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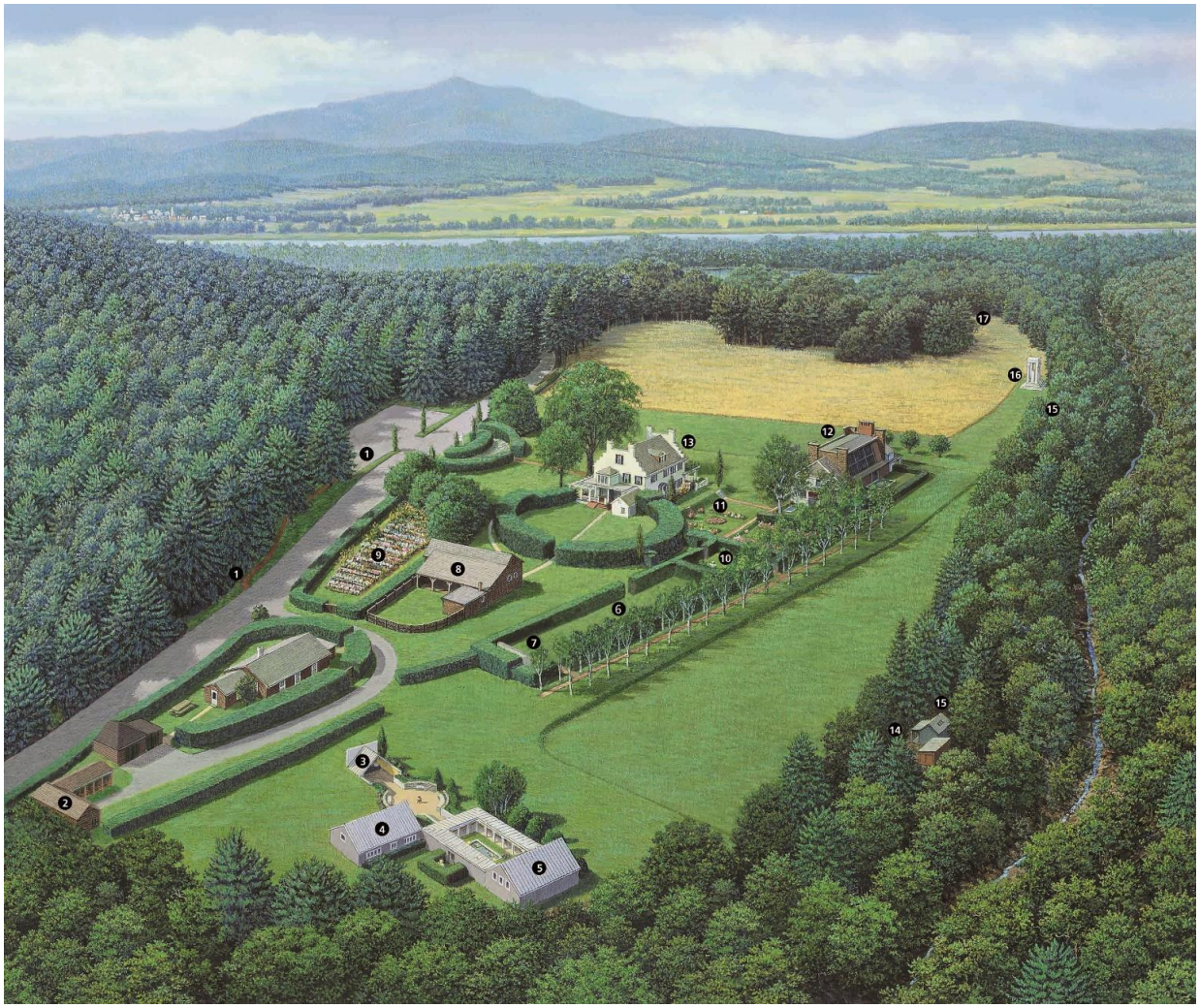
Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Saint-Gaudens National Historic Site

Natural Resource Report NPS/SAGA/NRR—2018/1730



ON THIS PAGE
Aerial representation of Saint-Gaudens National Historic Site in Cornish, New Hampshire, looking west across the Connecticut River toward Mt. Ascutney, Vermont. Courtesy of NPS.

