park Service. Philadelphia, Pennsylvania.

Peterjohn, B. G. and J. R. Sauer. 1995. Population trends of the Loggerhead Shrike from the North American Breeding Bird Survey. Pages 117-121. *In* Shrikes (Laniidae) of the world: Biology and conservation. R. Yosef and F. E. Lohrer, eds. Proceedings of the Western Foundation of Vertebrate Zoology. No. 6.

Porter, E. 2003. Ozone sensitive plant species on National Park Service and U. S. Fish and Wildlife Service Lands: Results of a June 24-25, 2003 workshop Baltimore, Maryland. National Park Service, Air Resources Division, Denver Colorado, Natural Resources Report NPS/NRARD/NRR-2003/01.

Robinson, S. K., and D. S. Wilcove. 1994. Forest fragmentation in the Temperate Zone and its effects on migrating songbirds. *Bird Conservation International* 4:233–249.

Rosenberg, K. V., and J. V. Wells. 1999. Global Perspectives on Neotropical Migrant Conservation in the Northeast: Long-term responsibility vs. immediate concern. In: R. E. Bonney, D. Pashley, R. J. Cooper, and L. Niles (Eds.). Strategies for bird conservation: The Partners in Flight planning process. Cornell Lab of Ornithology. Ithaca, New York.

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

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

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding amphibians. *Conservation Biology* 12:1113–1119.

Sharpe, P. J., G. Kneipp, and A. Forget. 2016. Comparison of alternative approaches for wetlands mapping: A case study from three U.S. National Parks. *Wetlands*. Published online 8 April 2016. DOI 10.1007/s13157-016-0764-5.

Southerland, M. T., G. M. Rogers, M. J. Kline, R. P. Morgan, D. M. Boward, P.F. Kazyak, R. J. Klauda, and S. A. Stranko. 2005. New biological indicators to better assess the condition of Maryland streams. Maryland Department of Natural Resources, Annapolis, Maryland.

Srivastava, D. S., M. K. Trzcinski, B. A. Richarson, and B. Gilbert. 2008. Why are predators more sensitive to habitat size than their prey? Insights from Bromeliad Insect Food webs. *The American Naturalist.* 172:761–771.

Stainbrook, D. P., and D. R. Diefenbach. 2012. Estimating white-tailed deer abundance at Gettysburg National Military Park and Eisenhower National Historic Site. Natural Resource Technical Report NPS/NER/NRTR—2012/626. National Park Service. Fort Collins, Colorado.

Storm, G. L., R. H. Yahner, D. F. Cottam, and G. M. Vecellio. 1989. Population status, movements, habitat use, and impact of white-tailed deer at Gettysburg National Military Park and Eisenhower National Historic Site, Pennsylvania. Technical Report NPS/MAR/NRTR-89/043. National Park Service.

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

Templeton and Sacre. 1997. Acoustics in the built environment: advice for the design team. Architectural Press.

Thornberry-Ehrlich, T. 2009. Gettysburg National Military Park and Eisenhower National Historic Site Geologic Resources Inventory Report. Natural Resource Report NPS/NRPC/ GRD/NRR—2009/083. National Park Service. Denver, Colorado.

U.S. Census Bureau. 2010. 2010 Census Urban and Rural Classification. Available at http://www2.census.gov/geo/tiger/TIGER2010/UA/2010 (accessed 28 June 2013).

U.S. Department of Agriculture (USDA), Forest Service. 1992. Report to Congress. Potential impacts of aircraft overflights of National Forest System wildernesses.

U.S. Department of Agriculture (USDA) Forest Service. 2015. Forest Health Protection Mapping and Reporting. Available at http://foresthealth.fs.usda.gov/portal (accessed 17 August 2015).

U.S. Department of Agriculture (USDA) Plants Database. 2016. Available at http://plants.usda.gov/java/ (accessed 19 December 2016).

U.S. Environmental Protection Agency (US EPA). 1971. Community Noise. Washington, D.C.

U.S. Environmental Protection Agency (US EPA). 2014a. Technology Transfer Network National Ambient Air Quality Standards (NAAQS), Ozone (O_3) Standards. Available at http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html (accessed 10 January 2014).

U.S. Environmental Protection Agency (US EPA). 2014b. Visibility, EPA's Regional Haze Program. Available at http://www.epa.gov/airquality/visibility/program.html (accessed 24 January 2014).

U.S. Environmental Protection Agency (US EPA). 2016a. How's My Waterway. Available at http://watersgeo.epa.gov/mywaterway/rlist.html (accessed 19 January 2016).

U.S. Environmental Protection Agency (US EPA). 2016b. Site information for Westinghouse Elevator Co. Plant. Available at https://cumulis.epa.gov/supercpad/cursites/dsp_ssppSiteData1.cfm?id=0300932#Status (accessed 13 May 2016).

U.S. Fish and Wildlife Service (USFWS). 2015. Available at http://www.fws.gov/Midwest/endangered/mammals/nlba/index.html (accessed 29 May 2015).

U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service. 2011. Federal land managers' interagency guidance for nitrogen and sulfur deposition analyses: November 2011. Natural Resource Report NPS/NRSS/ARD/NRR—2011/465. National Park Service, Denver, Colorado.

USGS Nonindigenous Aquatic Species (USGS NAS). 2015. Available at http://nas.er.usgs.gov/ (accessed 1 September 2015).

Vecellio, G.M., R.H. Yahner, and G.L. Storm. 1994. Crop damage by deer at Gettysburg Park. *Wildlife Society Bulletin* 22:89–93.

Veilleux, J. P. 2005. Preliminary report of the roosting habits of the eastern small-footed bat, *Myotis leibii*, in New Hampshire. Abstract. Bat Research News 46:226.

Vickery, P. D., P. L. Tubaro, J. M. Cardosa da Silva, B. G. Peterjohn, J. R. Herkert, and R. B. Cavalcanti. 1999. Conservation of grassland birds in the Western Hemisphere. *Studies in Avian Biology* 19:2–26.

Vile, J. 2008. Fish IBI report, 2006 sampling, round 2, year 2 of 5. Volume 1. New Jersey Department of Environmental Protection. Trenton, New Jersey. Available at http://www.state.nj.us/dep/wms/bfbm/download/ibi2006Vol1.pdf (accessed 20 May 2015).

Watershed Alliance of Adams County. 2015a. Available at http://www.adamswatersheds.org/, http://www.adamswatersheds.org/images/marshcreekwatershed.pdf (accessed 27 May 2015).

Watershed Alliance of Adams County. 2015b. Available at http://www.adamswatersheds.org/, http://www.adamswatersheds.org/images/RockFact.pdf (accessed 27 May 2015).

White-Nose Syndrome.org. 2015. Available at http://www.whitenosesyndrome.org/resources (accessed 28 May 2015).

Yahner, R. H., K. L. Derge, and J. Mravintz. 2001a. Inventorying of amphibian and reptile species at Gettysburg National Military Park and Eisenhower National Historic Site. Technical Report NPS/PHSO/NRTR-01/084. National Park Service. Philadelphia, Pennsylvania.

Yahner, R. H., B. D. Ross, G. S. Keller, and D. S. Klute. 2001b. Comprehensive inventory program for birds at six Pennsylvania National Parks. Technical report NPS/PHSO/NRTR-01/085. National Park Service, Philadelphia, Pennsylvania.

Yahner, R. H., G. L. Storm, G. S. Keller, B. D. Ross, and R. W. Rohrbaugh. 1997. Inventorying and monitoring protocols of vertebrates in the National Parks of the Eastern United States: Mammals. Technical Report NPS/PHSO/NRTR-97/073. National Park Service. Philadelphia, Pennsylvania.

Yahner, R. H., G. L. Storm, G. S. Keller, B. D. Ross, and R. W. Rohrbaugh. 1999a. Inventorying and monitoring protocols of amphibians and reptiles in the National parks of the Eastern United States. Technical Report NPS/PHSO/NRTR-99/076. National Park Service. Philadelphia, Pennsylvania.

Yahner, R. H., G. L. Storm, G. S. Keller, B. D. Ross, and R. W. Rohrbaugh. 1999b. Inventorying and monitoring protocols of terrestrial vertebrates in the National Parks of the Eastern United States: Gettysburg National Military Park and Eisenhower National Historical Site. Technical Report NPS/PHSO/NRTR-00/080. National Park Service. Philadelphia, Pennsylvania.

Yahner, R. H., G. L. Storm, R. E. Melton, G. M. Vecellio, and D. F. Cottam. 1992. Floral inventory, cover-type mapping, and wetland inventory of Gettysburg National Military Park and Eisenhower National Historic Site. *Journal of the Pennsylvania Academy of Science* 65(3):127–133.

Yetter, S., J. Bishop, S. Hurteau, S. Chamberlain, M. Nassry, H. Ingram, A. Taylor, and R. Brooks. 2013. Allegheny Portage Railroad National Historic Site natural resource condition assessment.

Natural Resource Report NPS/ALPO4/NRR—2013/727. National Park Service, Fort Collins, Colorado.

Sources of Expertise

C. Musselman, National Park Service Cartographer, Gettysburg National Military Park, Gettysburg, PA.

D. Reiner, Biologist, Gettysburg National Military Park and Eisenhower National Historic Site, Gettysburg, PA.

J. Comiskey, Northeast Region Inventory and Monitoring Program Manager, National Park Service, Fredericksburg, VA.

M. J. Johnson, Data Manager / Ecologist, Mid-Atlantic Network, Inventory and Monitoring Program, National Park Service, 120 Chatham Lane, Fredericksburg, VA 22405.

N. Dammeyer, Hydrologic Technician, Mid-Atlantic Network, Inventory and Monitoring Program, National Park Service, 120 Chatham Lane, Fredericksburg, VA 22405.

P. Sharpe, Northeast Regional Hydrologist, National Park Service, 200 Chestnut Street, Philadelphia, PA 19106.

S. Colwell, Wildlife Biologist, National Park Service, 424 Forest Resources Building, University Park, PA.

Z. Bolitho, Chief, Resource Management, Gettysburg National Military Park and Eisenhower National Historic Site.

Appendix A. Tables

Appendix Table 57. Vegetation observed at GETT (G) and EISE (E) as documented in NPSpecies (2015). Invasive and state listed species are indicated in bold type. MIDN forest vegetation monitoring indicator taxa (invasive, deer browse preference, impedes regeneration (due to heavy growth cover), and vines [after Comiskey and Wakamiya 2012]) are highlighted by gray shading. Scientific nomenclature follows ITIS.gov guidelines; non-accepted synonyms as listed in NPSpecies (2015) are given parentheses.