ON THE COVER
View from Saint-Gaudens National Historic Site looking west across the lawn toward Mt. Ascutney, Vermont. Courtesy of NPS.

Natural Resource Condition Assessment

Saint-Gaudens National Historic Site

Natural Resource Report NPS/SAGA/NRR—2018/1730

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Contents

Contents (continued)

Page

Contents (continued)

Figures

Page

Figures (continued)

Page

Tables

Page

Tables (continued)

Page

Tables (continued)

Page

Appendices

Page

Executive Summary

This Natural Resource Condition Assessment evaluates current conditions and trends for a subset of natural resource indicators and identifies critical data gaps for Saint-Gaudens National Historic Site. The indicators of condition included herein reflect the park's resource setting, status of resource stewardship planning and science, and availability of data and expertise to assess current conditions for a variety of potential indicators. The goal of this report is to provide clear, credible, integrative reporting to assist and inform park managers, stake-holders and the public.

This 77-hectare (191-acre) National Historic Site preserves and interprets the artwork and historically significant properties associated with the foremost American sculptor Augustus Saint-Gaudens (1848-1907). Located in Cornish, New Hampshire, the park preserves the home, studio, gardens and natural areas where Saint-Gaudens lived and worked at the turn of the last century. This estate was a focal point of the Cornish Art Colony, a social group of artists, writers and others attracted to the natural beauty of the area, including spectacular views of Mount Ascutney to the west across the Connecticut River. In all, the park preserves 19 historic buildings, four cultural landscapes, a collection of more than 10,000 catalogued objects including hundreds of original works of art, as well as hectares of forested ravine, agricultural lands, sections of two perennial streams, a pond, wetlands, and a stretch of shoreline along the Connecticut River. The park provides habitat for a variety of wildlife species including several species of conservation interest.

Using the National Park Service Vital Signs Indicator Framework, 25 indicators of natural resource condition were selected for assessment and reporting herein. Assessment points were established to distinguish between acceptable or desired conditions (i.e., *good condition*) and those that warrant *moderate concern* or *significant concern*. These assessment points were derived from knowledge of ecological integrity, regulatory or program standards, park management goals, historical data or other sources.

Key findings and recommendations are summarized by resource category in Table E-1.

Table E-1. Summary of key findings and recommendations for natural resource condition at Saint Gaudens National Historic Site.

Resource Category	Key findings	Recommendations
Air and Climate	Estimated **ozone** pollution warranted *moderate concern* for human health, and showed *good condition* for park vegetation. Data was not sufficient to assess trend.	Continue to monitor and work collaboratively with federal, state and local partners to reduce air pollution.
	Estimated wet deposition of nitrogen warranted *moderate concern* for **acidic deposition**, while estimated wet deposition of sulfur warranted *significant concern* to sensitive park ecosystems. Regional trends are improving.	Continue to monitor and work collaboratively with federal, state and local partners to reduce air pollution.
	Estimated impairment of park views due to anthropogenic haze warranted *moderate concern* for **visibility and particulate matter**. Regional trends are improving.	Continue to monitor and work collaboratively with federal, state and local partners to reduce air pollution.
	Estimated mercury wet deposition and predicted methyl mercury concentration in park surface waters warranted *moderate concern* for **mercury contamination**. Data was not sufficient to assess trend.	Continue to monitor and work collaboratively with federal, state and local partners to reduce air pollution.
	Current condition of temperature and precipitation variables show extreme warm and wet conditions compared to the historical record, and warranted *significant concern* for **climate**.	Expand efforts to identify and monitor status and trends of key indicators of climate change, and to identify and monitor valued park resources at high risk to climate change impacts.
	Modeled data suggest anthropogenic sound such as automobile traffic and aircraft overflights may reduce park listening area 30 - 50%, warranting *moderate concern* for **soundscape**. Data was not available to assess trend.	Consider on-site monitoring.
	Modeled data suggest anthropogenic light sources visibly impact park views of the night sky, warranting *moderate concern* for **lightscape**. Data was not available to assess trend.	Consider on-site monitoring.
	Viewshed is a data gap.	Consider identifying key park views to monitor using time-lapse photography.
Geology and Soils	Analysis of **forest soils** indicated soils are well buffered, but warranted *significant concern* for nitrogen saturation and *moderate concern* for aluminum toxicity. Data was not sufficient to assess trends.	Continue to monitor and work collaboratively with federal, state and local partners to reduce air pollution, a major stressor affecting forest soil chemistry**.**

Table E-1 (continued). Summary of key findings and recommendations for natural resource condition at Saint Gaudens National Historic Site.

Resource Category	Key findings	Recommendations
Water Quantity and Quality	Assessment points for understanding condition of **water quantity** have not been established. Ten-year trends in stream discharge for Blow-me-up and Blow-me-down Brooks were unchanging.	Establish assessment points based on monitored levels and ecological function.
	Overall, **water quality** in Blow-me-down Pond and two streams showed *good condition* for many metrics, but warranted *moderate concern* for high phosphorus levels, mercury and aluminum contamination, and for deteriorating trends in chloride and phosphorus.	Continue to monitor water chemistry. Investigate sources of chloride loading to Blow-me-up Brook. Work collaboratively with state agencies and park neighbors to reduce water pollution from roads and other sources.
	Current data were not available to assess **macroinvertebrate** condition.	Consider monitoring using available protocols.
Biological Integrity	Invasion of Blow-me-down Pond and park forests by **exotic plants** warranted *moderate concern*, and showed a deteriorating eight-year trend in forest habitats.	Continue invasive plant detection and management.
	Hemlock wooly adelgid has been detected in Sullivan County, both the emerald ash borer and winter moth have been detected in neighboring counties, and crazy snake worm (*Amynthas agrestis*) has been detected in the park. These **invasive exotic pests** are a *significant concern* to park ecosystems.	Early detection of key forest pests and rapid response must continue to be a high priority.
	Wetland vegetation is not monitored. Preliminary assessment of wetland buffers indicated *moderate concern* for buffer width.	Monitor park wetlands using rapid assessment methods.
	Forest vegetation fell short of desired late-successional forest structure, warranting *moderate concern*. Low levels of standing dead trees (snags) and coarse woody debris warranted *moderate concern*; no significant trend was detected. Tree regeneration and tree mortality showed *good condition*, while tree foliage damage warranted *moderate concern*.	Continue to monitor. Allow snags and coarse woody debris to remain in place wherever appropriate.
	Mean regional **white-tailed deer** density estimates indicated good condition with an unchanging trend. Assessment of deer-browse indicator species in forest plots also indicated *good condition*.	Continue to monitor deer-browse impacts.
	Fish communities are a data gap.	Consider monitoring to determine status and trends of key species or guilds.
	Six of thirteen **forest bird** condition guilds showed *good condition* for ecological integrity, while another six guilds warranted *moderate concern*, and one guild warranted *significant concern*. The majority of guilds showed no change between two recent time periods. Status and trend of bird species at the Blow-me-down Farm property is a data gap.	Continue to monitor forest bird species. Inventory and monitor bird species at the Blow-me-down Farm property, including field habitats.

Table E-1 (continued). Summary of key findings and recommendations for natural resource condition at Saint Gaudens National Historic Site.

Resource Category	Key findings	Recommendations
Biological Integrity (cont.)	Current condition of amphibian and reptile communities is a data gap. Sensitive species, pond-breeding salamanders and vernal pool-breeding amphibians were represented in the **amphibian** community at the time of the park inventory in 2001. Numbers of red-backed salamanders observed beneath coverboard arrays showed an unchanging trend.	Consider monitoring to determine status and trends of key species or guilds.
	Population status and trends for **mammal** species are a data gap.	Consider monitoring to determine status and trends of key species or guilds.
	Population status and trends for **bat** species are a data gap.	Consider monitoring to determine status and trends of key species or guilds.
	Population status and trends for **terrestrial invertebrate** species are a data gap.	Consider monitoring to determine status and trends of key species or guilds.
Landscapes	Forest patch size was sufficient to support invertebrates, small mammals and many bird species, but patch configuration and perforation has reduced the amount of interior or intact forest habitat, warranting *moderate concern* for **landcover/connectivity**.	Continue to monitor, and work with local partners to advocate for appropriate land uses in the area.
	Low levels of anthropogenic land use surrounding forest plots and minimal coverage by impervious surfaces both showed *good condition* for **land use**.	Continue to monitor, and work with local partners to advocate for appropriate land uses in the area.