Scientific Name	Common Name	Nativity[1]	Park
Abutilon theophrasti	Velvetleaf	Non-native	G, E
Acalypha rhomboidea	Common threeseed mercury	Native	G, E
Acer campestre	Hedge maple	Non-native	G
Acer negundo	Boxelder	Native	G, E
Acer platanoides	Norway maple	Invasive (PA DCNR)	G, E
Acer rubrum	Red maple	Native	G, E
Acer saccharinum	Silver maple	Native	G, E
Acer saccharum	Sugar maple	Native	G, E
Achillea millefolium	Common yarrow	Native	G, E
Acorus calamus	Sweetflag	Native	G
Actaea species	Baneberry species	Native	G
Adiantum pedatum	Northern maidenhair	Native	G
Aegopodium podagraria[3]	Bishop’s goutweed	Invasive (PA DCNR)	G
Aesculus flava	Yellow buckeye	Native	G
Aesculus glabra[3]	Ohio buckeye	Native	G
Agalinis tenuifolia	Slenderleaf false foxglove	Native	G
Ageratina altissima var. altissima	White snakeroot	Native	G
Agrimonia gryposepala	Tall hairy agrimony	Native	G
Agrimonia microcarpa[3]	Small-fruited agrimony	Native	G
Agrimonia parviflora	Harvestlice	Native	G, E
Agrimonia pubescens[3]	Soft agrimony	Native	G
Agrimonia rostellata	Beaked agrimony	Native	G
Agrimonia striata[4]	Roadside agrimony	Native	G
Agropyron species	Wheatgrass species	Non-native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Agrostis gigantea	Redtop	Non-native	G, E
Agrostis perennans	Upland bentgrass	Native	G
Agrostis stolonifera	Creeping bentgrass	Non-native	G, E
Ailanthus altissima	Tree of heaven	Invasive (PA DCNR)	G, E
Albizia julibrissin	Mimosa	Invasive (PA DCNR)	G
Alisma subcordatum	American water plantain	Native	G, E
Alliaria petiolata (invasive)	Garlic mustard	Invasive (PA DCNR)	G, E
Allium canadense	Meadow garlic	Native	G
Allium cernuum	Nodding onion	Native	G
Allium vineale	Wild garlic	Non-native	G, E
Alnus glutinosa	Black Alder	Invasive (PA DCNR)	G
Alnus species	Alder species	n/a	E
Amaranthus albus	Prostrate pigweed	Non-native	G
Ambrosia artemisiifolia	Annual Ragweed	Native	G, E
Ambrosia trifida	Great ragweed	Native	G, E
Amelanchier arborea	Common serviceberry	Native	G
Amphicarpaea bracteata	American hogpeanut	Native	G, E
Anagallis arvensis	Scarlet pimpernel	Non-native	G
Andropogon gerardii	Big bluestem	Native	G
Andropogon virginicus	Broom-sedge	Native	G
Anemone americana (Hepatica nobilis var. obtusa)	Roundlobe hepatica	Native	G
Anemone canadensis[4]	Canadian anemone	Native	G
Anemone virginiana	Tall thimbleweed	Native	G
Antennaria parlinii	Parlin's pussytoes	Native	G
Antennaria howellii ssp. neodioica	Howell's pussytoes	Native	G
Antennaria neglecta	Field pussytoes	Native	G
Antennaria plantaginifolia	Woman's tobacco	Native	G
Anthemis arvensis	Corn chamomile	Non-native	G
Anthemis cotula	Stinking chamomile	Non-native	G, E
Anthoxanthum odoratum	Sweet vernal grass	Non-native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Aplectrum hyemale	Adam and Eve	Native, PA-R	G
Apocynum androsaemifolium	Spreading dogbane	Native	G
Apocynum cannabinum	Indianhemp	Native	G, E
Aquilegia vulgaris[4]	European columbine	Non-native	G
Arabidopsis thaliana	Mouse-ear cress	Non-native	G
Aralia racemosa[3]	American spikenard	Native	G
Arctium minus	Lesser burdock	Non-native	G, E
Arenaria serpyllifolia	Thyme-leaf sandwort	Non-native	G
Arisaema dracontium	Green dragon	Native	G, E
Arisaema triphyllum (deer avoid)	Jack-in-the-pulpit	Native	G, E
Aristida dichotoma var. dichotoma	Churchmouse threeawn	Native	G
Aristolochia serpentaria	Virginia snakeroot	Native	G
Armoracia rusticana	Horseradish	Native	G
Arrhenatherum elatius var. elatius	Tall oatgrass	Non-native	G
Artemisia annua	Sweet sagewort	Non-native	G
Arthraxon hispidus	Small carpetgrass	Invasive watch list (PA DCNR)	G, E
Asarum canadense	Canadian wildginger	Native	G, E
Asclepias incarnata	Swamp milkweed	Native	G, E
Asclepias purpurascens	Purple milkweed	Native	G
Asclepias quadrifolia	Fourleaf milkweed	Native	G
Asclepias tuberosa	Butterfly milkweed	Native	G
Asclepias variegata[3]	Redring milkweed	Native, PA-E	G
Asclepias verticillata	Whorled milkweed	Native	G
Asclepias viridiflora	Green milkweed	Native	G
Asclepias syriaca	Common milkweed	Native	G, E
Asimina triloba	Pawpaw	Native	G
Asparagus officinalis	Garden asparagus	Non-native	G
Asplenium platyneuron	Ebony spleenwort	Native	G
Aster species	Aster species	n/a	G, E
Baptisia tinctoria	Horseflyweed	Native	G
Barbarea vulgaris	Garden yellowrocket	Non-native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Berberis thunbergii (invasive)	Japanese barberry	Invasive (PA DCNR)	G, E
Betula lenta	Sweet birch	Native	G
Bidens bipinnata	Spanish needles	Native	G
Bidens cernua	Nodding beggartick	Native	G, E
Bidens tripartita	Threelobe beggartick	Native	G
Bidens vulgata	Big devils beggartick	Native	G, E
Bidens frondosa	Devil's beggartick	Native	G, E
Boechera canadensis (Arabis canadensis)	Sicklepod	Native	G
Boehmeria cylindrica	False stinging-nettle	Native	G, E
Botrychium dissectum (deer avoid, impedes regeneration)	Cutleaf grapefern	Native	G
Botrychium virginianum (deer avoid, impedes regeneration)	Rattlesnake fern	Native	G
Brachyelytrum erectum	Bearded shorthusk	Native	G
Bromus arvensis	Field brome	Non-native	G
Bromus kalmii	Artic brome	Native, PA-T	G
Bromus latiglumis	Earlyleaf brome	Native	G
Bromus pubescens	Hairy woodland brome	Native	G
Bromus racemosus	Bald brome	Non-native	E
Bromus tectorum	Cheatgrass	Non-native	G
Bromus inermis	Smooth brome	Native	G
Bromus sterilis	Poverty brome	Invasive (PA DCNR)	G
Buglossoides arvensis	Corn gromwell	Non-Native	G
Callitriche heterophylla	Twoheaded water-starwort	Native	G
Callitriche terrestris	Terrestrial water-starwort	Native	G
Calystegia sepium	Hedge false bindweed	Non-native	G
Calystegia spithamaea[3]	Low false bindweed	Native	G
Campsis radicans (vine, deer avoid)	Trumpet creeper	Native	G
Capsella bursa-pastoris	Shepherd's-purse	Non-native	G
Cardamine bulbosa	Bulbous bittercress	Native	G
Cardamine concatenata	Cutleaf toothwort	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Cardamine hirsuta	Hairy bittercress	Non-native	G
Cardamine parviflora	Sand bittercress	Native	G
Cardamine pensylvanica	Pennsylvania bitter-cress	Native	G
Carex aggregata	Glomerate sedge	Native	G
Carex amphibola	Eastern narrowleaf sedge	Native	G, E
Carex annectens	Yellowfruit sedge	Native	G, E
Carex atlantica ssp. atlantica[3]	Prickly bog sedge	Native	G
Carex blanda	Eastern woodland sedge	Native	G, E
Carex bromoides	Brome sedge	Native	G
Carex bushii	Bush's sedge	Native	G, E
Carex buxbaumii	Buxbaum's sedge	Native, PA-R	G
Carex cephalophora	Oval-leaf sedge	Native	G
Carex conjuncta	Soft fox sedge	Native	G
Carex conoidea	Openfield sedge	Native	G
Carex crinita var. crinita	Fringed sedge	Native	G
Carex davisii	Davis' sedge	Native	G
Carex digitalis	Slender woodland sedge	Native	G
Carex festucacea	Fescue sedge	Native	G, E
Carex folliculata	Northern long sedge	Native	E
Carex frankii	Frank's sedge	Native	G
Carex glaucodea	Blue sedge	Native	G
Carex granularis	Limestone meadow sedge	Native	G
Carex grayi	Gray's sedge	Native	G, E
Carex grisea	Inflated narrow-leaf sedge	Native	G
Carex gynandra[3]	Nodding sedge	Native	G
Carex hirsutella	Fuzzy wuzzy sedge	Native	G
Carex hystericina	Bottlebrush sedge	Native	G
Carex interior[3]	Inland sedge	Native	G
Carex intumescens	Greater bladder sedge	Native	G
Carex laxiculmis	Spreading sedge	Native	G

Scientific Name	**Common Name**	**Nativity**[1]	**Park**
Carex laxiflora	Broad looseflower sedge	Native	G
Carex leavenworthii[4]	Leavenworth’s sedge	Native	G
Carex lupulina	Hop sedge	Native	G
Carex lurida	Shallow sedge	Native	G
Carex molesta	Troublesome sedge	Native	G, E
Carex normalis	Greater straw sedge	Native	G, E
Carex pellita	Woolly sedge	Native	G
Carex pensylvanica	Pennsylvania sedge	Native	G
Carex prasina	Drooping sedge	Native	G
Carex radiata	Eastern star sedge	Native	G, E
Carex retroflexa	Reflexed sedge	Native	G
Carex rosea	Rosy sedge	Native	G
Carex scoparia	Broom sedge	Native	G, E
Carex shortiana	Short’s sedge	Native, PA-R (N)	G
Carex squarrosa	Squarrose sedge	Native	G, E
Carex stipata	Awlfruit sedge	Native	G, E
Carex stricta	Uptight Sedge	Native	G
Carex swanii	Swan's sedge	Native	G
Carex tetanica	Rigid sedge	Native, PA-T	G
Carex tribuloides	Blunt broom sedge	Native	G
Carex umbellata	Parasol sedge	Native	G
Carex virescens	Ribbed sedge	Native	G
Carex vulpinoidea	Fox sedge	Native	G, E
Carex willdenowii	Willdenow’s sedge	Native	G
Carex albicans var. albicans	Whitetinge sedge	Native	G
Carpinus caroliniana	American hornbeam	Native	G, E
Carya cordiformis	Bitternut Hickory	Native	G, E
Carya glabra	Pignut Hickory	Native	G
Carya illinoinensis[3]	Pecan	Native	E
Carya laciniosa	Shellbark hickory	Native, PA-SP (N)	G, E
Carya ovalis	Red hickory	Native	G
Carya ovata	Shagbark Hickory	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Carya tomentosa (C. alba)	Mockernut hickory	Native	G
Castanea species	Chestnut	n/a	E
Catalpa speciosa	Southern catalpa	Native	G, E
Catalpa bignonioides[3]	Southern catalpa	Native	G
Ceanothus americanus	New Jersey tea	Native	G
Celastrus orbiculatus (invasive, vine)	Asian Bittersweet	Invasive (PA DCNR)	G
Celastrus scandens[3]	American bittersweet	Native	G
Celtis occidentalis	Common hackberry	Native	G, E
Centaurea stoebe ssp. micranthos	Spotted knapweed	Invasive (PA DCNR)	G
Cephalanthus occidentalis	Buttonbush	Native	G
Cerastium arvense	Field chickweed	Native	G
Cerastium arvense ssp. arvense	Field chickweed	Native	G
Cerastium fontanum	Common mouse-ear chickweed	Non-native	G, E
Cercis canadensis	Eastern redbud	Native	G
Chaenorhinum minus	Dwarf snapdragon	Non-native	G
Chamaecrista fasciculata	Partridge pea	Native	G
Chamaecrista nictitans	Sensitive partridge pea	Native	G, E
Chamaecyparis lawsoniana[3]	Port Orford cedar	Native	G
Chamaesyce maculata	Spotted sandmat	Native	G
Chelidonium majus	Celandine	Invasive (PA DCNR)	G
Chelone glabra	White turtlehead	Native	G, E
Chenopodium album	Lambsquarters	Native	G
Chenopodium simplex	Mapleleaf goosefoot	Native	G
Chimaphila maculata	Striped princes pine	Native	G
Chimaphila umbellata	Pipsissewa	Native	G
Cichorium intybus	Chicory	Non-native	G, E
Cicuta bulbifera[3]	bulblet-bearing water-hemlock	Native	G
Cicuta maculata	Spotted water hemlock	Native	G, E
Cinna arundinacea	Sweet woodreed	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Cinna latifolia[4]	Drooping woodreed	Native	G
Circaea lutetiana	Broadleaf enchanter's nightshade	Non-native	G, E
Cirsium altissimum[3]	Tall thistle	Native	G
Cirsium muticum	Swamp thistle	Native	G
Cirsium species	Thistle	n/a	G
Cirsium arvense (invasive)	Canada thistle	Invasive (PA DCNR)	G, E
Cirsium discolor	Field thistle	Native	G, E
Cirsium pumilum	Pasture thistle	Native	G
Cirsium vulgare	Bull thistle	Invasive (PA DCNR)	G, E
Claytonia virginica	Virginia springbeauty	Native	G
Clematis terniflora (invasive, vine)	Sweet autumn clematis	Non-native	G
Clematis virginiana	Devil's darning needles	Native	G, E
Clinopodium vulgare	Wild basil	Native	G
Coleataenia anceps (Panicum anceps)	Beaked panic grass	Native	G
Coleataenia longifolia ssp. rigidula (Panicum rigidulum)	Redtop panicgrass	Native	G
Collinsonia canadensis	Richweed	Native	G
Comandra umbellata	Bastard toadflax	Native	G
Commelina communis	Asiatic dayflower	Non-native	G, E
Conium maculatum	Poison hemlock	Invasive (PA DCNR)	G
Convallaria majalis	European lily of the valley	Non-native	G
Conyza canadensis	Canadian horseweed	Native	G
Cornus alternifolia	Alternateleaf dogwood	Native	G
Cornus amomum	Silky dogwood	Native	G, E
Cornus florida	Flowering dogwood	Native	G
Cornus racemosa	Gray dogwood	Native	G
Cornus sericea ssp. sericea[3]	Redosier dogwood	Native	G, E
Corydalis flavula	Yellow fumewort	Native	G
Corydalis sempervirens[3]	Rock harlequin	Native	G
Corylus americana	American hazelnut	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Crataegus crus-galli	Cockspur hawthorn	Native	G
Crataegus phaenopyrum[3]	Washington hawthorn	Native	G
Crataegus uniflora	Dwarf hawthorn	Native	G
Crataegus species	Hawthorn species	n/a	G, E
Crotalaria sagittalis	Arrowhead rattlebox	Native	G
Cryptotaenia canadensis	Canadian honewort	Native	G
Cunila origanoides	Common dittany	Native	G
Cuphea viscosissima	Blue waxweed	Native	G
Cuscuta gronovii	Scaldweed	Native	G, E
Cynoglossum officinale[4]	Gypsyflower	Non-native	G
Cynoglossum virginianum	Wild comfrey	Native	G
Cyperus echinatus (deer avoid)	Globe flatsedge	Native	G
Cyperus erythrorhizos (deer avoid)	Redroot flatsedge	Native	G
Cyperus esculentus (deer avoid)	Yellow nutsedge	Native	G
Cyperus squarrosus (deer avoid)	Bearded flatsedge	Native	G
Cyperus strigosus (deer avoid)	Strawcolored flatsedge	Native	G, E
Cypripedium parviflorum var. pubescens	Large yellow lady's-slipper	Native, PA-V	G
Dactylis glomerata	Orchard-grass	Non-native	G, E
Danthonia spicata	Poverty oatgrass	Native	G
Datura stramonium	Jimsonweed	Invasive (PA DCNR)	G
Daucus carota	Queen Anne's lace	Non-native	G, E
Dennstaedtia punctilobula (deer avoid, impedes regeneration)	Eastern hay-scented fern	Native	G
Deschampsia flexuosa	Wavy hairgrass	Native	G
Desmodium canadense[3]	Showy ticktrefoil	Native	G
Desmodium glutinosum	Pointedleaf tickrefoil	Native	G
Desmodium marilandicum	Smooth small-leaf tickrefoil	Native	G
Desmodium nudiflorum	Nakedflower ticktrefoil	Native	G
Desmodium paniculatum	Panicledleaf ticktrefoil	Native	G
Desmodium perplexum	Perplexed ticktrefoil	Native	G
Desmodium rotundifolium	Prostrate ticktrefoil	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Dianthus armeria	Deptford pink	Non-native	G
Dicentra cucullaria	Dutchman's breeches	Native	G
Dichanthelium acuminatum (Panicum acuminatum)	Tapered rosette grass	Native	G
Dichanthelium boscii	Bosc's panicgrass	Native	G
Dichanthelium clandestinum	Deer-tongue grass	Native	G, E
Dichanthelium commutatum	Variable panicgrass	Native	G
Dichanthelium depauperatum	Starved panicgrass	Native	G
Dichanthelium dichotomum	Cypress panicgrass	Native	G
Dichanthelium dichotomum var. dichotomum	Cypress panicgrass	Native, PA-E	G
Dichanthelium linearifolium	Slimleaf panicgrass	Native	G
Dichanthelium oligosanthes (D. oligosanthes var. scribnerianum)	Heller's rosette grass	Native, PA-T (N)	G
Dichanthelium acuminatum var. acuminatum	Tapered rosette grass	Native	G
Digitaria ischaemum	Smooth crabgrass	Non-native	G
Digitaria sanguinalis	Hairy crabgrass	Non-native	G
Dioscorea quaternata	Fourleaf yam	Native	G
Dioscorea villosa	Wild yam	Native	G, E
Diospyros virginiana	Common persimmon	Native	G
Dipsacus fullonum	Fuller's teasel	Non-native	G, E
Draba verna	Spring draba	Non-native	G
Dryopteris carthusiana (deer avoid, impedes regeneration)	Spinulose woodfern	Native	G
Dryopteris intermedia (deer avoid, impedes regeneration)	Intermediate woodfern	Native	G
Dryopteris marginalis (deer avoid, impedes regeneration)	Marginal woodfern	Native	G
Duchesnea indica	Indian strawberry	Non-native	G
Echinochloa crus-galli	Barnyardgrass	Non-native	G, E
Echinochloa muricata	Rough barnyardgrass	Native	G
Echinocystis lobata	Wild cucumber	Native	G
Echium vulgare	Common viper's bugloss	Non-native	G
Eclipta prostrata	False daisy	Native	G, E
Elaeagnus angustifolia[3]	Russian olive	Invasive (PA DCNR)	G

Scientific Name	Common Name	Nativity[1]	Park
Elaeagnus umbellata	Autumn olive	Invasive (PA DCNR)	G
Eleocharis elliptica	Elliptic spikerush	Native, PA-E	G
Eleocharis erythropoda	Bald spikerush	Native	G
Eleocharis obtusa	Blunt spikerush	Native, PA-E	G, E
Eleocharis ovata[2, 3]	Ovate spike rush	n/a	G
Eleocharis palustris	Common spikerush	Native	G
Eleocharis tenuis	Slender spikerush	Native	G
Eleusine indica	Indian goosegrass	Non-native	G
Elodea canadensis	Canadian waterweed	Native	G, E
Elymus hystrix	Eastern bottlebrush grass	Native	G, E
Elymus repens	Quackgrass	Non-native	G, E
Elymus riparius	Riverbank wildrye	Native	G, E
Elymus species	Wildrye species	n/a	G
Elymus villosus	Hairy wildrye	Native	G
Epifagus virginiicus	Virginia wildrye	Native	G, E
Epilobium ciliatum ssp. glandulosum[3]	Fringed willowherb	Native	G
Epilobium coloratum	Purpleleaf willowherb	Native	G, E
Epilobium species	Willowherb species	n/a	G
Epipactis helleborine	Broadleaf helleborine	Non-native	G
Equisetum arvense	Field horsetail	Native	G
Eragrostis hypnoides	Teal lovegrass	Native	G, E
Eragrostis pectinacea	Tufted lovegrass	Native	G
Eragrostis species	Lovegrass species	n/a	G
Eragrostis spectabilis	Purple lovegrass	Native	G
Erechtites hieraciifolius	American burnweed	Native	G, E
Erigeron philadelphicus	Philadelphia fleabane	Native	G
Erigeron annuus	Eastern daisy fleabane	Native	G
Erigeron pulchellus	Robin's plantain	Native	G
Erigeron strigosus	Prairie fleabane	Native	G, E
Erythronium americanum	Dogtooth violet	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Euonymus alatus	Winged euonymus	Invasive (PA DCNR)	G
Euonymus americanus	Bursting-heart	Native	G
Euonymus atropurpureus	Burningbush	Native	G, E
Eupatoriadelphus maculatus[3]	Spotted joe pye weed	Native	G
Eupatorium perfoliatum	Common boneset	Native	G, E
Eupatorium pilosum[3]	Rough boneset	Native	G
Eupatorium serotinum[3]	Lateflowering thoroughwort	Native	G
Eupatorium species	Bonset species	n/a	G
Euphorbia corollata	Flowering spurge	Native	G
Euphorbia cyparissias	Cypress spurge	Non-native	G
Euphorbia peplus[3]	Petty spurge	Non-native	G
Euphorbia species	Spurge species	n/a	G
Eurybia divaricate (deer prefer)	White wood aster	Native	G, E
Eurybia macrophylla	Bigleaf aster	Native	G
Euthamia (caroliniana) graminifolia	Flat-top goldentop	Native	G, E
Eutrochium (Eupatorium) purpureum	Sweetscented joe pye weed	Native	G
Eutrochium fistulosum (Eupatoriadelphus fistulosus)	Trumpetweed	Native	G, E
Fallopia scandens (Polygonum scandens)	Climbing false buckwheat	Native	G, E
Fallopia convolvulus (Polygonum convolvulus)	Black bindweed	Non-native	G
Fescue species	Fescue species	n/a	G
Festuca rubra	Red fescue	Native	G, E
Festuca subverticillata	Nodding fescue	Native	G
Fimbristylis autumnalis	Slender fimbry	Native	G
Floerkea proserpinacoides	False mermaidweed	Native	G
Forsythia	Forsythia	Non-native	G
Fragaria vesca	Woodland strawberry	Native	G
Fragaria virginiana	Virginia strawberry	Native	G
Fragaria virginiana ssp. virginiana	Virginia strawberry	Native	G
Fraxinus americana	White ash	Native	G, E
Fraxinus nigra	Black ash	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Fraxinus pennsylvanica	Green ash	Native	G, E
Fraxinus species	Ash species	n/a	G, E
Galearis spectabilis (deer prefer)	Showy orchid	Native	G
Galinsoga quadriradiata	Shaggy soldier	Non-native	G
Galium aparine	Stickywilly	Native	G
Galium asprellum	Rough bedstraw	Native	G, E
Galium boreale[3]	Northern bedstraw	Native	G
Galium circaezans	Licorice bedstraw	Native	G, E
Galium concinnum	Shining bedstraw	Native	G
Galium lanceolatum	Lanceleaf wild licorice	Native	G
Galium obtusum	Bluntleaf bedstraw	Native	G
Galium species	Bedstraw species	n/a	G
Galium triflorum	Fragrant bedstraw	Native	G
Galium mollugo	False baby's breath	Non-native	G
Galium palustre[4]	Common marsh bedstraw	Native	G
Galium pilosum	Hairy bedstraw	Native	G
Galium tinctorium	Stiff marsh bedstraw	Native	G
Gentiana clausa	Bottle gentian	Native	G
Gentiana species	Gentian species	n/a	G
Geranium maculatum	Spotted geranium	Native	G, E
Geranium pusillum	Small geranium	Non-native	G
Geum aleppicum[3]	Yellow avens	Native	G
Geum canadense	White avens	Native	G, E
Geum laciniatum	Rough avens	Native	G, E
Geum species	Avens	n/a	G
Geum vernum	Spring avens	Native	G
Geum virginianum[3]	Cream avens	Native	G
Glechoma hederacea	Ground ivy	Non-native	G, E
Gleditsia triacanthos	Honeylocust	Native	G
Glyceria species	Mannagrass species	N/a	G
Glyceria septentrionalis	Floating mannagrass	Native	G
Glyceria striata	Fowl mannagrass	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Glycine max	Soybean	Non-native	G, E
Goodyera pubescens	Downy rattlesnake plantain	Native	G
Gratiola neglecta	Clammy hedgehyssop	Native	G
Gymnocladus dioicus	Kentucky coffee-tree	Native	G
Hackelia virginiana	Beggarslice	Native	G, E
Hamamelis virginiana	American witch-hazel	Native	G
Hedeoma pulegioides	American false pennyroyal	Native	G
Hedera helix (invasive, vine)	English ivy	Invasive (PA DCNR)	G
Helenium autumnale	Common sneezeweed	Native	G, E
Helianthemum bicknellii	Bicknell's hoary rockrose	Native (PA-E)	G
Helianthus divaricatus	Woodland sunflower	Native	G
Helianthus strumosus	Paleleaf woodland sunflower	Native	G
Heliopsis helianthoides	Smooth oxeye	Native	G
Hemerocallis fulva (invasive)	Orange daylily	Invasive watch list (PA DCNR)	G, E
Hesperis matronalis	Dames rocket	Invasive (PA DCNR)	G, E
Heuchera americana[3]	American alumroot	Native	G
Heuchera pubescens	Downy alumroot	Native	G
Hibiscus trionum	Flower of an hour	Non-native	G
Hieracium caespitosum	Yellow hawkweed	Non-native	G
Hieracium species	Hawkweed species	n/a	G
Hieracium venosum	Rattlesnakeweed	Native	G
Holcus lanatus	Common velvetgrass	Invasive watch list (PA DCNR)	G
Houstonia caerulea	Azure bluet	Native	G
Hydrophyllum virginianum	Eastern waterleaf	Native	E
Hylotelephium telephium (var. telephium)	Witch's moneybags	Non-native	G
Hypericum ascyron[4]	Great St. Johnswort	Native	G
Hypericum mutilum	Dwarf St. Johnswort	Native	G, E
Hypericum perforatum	Common St. Johnswort	Non-native	G

Scientific Name	Common Name	Nativity[1]	Park
Hypericum prolificum	Shrubby St. Johnswort	native	G
Hypericum punctatum	Spotted St. Johnswort	Native	G
Hypoxis hirsuta	Common goldstar	Native	G
Ilex opaca	American holly	Native, PA-T	G
Ilex verticillata	Common winterberry	Native	G
Impatiens capensis (deer prefer)	Jewelweed	Native	G, E
Impatiens pallida	Pale touch-me-not	Native	E
Impatiens species	Jewelweed species	n/a	G
Ipomoea pandurata	Man of the Earth	Native	G
Ipomoea purpurea	Tall morning glory	Non-native	G, E
Ipomoea species	Morning glory species	n/a	G, E
Iris domestica (Belamcanda chinensis)	Blackberrry lily	Non-native	G
Iris germanica	Bearded Iris	Non-native	G
Iris species	Iris species	n/a	G
Iris versicolor	Harlequin blueflag	Native	G
Juglans cinerea	Butternut	Native	G, E
Juglans nigra	Black walnut	Native	G, E
Juncus acuminatus	Tapertip rush	Native	G
Juncus biflorus	Grass-leaved rush	Native, PA-T	G, E
Juncus brachycarpus	Short-fruited rush	Native, PA-E	G
Juncus canadensis[4]	Canadian rush	Native	G
Juncus effusus	Common rush	Native	G, E
Juncus marginatus	Grassleaf rush	Native	G
Juncus secundus	Lopsided rush	Native	G
Juncus tenuis (var. tenuis)	Poverty rush	Native	G, E
Juncus effusus ssp. solutus	Lamp rush	Native	G
Juniperus virginiana	Eastern red cedar	Native	G, E
Juniperus communis[3]	Common juniper	Native	G
Krigia biflora	Twoflower dwarfdandelion	Native	G
Kummerowia striata	Japanese clover	Non-native	G
Lactuca biennis	Tall blue lettuce	Native	G
Lactuca saligna	Willowleaf lettuce	Non-native	G