Acknowledgments

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List of Terms and Acronyms

Al	Aluminum
ALR	Anthropogenic light ratio, a measure of how much total nighttime sky brightness is elevated over natural levels
ALU	Anthropogenic land use
AMNet	Atmospheric Mercury Network
AmphIBI	Amphibian Index of Biotic Integrity, of the Ohio EPA
ANC	Acid neutralizing capacity, a measure of buffering capacity
ARD	Air Resources Division, of NPS
BBD	Beech bark disease
BMD	Blow-me-down, a regional name as in BMD Brook
BMU	Blow-me-up, a regional name as in BMU Brook
BS	Base saturation, the percentage of the soil exchange sites occupied by basic cations
C	Carbon
C of C	Coefficient of conservatism, a measure of species sensitivity to disturbance
Ca	Calcium
CASTNET	Clean Air Status and Trends Network
CWD	Coarse woody debris
dBa	Decibels adjusted (weighted) to reflect human hearing sensitivity to frequencies from 1,000 to 6,000 Hertz
DO	Dissolved oxygen, an indicator of water quality
dv	Deciviews, a linear scale of human-perceived changes in air quality
EAB	Emerald ash borer (*Agrilus planipennis)*
FIA	Forest Inventory and Analysis, a program of the USDA Forest Service
GMP	General Management Plan
Hg	Mercury
HIS	Hydrographic and Impairment Statistics, an NPS database
HRV	Historical range of variability
HWA	Hemlock wooly adelgid (*Adelges tsugae)*
I&M	Inventory & Monitoring, an NPS program
IBI	Index of Biotic Integrity
IC	Impervious cover
IMPROVE	Interagency Monitoring of Protected Visual Environments, a monitoring network

IRMA	Integrated Resource Management Application, an NPS database
ISED	Invasive Species Early Detection
K	Potassium
L_{50}	Noise level exceeded 50% of the time
LOI	Loss-on-ignition, a measure of organic and carbonate content
MDN	Mercury Deposition Network
MeHg	Methyl mercury
Mg	Magnesium
Mn	Manganese
N	Nitrogen
NABat	North American Bat Monitoring Program
NADP	National Atmospheric Deposition Program
NALCC	North Atlantic Landscape Conservation Cooperative
NETN	Northeast Temperate Network, of NPS
NH DES	New Hampshire Department of Environmental Services
NH FGD	New Hampshire Fish and Game Department
NHS	National Historic Site
nL	nanolamberts, a unit of luminance
NLCD	National Land Cover Database
NPS	National Park Service
NRCA	Natural Research Condition Assessment
NSNSD	Natural Sounds & Night Skies Division, of NPS
NWI	National Wetlands Inventory
P	Phosphorus
ppb	parts per billion
ppm	parts per million
RMP	Resource Management Plan
S	Sulfur
SAGA	Saint-Gaudens National Historic Site
SC	Special Concern, a designation for species that could become threatened in the foreseeable future
SCPN	Southern Colorado Plateau Network, of NPS
SGCN	Species of Greatest Conservation Need
SPL	Sound pressure level, a measure of sound in decibels

SPNHF	Society for Protection of New Hampshire Forests
SQI	Soil Quality Index
TC	Total carbon
TN	Total nitrogen
USA-RAM	US EPA Rapid Assessment Method, for monitoring wetland condition
US EPA	US Environmental Protection Agency
US FWS	US Fish and Wildlife Service
VRP	Visual Resources Program of NPS
VT DEC	Vermont Department of Environmental Conservation
WMA	Wildlife Management Area
WMU	Wildlife Management Unit
WNS	White-nose syndrome, a disease syndrome affecting hibernating bats
Zn	Zinc

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

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

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

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

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

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

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

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

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

Important NRCA Success Factors

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

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

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

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

NRCA Reporting Products…

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

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

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

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

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

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

2. Introduction and Resource Setting

2.1. Introduction

Saint-Gaudens National Historic Site (SAGA) preserves and interprets the artwork and historically significant properties associated with the foremost American sculptor Augustus Saint-Gaudens (1848-1907). Located in Cornish, New Hampshire, the 77-hectare (191-acre) site preserves the home, studio, gardens and natural areas where Saint-Gaudens lived and worked at the turn of the last century. This estate was a focal point of the Cornish Art Colony, a social group of artists, writers and others attracted to the natural beauty of the area, including spectacular views of Mount Ascutney to the west across the Connecticut River. SAGA also preserves part of the Blow-Me-Down (BMD) Farm property, owned by lawyer and patron- of-the-arts Charles C. Beaman, Jr., whose influence and generosity helped to bring Augustus Saint-Gaudens and other artists to the area.