Scientific Name	Common Name	Nativity[1]	Park
Lactuca serriola	Prickly lettuce	Non-native	G, E
Lactuca canadensis	Canada lettuce	Native	G
Lamium amplexicaule	Henbit deadnettle	Non-native	G
Lamium purpureum	Purple deadnettle	Non-native	G
Laportea canadensis (deer prefer)	Canadian woodnettle	Native	G, E
Larix kaempferi	Japanese larch	Non-native	G
Lechea pulchella[3]	Leggett's pinweed	n/a	G
Lechea species	Pinweed species	n/a	G
Leersia oryzoides	Rice cutgrass	Native	G, E
Leersia virginica	Whitegrass	Native	G, E
Lemna minor	Common duckweed	Native	G
Leonurus cardiaca	Common motherwort	Non-native	G
Lepidium campestre	Field pepperweed	Non-native	G
Lespedeza cuneate	Chinese lespedeza	Invasive (PA DCNR)	G
Lespedeza frutescens	Shrubby lespedeza	Native	G
Lespedeza hirta	Hairy lespedeza	Native	G
Lespedeza procumbens	Trailing lespedeza	Native	G
Lespedeza repens	Creeping lespedeza	Native	G
Lespedeza species	Lespedeza species	n/a	G
Lespedeza virgata[2, 4]	Wand lespedeza	Non-native	G
Lespedeza virginica	Slender lespedeza	Native	G
Leucanthemum vulgare	Oxeye daisy	Non-native	G, E
Ligustrum vulgare	European privet	Invasive (PA DCNR)	G
Ligustrum obtusifolium (invasive)	Border privet	Invasive (PA DCNR)	G
Ligustrum species	Privet species	n/a	G
Lilium canadense (deer prefer)	Canada lily	Native	E
Lilium philadelphicum (deer prefer)[3]	Wood lily	Native	G
Lilium superbum (deer prefer)	Turk's cap lily	Native	G
Linaria vulgaris	Butter-and-eggs	Non-native	G
Lindera benzoin	Northern spicebush	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Lindernia dubia (var. dubia)	Yellowseed false pimpernel	Native	G, E
Linum striatum	Ridged yellow flax	Native	G
Linum usitatissimum[3]	Common flax	Non-native	G
Linum virginianum	Woodland flax	Native	G
Liriodendron tulipifera	Tulip poplar	Native	G
Lithospermum canescens	Hoary puccoon	Native, PA-T (N)	G
Lithospermum officinale[3]	European stoneseed	Non-native	G
Lobelia cardinalis	Cardinalflower	Native	G, E
Lobelia inflata	Indian-tobacco	Native	G
Lobelia siphilitica	Great blue lobelia	Native	G, E
Lobelia spicata (var. spicata)	Palespike lobelia	Native	G
Lolium perenne	Perennial ryegrass	Non-native	G, E
Lonicera japonica (invasive, vine)	Japanese honeysuckle	Invasive (PA DCNR)	G, E
Lonicera maacki (invasive)	Amur honeysuckle	Invasive (PA DCNR)	G, E
Lonicera morrowii (invasive)	Marrow's honeysuckle	Invasive (PA DCNR)	G, E
Lonicera species	Honeysuckle species	n/a	G
Lonicera tatarica (invasive)[3]	Tartarian honeysuckle	Invasive (PA DCNR)	G
Lotus corniculatus	Bird's-foot trefoil	Non-native	G
Ludwigia palustris	Marsh seedbox	Native	E
Ludwigia alternifolia	Seedbox	Native	G, E
Lunaria annua[3]	Annual honesty	Non-native	G
Luzula bulbosa[3]	Bulbous wood-rush	Native, PA-E	G
Luzula multiflora	Common woodrush	Native	G
Luzula echinata[3]	Hedgehog woodrush	Native	G
Lycopus americanus	American water horehound	Native	G, E
Lycopus species	Horehound species	n/a	G
Lycopus uniflorus	Northern bugleweed	Native	E
Lycopus virginicus	Virginia water horehound	Native	E
Lysimachia ciliata	Fringed loosestrife	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Lysimachia hybrida[3]	Lowland yellow loosestrife	Native, PA-T	G
Lysimachia lanceolata	lanceleaf loosestrife	Native	G
Lysimachia nummularia	Creeping jenny	Invasive (PA DCNR)	G, E
Lysimachia quadriflora	Fourflower yellow loosestrife	Native	G
Maclura pomifera	Osage-orange	Native	G
Maianthemum canadense	Canada mayflower	Native	G
Maianthemum stellatum	Starry false lily of the valley	Native	G
Maianthemum racemosum (deer prefer)	False Solomon's seal	Native	G, E
Malus baccata[3]	Siberian crabapple	Non-native	G
Malus coronaria	Sweet crabapple	Native	G
Malus pumila	Paradise apple	Non-native	G
Malus species	Apple species	n/a	G
Malva neglecta	Common mallow	Non-native	G
Matricaria discoidea	Disc mayweed	Non-native	G
Medicago lupulina	Black medick	Non-native	G
Melilotus albus	Sweetclover	Non-native	G
Melissa officinalis[3]	Common baom	Non-native	G
Menispermum canadense	Common moonseed	Native	G
Mentha arvensis	Wild mint	Native	G, E
Mentha X piperita	Peppermint	Native	G
Mentha spicata	Spearmiint	Non-native	G
Mertensia virginica	Virginia bluebells	Native	G
Micranthes (Saxifraga) virginiensis	Early saxifrage	Native	G
Microstegium vimineum (invasive)	Japanese stiltgrass	Invasive (PA DCNR)	G, E
Mimulus alatus	Sharpwing monkeyflower	Native	G, E
Mimulus ringens	Ringen monkeyflower	Native	G
Mitchella repens	Partridgeberry	Native	G
Mollugo verticillata	Green carpetweed	Native	G, E
Monarda clinopodia	White bergamot	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Monotropa hypopithys	Pinesap	Native	G
Monotropa uniflora	Indianpipe	Native	G
Morus rubra	Red mulberry	Native	G
Morus alba	White mulberry	Invasive watch list (PA DCNR)	G, E
Muhlenbergia frondosa	Wirestem muhly	Native	G
Muhlenbergia species	Muhly species	n/a	G
Muhlenbergia schreberi	Nimblewill	Native	G
Muhlenbergia sobolifera	Rock muhly	Native	G
Muscari botryoides	Common grape hyacinth	Non-native	G
Myosotis laxa	Bay forget-me-not	Non-native	G
Myosotis verna	Spring forget-me-not	Native	G
Myosoton aquaticum	Giantchickweed	Non-Native	G, E
Narcissus poeticus	Poet’s narcissus	Non-native	G
Narcissus pseudonarcissus	Daffodil	Non-native	G
Nasturtium officinale	Watercress	Non-native	G
Nepeta cataria	Catnip	Non-native	G
Nuphar lutea (spp. lutea)	Yellow pond-lily	Native	G
Nyssa sylvatica	Black gum	Native	G
Oenothera perennis	Little evening primrose	Native	G
Oenothera biennis	Common evening primrose	Native	G
Oenothera fruticosa	Narrowleaf evening primrose	Native	G
Onoclea sensibilis (deer avoid, impedes regeneration)	Sensitive fern	Native	G, E
Ophioglossum species	Adder’s tongue species	n/a	G
Ophioglossum vulgatum	Southern Aadderstongue	Native	G
Ornithogalum umbellatum	Star of Bethlehem	Invasive (PA DCNR)	G, E
Orobanche uniflora	Oneflowered broomrape	Native	G
Orontium aquaticum	Goldenclub	Native, PA-R	G
Osmorhiza claytonii[3]	Clayton's sweetroot	Native	G
Osmorhiza longistylis	Longstyle sweetroot	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Osmunda claytoniana (deer avoid, impedes regeneration)	Interrupted fern	Native	G
Ostrya virginiana	Eastern hop hornbeam	Native	G
Oxalis montana[3]	Mountain woodsorrel	Native	G
Oxalis species	Wood sorrel species	n/a	E
Oxalis stricta	Yellow woodsorrel	Native	G, E
Oxalis violacea	Violet woodsorrel	Native	G
Packera anonyma (synonym Senecio anonymus*)*[3]	Small's ragwort	Native, PA-R	G
Packera aurea	Golden ragwort	Native	G, E
Packera obovata[3]	Roundleaf ragwort	Native	G
Packera paupercula	Balsam groundsel	Native	G
Paeonia species	Peony species	n/a	G
Panax trifolius	Dwarf ginseng	Native	G
Panicum (gattingeri) philadelphicum (synonym P. tuckermanii)	Philadelphia panicgrass	Native, PA-T	G, E
Panicum capillare	Witchgrass	Native	G
Panicum dichotomiflorum	Fall panicgrass	Native	G
Panicum species	Panicgrass species	n/a	G
Papaver dubium	Blindeyes	Non-native	G
Parietaria pensylvanica	Pennsylvania pellitory	Native	G
Paronychia canadensis	Smooth forked nailwort	Native	G
Parthenocissus quinquefolia (vine, deer avoid)	Virginia creeper	Native	G, E
Paspalum laeve	Field paspalum	Native	G
Paspalum species	Paspalum species	n/a	G
Paspalum setaceum	Thin paspalum	Native	G
Pedicularis canadensis	Canadian lousewort	Native	G
Penstemon digitalis	Foxglove beardtongue	Native	G
Penstemon hirsutus	Hairy beardtongue	Native	G
Penstemon laevigatus	Eastern smooth beardtongue	Native (N, TU)	G, E
Penthorum sedoides	Ditch stonecrop	Native	G
Perilla frutescens	Beefsteakplant	Invasive (PA DCNR)	G
Persicaria (Polygonum) amphibium	Water knotweed	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Persicaria (Polygonum) hydropiper	Marshpepper knotweed	Non-native	G, E
Persicaria (Polygonum) hydropiperoides	Swamp snartweed	Native	G, E
Persicaria (Polygonum) lapathifolium	Curlytop knotweed	Native	G, E
Persicaria (Polygonum) pensylvanica	Pennsylvania smartweed	Native	G, E
Persicaria perfoliata (invasive)	Mile-a-minute	Invasive (PA DCNR)	G, E
Persicaria posumbu (Polygonum cespitosum)	Oriental ladysthumb	Invasive (PA DCNR)	G, E
Persicaria punctata (Polygonum punctatum)	Dotted smartweed	Native	G, E
Persicaria sagittata (Polygonum sagittatum)	Arrowleaf tearthumb	Native	G, E
Persicaria virginiana(Polygonum virginianum)	Jumpseed	Native	G
Persicaria maculosa (Polygonum persicaria)	Spotted ladysthumb	Non-native	G
Phalaris arundinacea	Reed canary grass	Native	G, E
Phleum pratense	Timothy	Non-native	G, E
Phlox maculata	Wild sweetwilliam	Native	G
Phlox pilosa	Downy phlox	Native, PA-E (TU)	G
Phlox subulata	Moss phlox	Native	G
Phlox subulata spp. subulata	Moss phlox	Native	G
Phryma leptostachya	American lopseed	Native	G
Physalis heterophylla	Clammy groundcherry	Native	G
Physalis longifolia var. subglabrata	Longleaf groundcherry	Native	G
Physocarpus opulifolius	Common ninebark	Native	G
Phytolacca americana	American pokeweed	Native	G, E
Picea abies	Norway spruce	Non-native	G
Picea glauca[3]	White spruce	Native	G
Picea pungens[3]	Blue spruce	Native	G
Pilea pumila	Canadian clearweed	Native	G, E
Pinus echinata[3]	Shortleaf pine	Native	G
Pinus resinosa	Red pine	Native	G
Pinus sylvestris	Scots pine	Non-native	G
Pinus rigida	Pitch pine	Native	G
Pinus strobus	Eastern white pine	Native	G
Pinus virginiana	Virginia pine	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Plantago virginica	Virginia plantain	Native	G
Plantago lanceolata	Narrowleaf plantain	Non-native	G, E
Plantago major	Common plantain	Non-native	G, E
Plantago rugelii	Blackseed plantain	Native	G
Plantago species	Plantain species	n/a	E
Platanthera lacera (deer prefer)	Green fringed orchid	Native	G
Platanthera orbiculata (deer prefer)[3]	Lesser roundleaved orchid	Native	G
Platanus occidentalis	American sycamore	Native	G, E
Poa compressa (deer avoid, impedes regeneration)	Canada bluegrass	Non-native	G, E
Poa nemoralis (deer avoid, impedes regeneration)	Wood bluegrass	n/a	G
Poa pratensis (deer avoid, impedes regeneration)	Kentucky bluegrass	Native	G, E
Poa species (deer avoid, impedes regeneration)	Grass species	n/a	G
Poa trivialis (deer avoid, impedes regeneration)	Rough bluegrass	Invasive watch list (PA DCNR)	G
Poa annua (deer avoid, impedes regeneration)	Annual bluegrass	Non-native	G
Podophyllum peltatum (deer avoid)	Mayapple	Native	G
Polygala verticillata	Whorled milkwort	Native	G
Polygonatum biflorum (var commutatum) (deer prefer)	Smooth Solomon's seal	Native	G, E
Polygonatum pubescens	Hairy Solomon's seal	Native	G
Polygonum species	Knotweed species	n/a	G, E
Polypodium virginianum	Rock polypoid	Native	G
Polystichum acrostichoides (deer avoid)	Christmas fern	Native	G
Populus alba[3]	White popular	Non-native	G
Populus tremuloides	Quaking aspen	Native	G
Portulaca oleracea	Little hogweed	Non-native	G
Potamogeton species	Pondweed species	n/a	G
Potentilla canadensis	Dwarf cinquefoil	Native	G, E
Potentilla norvegica	Norwegian cinquefoil	Non-native	E
Potentilla recta	Sulphur cinquefoil	Non-native	G, E
Potentilla simplex	Common cinquefoil	Native	G
Prenanthes alba[3]	White rattlesnakeroot	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Prenanthes altissima	Tall rattlesnakeroot	Native	G
Prenanthes serpentaria	Lion's foot	Native, PA-T (N)	G
Prenanthes trifoliolata[3]	Gall of the earth	Native	G
Prunella laciniata[3]	Cutleaf selfheal	Non-native	G
Prunella vulgaris	Common selfheal	Native	G
Prunus avium	Sweet cherry	Non-native	G, E
Prunus americana	American plum	Native	G
Prunus pensylvanica[3]	Pin cherry	Native	G
Prunus persica	Peach	Non-native	G
Prunus serotina	Black Cherry	Native	G, E
Prunus species	Prunus species	Non-native	G
Prunus virginiana	Common chokecherry	Native	G, E
Pseudognaphalium obtusifolium (ssp. obtusifolium)	Rabbit-tobacco	Native	G
Pseudotsuga menziesii[3]	Douglas-fir	Native	G
Pteridium aquilinum (deer avoid, impedes regeneration)	Western bracken fern	Native	G
Pycnanthemum incanum	Hoary mountainmint	Native	G
Pycnanthemum tenuifolium	Narrowleaf mountainmint	Native	G, E
Pycnanthemum virginianum	Virginia mountainmint	Native	G
Pyrus communis	Common pear	Non-Native	G
Quercus alba	White oak	Native	G, E
Quercus bicolor	Swamp White oak	Native	G, E
Quercus coccinea	Scarlet oak	Native	G
Quercus palustris	Pin oak	Native	G, E
Quercus prinus	Chestnut Oak	Native	G
Quercus rubra	Red Oak	Native	G, E
Quercus shumardii	Shumard's oak	Native, PA-E	G
Quercus species	Oak species	n/a	G
Quercus stellata	Post oak	Native	G
Quercus velutina	Black Oak	Native	G
Ranunculus abortivus	Littleleaf buttercup	Native	G
Ranunculus acris	Tall buttercup	Non-native	G
Ranunculus bulbosus	St. Anthony's turnip	Non-native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Ranunculus fascicularis[3]	Early buttercup	Native, PA-E	G
Ranunculus hispidus	Bristly buttercup	Native	G
Ranunculus micranthus	Rock buttercup	Native	G
Ranunculus pensylvanicus[3]	Pennsylvania buttercup	Native	G
Ranunculus pusillus	Low spearwort	Native, PA-E (N)	G
Ranunculus recurvatus	Blisterwort	Native	G
Ranunculus repens	Creeping buttercup	Non-native	G
Ranunculus species	Buttercup species	n/a	G
Ranunculus hispidus var. caricetorum	Bristly buttercup	Native	G
Ranunculus hispidus var. hispidus	Bristly buttercup	Native	G
Ranunculus hispidus var. nitidus[3]	Bristly buttercup	Native	G
Rhamnus (Frangula) alnus[3]	Glossy buckthorn	Invasive (PA DCNR)	G
Rhamnus cathartica[3]	Common buckthorn	Invasive (PA DCNR)	G
Rhododendron periclymenoides[3]	Pink azalea	Native	G
Rhododendron species	Rhododendron species	n/a	G
Rhus copallinum	Winged sumac	Native	G
Rhus typhina	Stagehorn sumac	Native	G
Rhus glabra	Smooth sumac	Native	G
Ribes americanum	American black currant	Native	G
Ribes cynosbati[3]	Eastern prickly gooseberry	Native	G
Ribes missouriense	Missouri gooseberry	Native, PA-E	G
Ribes rotundifolium[3]	Appalachian gooseberry	Native	G
Ribes species	Gooseberries and currants	n/a	G
Robinia pseudoacacia	Black locust	Native	G
Rorippa species	Yellowcress species	n/a	G
Rosa blanda[4]	Smooth rose	Native	G
Rosa carolina	Carolina rose	Native	G
Rosa multiflora (invasive)	Multiflora rose	Invasive (PA DCNR)	G, E
Rosa species	Rose species	n/a	G

Scientific Name	Common Name	Nativity[1]	Park
Rose palustris	Swamp rose	Native	G
Rubus allegheniensis (deer prefer)	Allegheny blackberry	Native	G, E
Rubus flagellaris (R. enslenii) (deer prefer)	Northern dewberry	Native	G, E
Rubus idaeus (deer prefer)[3]	American red raspberry	Non-native	G, E
Rubus occidentalis (deer prefer)	Black raspberry	Native	G, E
Rubus pensilvanicus (deer prefer)	Philidelphia blackberry	Native	G
Rubus phoenicolasius (deer prefer)	Wine raspberry	Invasive (PA DCNR)	G
Rubus species (deer prefer)	Blackberry species	n/a	G
Rudbeckia fulgida	Orange coneflower	Native, PA-T (N)	G
Rudbeckia triloba	Browneyed Susan	Native	G
Rudbeckia hirta	Black-eyed Susan	Native	G
Rudbeckia hirta var. pulcherrima	Black-eyed Susan	Native	G
Rudbeckia laciniata	Cutleaf coneflower	Native	G, E
Rumex (orbiculatus) britannica[4]	Greater water dock	Native	G
Rumex acetosella	Common sheep sorrel	Non-native	G
Rumex crispus	Curly dock	Non-native	G, E
Rumex obtusifolius	Bitter dock	Non-native	G, E
Rumex species	Curly dock species	n/a	G
Sabatia angularis	Rosepink	Native	G
Sagittaria species	Arrowhead species	n/a	G
Salix alba	White willow	Non-native	G
Salix fragilis[3]	Crack willow	Non-native	G
Salix humilis[3]	Prairie willow	Native	G
Salix nigra	Black willow	Native	G, E
Salix sericea	Silky willow	Native	G
Salix species	Willow species	n/a	G
Salvia lyrata	Lyreleaf sage	Native	E
Sambucus nigra ssp. canadensis	American black elderberry	Native	G, E
Sanguinaria canadensis (deer prefer)	Bloodroot	Native	G
Sanicula marilandica[3]	Maryland sanicle	Native	G
Sanicula species	Sanicle species	n/a	G

Scientific Name	Common Name	Nativity[1]	Park
Sanicula trifoliata[4]	Largefruit blacksnakeroot	Native	G, E
Sanicula canadensis	Canadian blacksnakeroot	Native	G, E
Sanicula odorata	Clustered blacksnakeroot	Native	G
Saponaria officinalis	Bouncingbet	Non-native	G
Sassafras albidum	Sassafras	Native	G
Schedonorus pratensis[3]	Meadow fescue	Non-native	G
Schedonorus (phoenix) arundinaceus	Tall fescue	Invasive watch list (PA DCNR)	G
Schizachyrium scoparium	Little bluestem	Native	G
Schoenoplectus tabernaemontani	Softstem bulrush	Native	G
Scirpus atrovirens	Green bulrush	Native	G, E
Scirpus cyperinus	Woolgrass	Native	G, E
Scirpus georgianus	Georgia bulrush	Native	G
Scirpus microcarpus[4]	Panicled bulrush	Native	G
Scirpus pendulus	Rufous bulrush	Native	G
Scirpus polyphyllus	Leafy bulrush	Native	G
Scirpus species	Bulrush species	n/a	G
Scleranthus annuus	German knotgrass	Non-native	G
Scrophularia lanceolata	Lanceleaf figwort	Native	G
Scrophularia marilandica	Carpenter's square	Native	G, E
Scutellaria elliptica	Hairy skullcap	Native	G
Scutellaria elliptica var. elliptica	Hairy skullcap	Native	G
Scutellaria incana[4]	Hoary skullcap	Native	E
Scutellaria integrifolia	Helmet flower	Native	G
Scutellaria lateriflora	Blue skullcap	Native	G
Scutellaria nervosa	Veiny skullcap	Native	G
Scutellaria parvula var. missouriensis	Leonard's skullcap	Native	G
Scutellaria species	Skullcap species	n/a	G
Securigera varia	Crownvetch	Non-native	G
Sedum sarmentosum	Stringy stonecrop	Non-native	G
Selaginella apoda	Meadow spikemoss	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Senna hebecarpa	American senna	Native	G
Senna marilandica[3]	Maryland senna	Native	G
Setaria faberi	Japanese bristlegrass	Non-native	G, E
Setaria species	Bristlegrass species	n/a	G
Setaria viridis	Green bristlegrass	Non-native	G
Setaria parviflora	Marsh bristlegrass	Native	G
Setaria pumila (var. pumila)	Yellow foxtail	Non-native	G
Sicyos angulatus	Oneseed burr cucumber	Native	G, E
Silene armeria[3]	Sweet William silene	non-native	G
Silene caroliniana	Sticky catchfly	Native	G
Silene latifolia	Bladder campion	Non-native	G
Silene stellata	Widowsfrill	Native	G
Silene vulgaris	Maidenstears	Non-native	G
Silphium trifoliatum	Whorled rosinweed	Native	G
Sisymbrium altissimum	Tall tumblemustard	Non-Native	G
Sisyrinchium angustifolium	Narrowleaf blue-eyed grass	Native	G
Sisyrinchium montanum[3]	Strict blue-eyed grass	Native	G
Sisyrinchium mucronatum	Needletip blue-eyed grass	Native	G
Smilax glauca (deer prefer, vine)	Cat greenbriers	Native	G
Smilax rotundifolia (deer prefer, vine)	Roundleaf greenbrier	Native	G, E
Smilax herbacea (deer prefer. vine)	Smooth carrionflower	Native	G
Smilax pulverulentav (deer prefer)	Downy carrionflower	Native	G
Smilax tamnoides (deer prefer)	Bristly greenbrier	Native	G
Solanum carolinense	Carolina horse-nettle	Native	G, E
Solanum dulcamara	Climbing nightshade	Non-native	G, E
Solanum nigrum[2]	Black nightshade	Non-native	G
Solidago altissima	Canada goldenrod	Native	G, E
Solidago bicolor	White goldenrod	Native	G
Solidago caesia	Wreath goldenrod	Native	G
Solidago canadensis	Canada goldenrod	Native	G
Solidago gigantea	Giant goldenrod	Native	G, E