The park encompasses a historic core, including Saint-Gaudens' home, gardens, and studios, as well as BMD Farm, the BMD Mill and Pond, the small Saint-Gaudens Farm area, and an area used for park operations (Figure 2-1). In all, SAGA preserves 19 historic buildings, four cultural landscapes, a collection of more than 10,000 catalogued objects including hundreds of original works of art, as well as hectares of forested ravine, agricultural lands, sections of two perennial streams, BMD Pond, wetlands, and a stretch of Connecticut River shoreline.

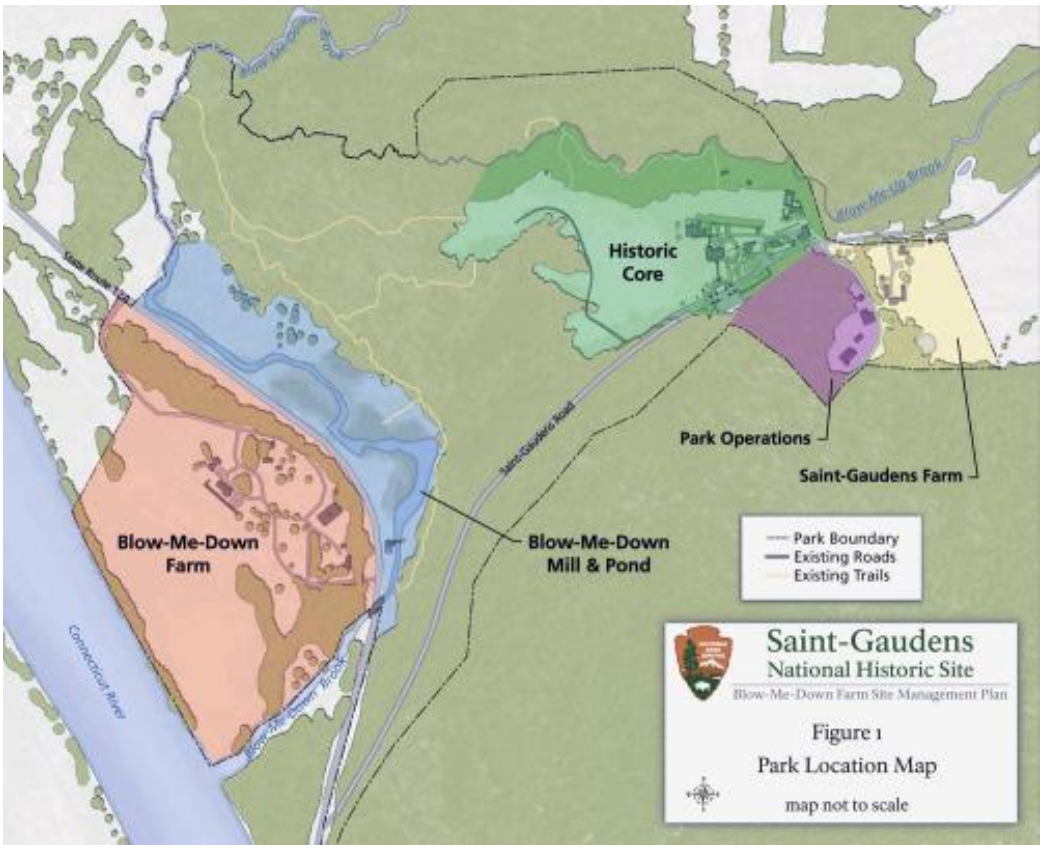

Figure 2-1. Layout of Saint-Gaudens National Historic Site in Cornish, New Hampshire. Courtesy of National Park Service.