Scientific Name	Common Name	Nativity[1]	Park
Solidago juncea	Early goldenrod	Native	G, E
Solidago nemoralis	Gray goldenrod	Native	G
Solidago patula[3]	Roundleaf goldenrod	Native	G
Solidago rugosa	Wrinkleleaf goldenrod	Native	G
Solidago species	Goldenrod species	n/a	G, E
Solidago ulmifolia	Elmleaf goldenrod	Native	G
Sonchus arvensis[4]	Field sowthistle	Non-native	G
Sonchus asper	Spiny sowthistle	Non-native	G
Sonchus oleraceus[4]	Common sowthistle	Non-native	G
Sorghastrum nutans	Indiangrass	Native	G
Sphenopholis intermedia	Slender wedgescale	Native	G
Sphenopholis nitida	Shiny wedgescale	Native	G
Sphenopholis obtusata (var. obtusata)	Prairie wedgescale	Native	G
Spiranthes lacera var. gracilis	Northern slender lady's tresses	Native	G
Sporobolus vaginiflorus	Puffsheath dropseed	Native	G
Stachys palustris[3]	Marsh hedgenettle	Native	G
Stachys species	Hedgenettle species	n/a	G
Staphylea trifolia	American bladdernut	Native	G
Stellaria alsine[3]	Bog chickweed	Native	G
Stellaria graminea	Grass-like starwort	Non-native	G, E
Stellaria longifolia	Longleaf starwort	Native	G
Stellaria media	Common chickweed	Non-native	G, E
Stellaria pubera	Star chickweed	Native	G
Stylosanthes biflora	Sidebeak pencilflower	Native, PA-E (TU)	G
Symphoricarpos orbiculatus	Coralberry	Native	G
Symphyotrichum (lowrieanum) cordifolium	Common blue wood aster	Native	G, E
Symphyotrichum lanceolatum var. lanceolatum	White panicle aster	Native	G, E
Symphyotrichum lateriflorum	Calico aster	Native	G
Symphyotrichum lateriflorum var. lateriflorum	Calico aster	Native	G, E
Symphyotrichum novae-angliae	New England aster	Native	G
Symphyotrichum patens var. patens	Late purple aster	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Symphyotrichum pilosum var. pilosum	Hairy white oldfield aster	Native	G
Symphyotrichum prenanthoides	Crookedstem aster	Native	G, E
Symphyotrichum puniceum var. puniceum (Aster firmus)	Purplestem aster	Native, PA-T	G
Symphyotrichum racemosum[3]	Smooth white oldfield aster	Native	G
Symphyotrichum shortii[3]	Short's aster	Native	G
Symphyotrichum undulatum	Wavyleaf aster	Native	G
Symplocarpus foetidus	Skunk cabbage	Native	G, E
Syringa vulgaris[3]	Common lilac	Non-native	G, E
Taraxacum officinale	Common dandelion	Non-native	G, E
Taraxacum species	Dandelion species	n/a	G
Taxus brevifolia[2, 3]	Pacific yew	n/a	G
Taxus canadensis	Canada yew	Native	G
Taxus species	Yew species	n/a	G
Teucrium canadense	Canada germander	Native	G, E
Thalictrum dioicum	Early meadow-rue	Native	G
Thalictrum pubescens	King of the meadow	Native	G
Thalictrum revolutum[4]	Waxyleaf meadow-rue	Native	G, E
Thalictrum thalictroides	Rue anemone	Native	G
Thaspium barbinode	Hairyjoint meadowparsnip	Native	G
Thelypteris noveboracensis (deer avoid, impedes regeneration)	New York Fern	Native	G
Thelyptreis palustris (deer avoid, impedes regeneration)	Eastern marsh fern	Native	G
Thlaspi arvense	Field pennycress	Non-native	G, E
Thuja occidentalis[3]	Arborvitae	Native	G
Tiarella cordifolia	Heartleaf foamflower	Native	G
Tilia americana	American basswood	Native	G, E
Tipularia discolor (deer prefer)	Crippled cranefly orchid	Native, PA-R	G
Toxicodendron radicans (vine, deer prefer)	Eastern Poison Ivy	Native	G, E
Tradescantia species	Spiderwort species	n/a	G
Tradescantia virginiana	Virginia spiderwort	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Trichophorum planifolium	Bashful bulrush	Native	G
Tridens flavus	Purpletop tridens	Native	G, E
Trifolium arvense	Rabbitfoot clover	Non-native	G, E
Trifolium campestre	Field clover	Non-native	G
Trifolium hybridum	Alsike clover	Non-Native	G
Trifolium pratense	Red clover	Non-native	G, E
Trifolium repens	White clover	Non-native	G, E
Trifolium aureum	Golden clover	Non-native	G, E
Trifolium species	Clover species	n/a	G
Trillium species	Trillium species	n/a	G
Triodanis perfoliata	Clasping Venus' looking-glass	Native	G, E
Triosteum angustifolium	Yellowfruit horse-gentian	Native, PA-E (TU)	G
Triosteum aurantiacum	Orangefruit horse-gentian	Native	G
Triosteum perfoliatum	Feverwort	Native	G
Triticum aestivum	Common wheat	Non-native	G, E
Tsuga canadensis	Eastern hemlock	Native	G
Tussilago farfara	Coltsfoot	Non-native	G
Typha latifolia	Broadleaf cattail	Native	G
Typha species	Cattail species	n/a	G
Ulmus americana	American elm	Native	G, E
Ulmus pumila	Siberian elm	Invasive (PA DCNR)	G
Ulmus species	Elm species	n/a	G
Ulmus thomasii[3]	Rock elm	Native	G
Ulmus rubra	Slippery elm	Native	G
Urtica dioica	Stinging nettle	Non-native	G, E
Uvularia perfoliata (deer prefer)	Perfoliate bellwort	Native	G
Uvularia sessilifolia (deer prefer)	Sessileleaf bellwort	Native	G
Vaccinium angustifolium (deer avoid, impedes regeneration)[3]	Low bush blueberry	Native	G
Vaccinium corymbosum (deer avoid, impedes regeneration)	Highbush blueberry	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Vaccinium pallidum (deer avoid, impedes regeneration)	Blue Ridge blueberry	Native	G
Vaccinium species (deer avoid, impedes regeneration)	Blueberry species	n/a	G
Vaccinium stamineum (deer avoid, impedes regeneration)	Upland highbush blueberry	Native	G
Valerianella locusta	Lewiston cornsalad	Non-native	G
Veratrum virginicum[3]	Virginia bunchflower	Native, PA-E (N)	G
Verbascum blattaria	Moth mullein	Non-native	G
Verbascum thapsus	Common mullein	Non-native	G
Verbena hastata	Swamp verbena	Native	G, E
Verbena simplex	Narrowleaf vervain	Native	G
Verbena urticifolia	White vervain	Native	G, E
Verbesina alternifolia	Wingstem	Native	G, E
Vernonia noveboracensis	New York ironweed	Native	G
Veronica arvensis	Corn speedwell	Non-native	G
Veronica officinalis	Common gypsyweed	Non-native	G
Veronica peregrina	Neckweed	Native	G
Veronica species	Speedwell species	n/a	G
Veronica persica	Birdeye speedwell	Non-native	G
Veronica serpyllifolia	Thymeleaf speedwell	Native	G
Veronicastrum virginicum	Culver's root	Native	G
Viburnum acerifolium	Maple-leaved viburnum	Native	G
Viburnum dentatum	Southern arrowwood	Native	G
Viburnum lentago[3]	Nannyberry	Native	G
Viburnum prunifolium	Blackhaw	Native	G, E
Viburnum recognitum	Northern arrowwood	Native	G
Viburnum species	Viburnum species	n/a	G
Vinca minor (invasive)	Common periwinkle	Invasive watch list (PA DCNR)	G
Viola (triloba) palmata	Three-lobe violet	Native	G
Viola blanda (var. palustriformis)[3]	Sweet white violet	Native	G
Viola cucullata	Marsh blue violet	Native	G

Scientific Name	Common Name	Nativity[1]	Park
Viola hirsutula	Southern woodland violet	Native	G
Viola pubescens var. pubescens	Downy yellow violet	Native	G, E
Viola pubescens var. scabriuscula	Downy yellow violet	Native	G
Viola sagittata var. ovata	Arrowleaf violet	Native	G
Viola sagittata var. sagittata	Arrowleaf violet	Native	G
Viola sororia	Common blue violet	Native	G, E
Viola sororia var. affinis (V. affinis)[3]	Sand violet	Native	G
Viola species	Violet species	n/a	G
Viola striata[3]	Striped cream violet	Native	G
Viola labradorica	Alpine violet	Native	G
Vitis aestivalis (vine, deer prefer)	Summer grape	Native	G, E
Vitis labrusca (vine, deer prefer)	Fox grape	Native	G
Vitis riparia (vine, deer prefer)	Riverbank grape	Native	G, E
Vitis species (vine, deer prefer)	Grape species	n/a	G, E
Vitis vulpina (vine, deer prefer)	Frost grape	Native	G
Vulpia octoflora	Sixweeks fescue	Native	G
Waldsteinia fragarioides[4]	Appalachian barren strawberry	Native	G
Woodsia obtusa (deer avoid, impedes regeneration)	Bluntlobe cliff fern	Native	G
Xanthium strumarium (var. glabratum)	Rough cocklebur	Native	G, E
Yucca flaccida[2]	Weak-leaf yucca	n/a	G
Yucca species	Yucca species	n/a	G
Zanthoxylum americanum	Common prickleyash	Native	G
Zea mays	Corn	Non-native	G, E
Zizia aptera	Meadow zizia	Native	G
Zizia aurea	Golden zizia	Native	G
GETT Plant Species			**933**
EISE Plant Species			**258**

[1] Species codes: PA-E: State-listed endangered, PA-T: state-listed threatened, PA-R: state-listed rare, PA-V: state-listed vulnerable, (N): state-listed status under review, (TU): status tentatively undetermined but in danger of population decline (source PA NHP 2015, USDA Plants Database 2016).

[2.] Indicates plants that were shown as not being present in Pennsylvania according to USDA Plants Database (2016)

[3] Indicates plants that were listed in NPSpecies (2015) but were unconfirmed as being present in park.

[4] Indicates plants that were listed as unconfirmed in NPSpecies (2015) but were listed by Perles et al. (2006).

Appendix Table 58. Pennsylvania water quality criteria uses.

Symbol	*Description*
Aquatic Life	
CWF	*Cold Water Resident Fishes*—Maintenance or propagation, or both, of fish species including the family *Salmonidae* and additional flora and fauna which are indigenous to a cold water habitat.
WWF	*Warm Water Resident Fishes*—Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
MF	*Migratory Fishes*—Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which move to or from flowing waters to complete their life cycle in other waters.
TSF	*Trout Stocking*—Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Water Supply	
PWS	*Potable Water Supply*—Used by the public as defined by the Federal Safe Drinking Water Act, 42 U.S.C.A. § 300F, or by other water users that require a permit from the Department under the Pennsylvania Safe Drinking Water Act (35 P. S. § § 721.1—721.18), or the act of June 24, 1939 (P. L. 842, No. 365) (32 P. S. § § 631—641), after conventional treatment, for drinking, culinary and other domestic purposes, such as inclusion into foods, either directly or indirectly.
IWS	*Industrial Water Supply*—Use by industry for inclusion into nonfood products, processing and cooling.
LWS	*Livestock Water Supply*—Use by livestock and poultry for drinking and cleansing.
AWS	*Wildlife Water Supply*—Use for waterfowl habitat and for drinking and cleansing by wildlife.
IRS	*Irrigation*—Used to supplement precipitation for crop production, maintenance of golf courses and athletic fields and other commercial horticultural activities.
Recreation and Fish Consumption	
B	*Boating*—Use of the water for power boating, sail boating, canoeing and rowing for recreational purposes when surface water flow or impoundment conditions allow.
F	*Fishing*—Use of the water for the legal taking of fish. For recreation or consumption.
WC	*Water Contact Sports*—Use of the water for swimming and related activities.
E	*Esthetics*—Use of the water as an esthetic setting to recreational pursuits.
Special Protection	

Symbol	***Description***
HQ	High Quality Waters
EV	Exceptional Value Waters
Other	
N	*Navigation*—Use of the water for the commercial transfer and transport of persons, animals and goods.

Appendix Table 59. Pennsylvania water quality criteria (Pennsylvania Code §93.7).

Parameter	Symbol	Critical Uses[1]	Criteria
Alkalinity	ALK	CWF, WWF, TSF, MF	Minimum 20 mg/l as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.
Ammonia Nitrogen	AM	CWF, WWF, TSF, MF	The maximum total ammonia nitrogen concentration (in mg/L) at all times shall be the numerical value given by: un-ionized ammonia nitrogen (NH_3-N) x (log-1[pKT-pH] + 1), where un-ionized ammonia nitrogen = 0.12 x f(T)/f(pH); f(pH) = 1 + $10^{1.03(7.32-pH);}$ f(T) = 1, T >= 10°C; f(T) = 1 + $10^{(9.73-pH)}$, T ‹ 10°C; 1 + 10(^{pK} $_{T-}$^{pH}) and pKT =the dissociation 0.090 +…constant for ammonia in water. 2730 (T + 273.2)
Bacteria	Bac_1	WC	(Fecal coliforms/ 100 ml)—During the swimming season (May 1 to September 30), the maximum fecal coliform level shall be a geometric mean of 200 per 100 milliliters (ml) based on a minimum of five consecutive samples each sample collected on different days during a 30-day period. No more than 10% of the total samples taken during a 30-day period may exceed 400 per 100 ml. For the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 per 100 milliliters (ml) based on a minimum of five consecutive samples collected on different days during a 30-day period.
Bacteria	Bac_2	PWS	(Coliforms/100 ml)—Maximum of 5,000/100 ml as a monthly average value, no more than this number in more than 20 of the samples collected during a month, nor more than 20,000/100 ml in more than 5% of the samples.
Chloride	Ch	PWS	Maximum 250 mg/l.
Color	Col	PWS	Maximum 75 units on the platinum-cobalt scale; no other colors perceptible to the human eye.
Dissolved oxygen	DO_1	CWF	For flowing waters, 7-day average 6.0 mg/l; minimum 5.0 mg/l. For naturally reproducing salmonid early life stages, applied in accordance with subsection (b), 7-day average 9.0 mg/l; minimum 8.0 mg/l. For lakes, ponds and impoundments, minimum 5.0 mg/l.
Dissolved oxygen	DO_2	WWF	7-day average 5.5 mg/l; minimum 5.0 mg/l.
Dissolved oxygen	DO_2	TSF	For the period February 15 to July 31 of any year, 7-day average 5.5 mg/l; minimum 5.0 mg/l.

Parameter	Symbol	Critical Uses[1]	Criteria
Fluoride	F	PWS	Daily average 2.0 mg/l.
Iron	Fe_1	CWF, WWF, TSF, MF	30-day average 1.5 mg/l as total recoverable.
Iron	Fe_2	PWS	Maximum 0.3 mg/l as dissolved iron.
Manganese	Mn	PWS	Maximum 1.0 mg/l, as total recoverable.
Nitrite plus Nitrate	N	PWS	Maximum 10 mg/l as nitrogen.
Osmotic Pressure	OP	CWF, WWF, TSF, MF	Maximum 50 milliosmoles per kilogram.
pH	pH	CWF, WWF, TSF, MF	From 6.0 to 9.0 inclusive.
Specific Conductance[2]	Specific Conductance	n/a	Good: 2 to <500 µS/cm Moderate: 500-1500 µS/cm Significant Concern > 1500 µS/cm
Phenolics	Phen	PWS	Maximum 0.005 mg/l.
Sulfate	Sul	PWS	Maximum 250 mg/l.
Total dissolved solids	TDS	PWS	500 mg/l as a monthly average value; maximum 750 mg/l.
Total residual chlorine	TRC	CWF, WWF, TSF, MF	Four-day average 0.011 mg/l; 1-hour average 0.019 mg/l.

[1] Refer to Appendix Table 57.

[2] There are no state standards for specific conductance, these ranges are based on US EPA guidelines.

Appendix Table 60. Pennsylvania standards for maximum water temperatures in the receiving water body resulting from heated waste sources regulated under Chapters 92a, 96 and other sources where temperature limits are necessary to protect designated and existing uses (Pennsylvania Code §93.7).

Dates	Cold water fishery Temp °F (°C)	Warm water fishery Temp °F (°C)	Trout stocked fishery waters Temp °F (°C)
Jan 1-31	38 (3)	40 (4)	40 (4)
Feb 1-29	38 (3)	40 (4)	40 (4)
March 1-31	42 (6)	46 (8)	46 (8)
April 1-15	48 (9)	52 (11)	52 (11)
April 16-30	52 (11)	58 (14)	58 (14)
May 1-15	54 (12)	64 (18)	64 (18)
May 16-31	58 (14)	72 (22)	68 (20)
June 1-15	60 (16)	60 (16)	70 (21)
June 16-30	64 (18)	84 (29)	72 (22)
July 1-30	66 (19)	87 (31)	74 (23)
Aug 1-15	66 (19)	87 (31)	80 (27)
Aug 16-30	66 (19)	87 (31)	87 (31)
Sept 1-15	64 (18)	84 (29)	84 (29)
Sept 16-30	60 (16)	78 (26)	78 (26)
Oct 1-15	54 (12)	72 (22)	72 (22)
Oct 16-31	50 (10)	66 (19)	66 (19)
Nov 1-15	46 (8)	58 (14)	58 (14)
Nov 16-30	42 (6)	50 (10)	50 (10)
Dec 1-31	40 (4)	42 (6)	42 (6)

Appendix Table 61. Birds observed at GETT and EISE in 2001 and 2005. In 2005, only grassland and shrubland birds were surveyed in the parks. Bold text indicates Partner in Flight, state, or federally listed species.

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Accipiter cooperii	Cooper's hawk	raptor	X	X		X	
Accipiter striatus	Sharp-shinned hawk	raptor	X	X		X	
Actitis macularius	Spotted sandpiper	shorebird	X				
Aegolius acadicus	Northern saw-whet owl	owl	X	X			
Agelaius phoeniceus	Red-winged blackbird	passerine	X	X	X	X	
Aix sponsa	Wood duck	waterfowl	X	X			
Ammodramus henslowii (IB, PA-CR)	Henslow's sparrow	passerine		X			
Ammodramus savannarum	Grasshopper sparrow	passerine	X	X	X	X	X
Anas americana	American wigeon	waterfowl	X				
Anas discors	Blue-winged teal	waterfowl	X				
Anas platyrhynchos	Mallard	waterfowl	X	X		X	
Anas rubripes (I)	American black duck	waterfowl	X				
Anas strepera	Gadwall	waterfowl	X				
Aquila chrysaetos	Golden eagle	raptor		X			
Archilochus colubris	Ruby-throated hummingbird	passerine	X	X		X	
Ardea alba	Great egret	wader	X				
Ardea herodias	Great blue heron	wader	X	X		X	
Asio flammeus (PA-PE)	Short-eared owl	owl	X	X			
Aythya collaris	Ringed-neck duck	waterfowl	X				
Baeolophus bicolor	Tufted titmouse	passerine	X	X		X	

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Bartramia longicauda (IB, PA-PE)	Upland sandpiper	shorebird		X			
Bombycilla cedrorum	Cedar waxwing	passerine	X	X		X	
Bonasa umbellus	Ruffed grouse	groundbird	X				
Branta canadensis	Canada goose	waterfowl	X	X		X	
Bubo virginianus	Great horned owl	owl	X	X			
Bucephala albeola	Bufflehead	waterfowl	X				
Buteo jamaicensis	Red-tailed hawk	raptor	X	X		X	
Buteo lineatus	Red-shouldered hawk	raptor	X	X		X	
Buteo platypterus	Broad-winged hawk	raptor	X	X			
Butorides virescens (IIA)	Green heron	wader	X	X		X	
Callipepla squamata	Scaled quail	groundbird	X				
Cardinalis cardinalis	Northern cardinal	passerine	X	X	X	X	
Carduelis tristis	American goldfinch	passerine	X	X		X	
Carpodacus mexicanus	House finch	passerine	X	X		X	
Carpodacus purpureus	Purple finch	passerine	X	X		X	
Cathartes aura	Turkey vulture	raptor	X	X		X	
Catharus fuscescens	Veery	passerine	X	X		X	
Catharus guttatus	Hermit thrush	passerine	X	X		X	
Catharus minimus	Gray-cheeked thrush	passerine	X				
Catharus ustulatus	Swainson's thrush	passerine	X	X			
Certhia americana	Brown creeper	passerine	X	X		X	
Chaetura pelagica (IIA)	Chimney swift	passerine	X	X		X	
Charadrius vociferus	Killdeer	shorebird	X	X		X	

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Chordeiles minor	Common nighthawk	passerine	X	X			
Circus cyaneus	Northern harrier	raptor	X	X		X	
Cistothorus palustris	Marsh wren	passerine	X				
Coccyzus americanus	Yellow-billed cuckoo	passerine	X	X		X	
Coccyzus erythropthalmus	Black-billed cuckoo	passerine	X	X			
Colaptes auratus	Northern flicker	woodpecker	X	X		X	
Colinus virginianus (IIA)	Northern bobwhite	groundbird	X				
Columba livia	Rock dove	groundbird	X	X		X	
Contopus virens	Eastern wood-pewee	passerine	X	X		X	
Coragyps atratus	Black vulture	raptor	X	X		X	
Corvus brachyrhynchos	American crow	passerine	X	X		X	
Corvus ossifragus	Fish crow	passerine	X	X		X	
Cyanocitta cristata	Blue jay	passerine	X	X		X	
Cygnus columbianus	Tundra swan	waterfowl	X	X			
Cygnus olor	Mute swan	waterfowl	X				
Dendroica caerulescens	Black-throated blue warbler	passerine	X	X			
Dendroica castanea	Bay-breasted warbler	passerine		X			
Dendroica cerulean (IB)	Cerulean warbler	passerine		X			
Dendroica coronata	Yellow-rumped warbler	passerine	X	X		X	
Dendroica discolor (IA)	Prairie warbler	passerine	X	X		X	
Dendroica fusca	Blackburnian warbler	passerine	X	X			

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Dendroica magnolia	Magnolia warbler	passerine	X	X		X	
Dendroica palmarum	Palm warbler	passerine		X		X	
Dendroica pensylvanica	Chestnut-sided warbler	passerine	X	X		X	
Dendroica petechia	Yellow warbler	passerine	X	X		X	
Dendroica pinus	Pine warbler	passerine	X	X		X	
Dendroica striata	Blackpoll warbler	passerine	X	X			
Dendroica tigrina	Cape May warbler	passerine	X	X			
Dendroica virens	Black-throated green warbler	passerine	X	X		X	
Dolichonyx oryzivorus	Bobolink	passerine	X	X	X	X	X
Dryocopus pileatus	Pileated woodpecker	woodpecker	X	X		X	
Dumetella carolinensis	Gray catbird	passerine	X	X	X	X	
Empidonax minimus	Least flycatcher	passerine		X			
Empidonax traillii (IB)	Willow flycatcher	passerine	X	X	X	X	
Empidonax virescens (IIB)	Acadian flycatcher	passerine	X	X		X	
Eremophila alpestris	Horned lark	passerine	X	X			
Euphagus carolinus (IIA)	Rusty blackbird	passerine		X			
Falco columbarius	Merlin	raptor	X				
Falco sparverius	American kestrel	raptor	X	X		X	
Fulica americana	American coot	waterfowl	X				
Gallinago gallinago	Common snipe	wader	X	X		X	
Geothlypis trichas	Common yellowthroat	passerine	X	X	X	X	
Haliaeetus leucocephalus (PA-PT)	Bald eagle	raptor	X				

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Helmitheros vermivorum (IB)	Worm-eating warbler	passerine	X	X		X	
Hirundo rustica	Barn swallow	passerine	X	X			
Hylocichla mustelina (IA)	Wood thrush	passerine	X	X		X	
Icterus galbula	Baltimore oriole	passerine	X	X		X	
Icterus spurius	Orchard oriole	passerine	X	X		X	
Junco hyemalis	Dark-eyed junco	passerine	X	X		X	
Lanius ludovicianus (IIC, PA-PE - migratory only)	Loggerhead shrike	passerine				X	
Larus delawarensis	Ring-billed gull	shorebird	X	X		X	
Leucophaeus atricilla	Laughing gull	shorebird		X			
Lophodytes cucullatus	Hooded merganser	waterfowl	X				
Loxia leucoptera	White-winged crossbill	passerine	X				
Megaceryle alcyon	Belted kingfisher	passerine	X	X		X	
Megascops asio (IIA)	Eastern screech-owl	owl		X			
Melanerpes carolinus	Red-bellied woodpecker	woodpecker	X	X		X	
Melanerpes erythrocephalus (IB)	Red-headed woodpecker	woodpecker	X	X		X	
Meleagris gallopavo	Wild turkey	groundbird	X	X			
Melospiza georgiana	Swamp sparrow	passerine		X		X	
Melospiza lincolnii	Lincoln's sparrow	passerine				X	
Melospiza melodia	Song sparrow	passerine	X	X	X	X	
Mimus polyglottos	Northern mockingbird	passerine	X	X	X	X	
Mniotilta varia	Black-and-white warbler	passerine	X	X			

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Molothrus ater	Brown-headed cowbird	passerine	X	X		X	
Myiarchus crinitus	Great crested flycatcher	passerine	X	X		X	
Nyctanassa violacea	Yellow-crowned night heron	shorebird	X	X			
Oporornis formosus (IB)	Kentucky Warbler	passerine		X		X	
Oreothlypis celata	Orange-crowned warbler	passerine		X			
Pandion haliaetus	Osprey	raptor	X	X			
Parula americana	Northern parula	passerine	X	X			
Passer domesticus	House sparrow	passerine	X	X		X	
Passerculus sandwichensis	Savannah sparrow	passerine		X	X	X	X
Passerella iliaca	Fox sparrow	passerine	X	X			
Passerina cyanea	Indigo bunting	passerine	X	X	X	X	
Perdix perdix	Gray partridge	groundbird	X				
Phalacrocorax auritus	Double-crested cormorant	waterfowl	X	X			
Phasianus colchicus	Ring-necked pheasant	groundbird	X	X			
Pheucticus ludovicianus	Rose-breasted grosbeak	passerine	X	X		X	
Picoides pubescens	Downy woodpecker	woodpecker	X	X		X	
Picoides villosus	Hairy woodpecker	woodpecker	X	X		X	
Pipilo erythrophthalmus (IIA)	Eastern towhee	passerine	X	X	X	X	
Piranga olivacea (IIB)	Scarlet tanager	passerine	X	X		X	
Podiceps auritus	Horned grebe	waterfowl	X				

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Poecile atricapilla	Black-capped chickadee	passerine	X	X			
Poecile carolinensis	Carolina chickadee	passerine	X	X		X	
Polioptila caerulea	Blue-gray gnatcatcher	passerine	X	X		X	
Pooecetes gramineus	Vesper sparrow	passerine		X		X	
Progne subis	Purple martin	passerine	X	X			
Quiscalus quiscula	Common grackle	passerine	X	X		X	
Regulus calendula	Ruby-crowned kinglet	passerine	X	X		X	
Regulus satrapa	Golden-crowned kinglet	passerine	X	X		X	
Riparia riparia	Bank swallow	passerine				X	
Sayornis phoebe	Eastern phoebe	passerine	X	X		X	
Scolopax minor (IA)	American woodcock	shorebird	X	X			
Seiurus aurocapilla	Ovenbird	passerine	X	X		X	
Seiurus motacilla (IIB)	Louisiana waterthrush	passerine	X	X		X	
Seiurus noveboracensis	Northern waterthrush	passerine				X	
Setophaga ruticilla	American redstart	passerine	X	X		X	
Sialia sialis	Eastern bluebird	passerine	X	X		X	
Sitta canadensis	Red-breasted nuthatch	passerine	X	X		X	
Sitta carolinensis	White-breasted nuthatch	passerine	X	X		X	
Sphyrapicus varius	Yellow-bellied sapsucker	woodpecker	X	X		X	
Spinus pinus	Pine siskin	passerine	X	X			

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Spizella arborea	American tree sparrow	passerine	X	X		X	
Spizella passerina	Chipping sparrow	passerine	X	X		X	
Spizella pusilla (IIA)	Field sparrow	passerine	X	X	X	X	
Stelgidopteryx serripennis	Northern rough-winged swallow	passerine	X	X		X	
Strix varia	Barred owl	owl	X	X		X	
Sturnella magna	Eastern meadowlark	passerine	X	X	X	X	X
Sturnus vulgaris	European starling	passerine	X	X		X	
Tachycineta bicolor	Tree swallow	passerine	X	X		X	
Thryothorus ludovicianus	Carolina wren	passerine	X	X		X	
Toxostoma rufum	Brown thrasher	passerine	X	X	X	X	
Troglodytes aedon	House wren	passerine	X	X		X	
Troglodytes troglodytes	Winter wren	passerine	X	X			
Turdus migratorius	American robin	passerine	X	X		X	
Tyrannus tyrannus	Eastern kingbird	passerine	X	X		X	
Tyto alba (PA-CA)	Barn owl	owl	X	X			
Vermivora peregrina	Tennessee warbler	passerine	X	X			
Vermivora pinus (IB)	Blue-winged warbler	passerine	X	X			
Vermivora ruficapilla	Nashville warbler	passerine	X	X			
Vireo flavifrons	Yellow-throated vireo	passerine	X	X			
Vireo griseus	White-eyed vireo	passerine	X	X		X	
Vireo olivaceus	Red-eyed vireo	passerine	X	X		X	
Vireo philadelphicus	Philadelphia vireo	passerine	X				

Scientific Name[1]	Common Name	group	GETT Historical records	GETT 2001	GETT 2005 grassland & shrubland only	EISE 2001	EISE 2005 grassland only
Vireo solitarius	Blue-headed vireo	passerine	X	X		X	
Vireo gilvus	Warbling vireo	passerine		X		X	
Wilsonia canadensis (IB)	Canada warbler	passerine		X			
Wilsonia citrina	Hooded warbler	passerine	X	X			
Wilsonia pusilla	Wilson's sparrow	passerine	X	X			
Zenaida macroura	Mourning dove	groundbird	X	X		X	
Zonotrichia albicollis	White-throated sparrow	passerine	X	X		X	
Zonotrichia leucophrys	White-crowned sparrow	passerine	X	X		X	

[1] PIF status: IA: High Continental Priority, High Regional Responsibility; IB: High Continental Priority, Low Regional Responsibility; IIA: High Regional Concern; IIB: High Regional Responsibly; IIC: High Regional Threats; IV: Additional State Listed (Kearney 2003).

[2] Pennsylvania state status: PA-CA: candidate as risk; PA-CR: candidate rare; PA-SC: special concern, PA-PE: E; PA-T: threatened; PA-PX: extirpated - Species that have disappeared from Pennsylvania since 1600 but still exist elsewhere.

Appendix Table 62. Mammals present at EISE, GETT, could be expected to occur due to presence in Adams County (Adams) or has a distribution in the southeastern or Piedmont region of Pennsylvania (State) distribution. Bold type indicates federal and/or state listed species[1], respectively.

Scientific name	Common name	Observed
Blarina brevicauda	Northern short-tailed shrew	GETT, EISE
Canis latrans	Coyote	State
Castor canadensis	American beaver	State
Condylura cristata	Starnose mole	State
Cryptotis parva (PE)	Least shrew	GETT, EISE
Didelphis virginiana	Virginia opossum	GETT
Eptesicus fuscus	Big brown bat	GETT, EISE
Glaucomys Volans	Southern flying squirrel	GETT
Lasionycteris noctivagans (CR)	Silver-haired bat	State
Lasiurus borealis	Red bat	GETT, EISE
Lasiurus cinereus	Hoary bat	GETT
Lasiurus seminolus	Seminole bat	State
Lontra canadensis	River otter	GETT
Marmota monax	Woodchuck	GETT
Mephitis mephitis	Striped skunk	GETT
Microtus pennsylvanicus	Meadow vole	GETT, EISE
Microtus pinetorum	Woodland vole	GETT
Mus musculus	House mouse	EISE
Mustela erminea	Ermine	State
Mustela frenata	Long-tailed weasel	GETT
Mustela vison	Mink	GETT
Myodes gapperi	Southern red-backed vole	State
Myotis Keenii	Keen's myotis	State
Myotis leibii (PT)	Eastern small footed myotis	Adams
Myotis lucifugus	Little brown myotis	GETT, EISE
Myotis septentrionalis (LT, CR)	Northern myotis	GETT, EISE
Myotis sodalis (LE, PE)	Indiana bat	Adams
Nycticeius humeralis (CR)	Evening bat	State
Odocoileus virginianus	White-tailed deer	GETT
Ondatra zibethicus	Muskrat	GETT

Scientific name	Common name	Observed
Parascalops aquaticus	Hairytail mole	State
Peromyscus leucopus	White-footed mouse	GETT, EISE
Peromyscus maniculatus	Deer mouse	GETT
Peromyscus maniculatus bairdii	Prairie deer mouse	GETT
Pipistrellus subflavus	Eastern pipistrelle	GETT, EISE
Procyon lotor	Raccoon	GETT
Rattus norvegicus	Norway rat	GETT
Rattus rattus	Black rat	State
Scalopus aquaticus	Eastern mole	State
Sciurus carolinensis	Eastern gray squirrel	GETT
Sorax cinereus	Masked shrew	GETT
Sorex cinereus fontinalis	Maryland shrew	GETT, EISE
Sorex fumeus	Smokey shrew	State
Sorex hoyi	Pygmy shrew	GETT
Sylvilagus floridanus	Eastern cottontail	GETT
Sylvilagus obscurus	Appalachian cottontail	Adams
Synaptomys cooperi	Southern bog lemming	State
Tamias striatus	Eastern chipmunk	GETT
Tamiasciurus hudsonicus	Red squirrel	GETT
Urocyon cinereoargenteus	Gray fox	GETT
Ursus americanus	Black bear	State
Vulpes vulpes	Red fox	GETT
Zapus hudsonius	Meadow jumping mouse	GETT

[1] Federal listed codes: LE: Listed endangered, LT: Listed threatened EP: Proposed endangered; State listed status codes: CA: Candidate at risk, CU: Condition undetermined, CR: Candidate rare, PE: Pennsylvania endangered, PT: Pennsylvania threatened, PX: Pennsylvania extirpated.

Appendix Table 63. Timeline of Significant benchmarks and project communications for the GETT/EISE Natural Resource Condition Assessment report.

Date	Communication Type	Topics Discussed	Attendees
1 November 2016	email	Revised final draft incorporating D. Reiner comments, sent final draft to C. Arnott	MJ James, C. Arnott
12 October 2016	email	Received partial comments from D. Reiner	MJ James, C. Arnott
23 September 2016	email	Revised final draft NRCA with partial comments and sent final draft to C. Arnott	MJ James, C. Arnott
26 Aug 2016	email	Partial comments received on full draft version of NRCA – Comments from GETT staff (D. Reiner) not received yet	MJ James, C. Arnott
13 June – 1 July 2016	email	No cost extension requested and received (to incorporate in-house GIS data into NRCA)	MJ James, C. Arnott
June 2016	n/a	Incorporated new information from in-house GIS data into NRCA	n/a
6 June 2016	email	Received in-house GIS data files of wetlands, wood lots and agricultural fields	MJ James, C. Arnott, C. Musselman
16 May 2016	email	received reviewers comments on last section chapters	MJ James, C Arnott
11 April 2016	email	Sent last section chapters to C Arnott for review	MJ James, C Arnott
1 February 2016	conference call	progress of NRCA, Zach will send MJ box turtle info, MJ will send out sections in draft view for preliminary review	MJ James, C. Arnott, Z. Bolitho, D. Reiner, H. Salazer, Marianne, A., A. Weed
	email received	MJJ received preliminary comments on draft section 4.1	MJ James, C. Arnott
16 November 2015	email received	Received wetland (NWI) GIS shapefiles from GETT	From: D. Reiner To: MJ James
16 November 2015	email sent	Sent draft of section 4.1 to C. Arnott for distribution	To: C. Arnott From: MJ James
16 November 2015	Conference call	NRCA status update call. Requested wetland files, Deer EIS. Follow up conference call scheduled for 1 Feb 2016.	MJ James, C. Arnott, P. Sharpe, Z. Bolitho, D. Reiner, H. Salazer
10 November 2015	email sent & received	Prescribed burn maps for GETT	From: M Taylor, M. Boss

Date	Communication Type	Topics Discussed	Attendees
12 November 2015	email sent	Updated outline Chapter 4 outline attached.	From: MJ James. To: Z. Bolitho, D. Reiner, C. Roman, C. Arnott
22 October 2015	email received	Night sky and acoustic resource template received	From: C. Arnott, H. Salazer
1 October 2015	email received	received GMP vol 1	From: D. Reiner To: MJ James
28 September 2015	email sent & received	follow-up on benthic IBI data request. Data was received.	From: MJ James. To: N. Dammeyer, A. Weed
28 September 2015	email sent	Status of NRCA with working Chapter 4 outline attached. Request copy of GMP	From: MJ James. To: Z. Bolitho, D. Reiner, C. Roman, C. Arnott
2 September 2015	email sent	Benthic IBI data request	From: MJ James. To: N. Dammeyer, A. Weed
14 July 2015	In person at GETT/EISE	Natural Resource Condition Assessment kickoff meeting, field survey of park habitats.	Z. Bolitho, D. Reiner, C. Musselman, R. Krichten, W. Peterson, , E. Clarke, C. Chapin, C. Roman, S. Colwell, A. Weed, MJ James

Literature

Comiskey, J. A., and S. M. Wakamiya. 2012. Forest vegetation monitoring: Mid-Atlantic Network 2011 summary report. Natural Resource Data Series NPS/MIDN/NRDS—2012/324. National Park Service, Fort Collins, Colorado.

Faber-Langendoen, D., J. Rocchio, S. Thomas, M. Kost, C. Hedge, B. Nichols, K. Strakosch Walz, G. Kittel, S. Menard, J. Drake, and E. Muldavin. 2012. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. Part B. Ecological integrity assessment protocols for rapid field methods (L2). EPA/600/R-12/021b.

Pennsylvania Code §93.7. Specific Water Quality Criteria. Available at http://www.pacode.com/secure/data/025/chapter93/s93.7.html (accessed 13 January 2016).

Pennsylvania Natural Heritage Program (PA NHP). Species list. Available at www.naturalheritage.state.pa.us (accessed 19 November 2015).

Pennsylvania Department of Conservation and Natural Resources (PA DCNR). Invasive Plants in Pennsylvania. Available at http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_010314.pdf (accessed 8 May 2015).

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

NPS 305/135905, 446/135905, January 2017

National Park Service
U.S. Department of the Interior

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

www.nature.nps.gov