2.1.1. Enabling Legislation

SAGA was authorized in 1964 in order to preserve and interpret "historically significant properties associated with the life and cultural achievements of Augustus Saint-Gaudens" (Public Law 88-543). This law authorized SAGA to cooperate with the Saint-Gaudens Memorial, a private, non-profit organization dedicated to the preservation and exhibition of Augustus Saint-Gaudens' home, studios and estate, in order to achieve a "living memorial." Further legislation in 1976 and 2000 eased limitations on land acquisition and funding at SAGA (Public Laws 94-578 and 106-491). Federal legislation allows for future expansion of park land holdings, extending both to the north and south of lands already acquired by NPS.

2.1.2. Geographic Setting

SAGA is located in the rural, western New Hampshire town of Cornish, in Sullivan County, along the shore of the Connecticut River. This small town is inhabited by about 2,000 people, and population has been growing slowly in recent decades (Town of Cornish 2009).

SAGA is intersected by NH Route 12A, which separates BMD Farm from the rest of the park, as well as by Saint Gaudens Road, a town-designated Scenic Road.[1] An electric powerline runs east-west across the property south of Saint Gaudens Road. Town zoning regulations define the area surrounding SAGA as rural, with minimum 2-hectare (5-acre) lot size, and zoning includes protection for flood plains, shorelines, and wetlands, as well as restrictions on manufactured homes (Town of Cornish 2015). South of Saint Gaudens Road, the 313-hectare (773-acre) Dingleton property, owned by the Bulkely family, is forested land protected by conservation easement to preserve views from Mt. Ascutney (Town of Cornish 2009, SPNHF 2007). Part of the Dingleton property lies within SAGA's authorized legislative boundary for possible future acquisition. The 12-hectare (29-acre) Cornish State Wildlife Management Area (WMA), operated by the NH Fish and Game Department (NH FGD), lies southwest of SAGA along the Connecticut River shoreline. This WMA, much of which is under agricultural lease, provides boat and fishing access to the Connecticut River, as well as habitat for migrating waterfowl and other wildlife. The Town of Cornish Master Plan considers the possibility of a wildlife corridor linking protected lands in the Town's northwest corner, including SAGA (Town of Cornish 2009).

Park elevations range from approximately 85 to 200 meters (280 to 650 feet), and much of the park is forested in steeply sloping ravines. The park is underlain by bedrock of the Gile Mountain Formation, a formation of metamorphosed sedimentary rock, primarily schist and slate (Billings 1956, Bennett et al. 2006). This bedrock is overlain by deep, terraced glacial and fluvial sediment deposits (Cronan et al. 1981, NPS 2008). Soils are relatively young Inceptisols (dystrochrepts of the Warwick, Unadilla, and Dutchess series) and Entisols (of the Quonset, Hadley and Windsor series; SSURGO 2017). The climate at SAGA is humid continental with warm summers and cold snowy winters. Annual precipitation is about 900 mm (35.5 inches; NOAA 2017).

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[1] This designation allows for public input into protection of trees and stonewalls situated on the public right-of-way of Scenic Roads (Town of Cornish 2009).

2.1.3. Visitation Statistics

Annual visitation rates at SAGA averaged about 36,000 from 2011 – 2015. Visitation rates are highest during June through October and lowest during winter (NPS 2017a). Most visitors come to SAGA to view the work of Augustus Saint-Gaudens, to learn about him, or to attend concerts or special events (Manni et al. 2005).

2.2. Natural Resources

The park preserves more than 40 hectares (100 acres) of forests, sections of two perennial streams, BMD Pond, wetlands, and about 0.4 km (1/4 mi) of CT River shoreline with associated flood plain.

2.2.1. Ecological Units and Watersheds

SAGA lies within the BMD Brook watershed, except for much of the park land west of NH Route 12A, which drains directly into the Connecticut River. Under the modified Bailey's ecoregional classification, this region lies in the Northern Connecticut River Valley subsection (M212Bb) of the Vermont - New Hampshire Uplands section.

The park vegetation mapping project identified twelve vegetation types: four upland forest types, a successional old field, a forest seep, two riparian types, and four wetland types (Figure 2-2 and Table 2-1; Gawler and Bowman 2012). The park mapping project was underway before the park acquired the 17-hectare (43-acre) BMD Farm property in 2010, thus BMD Farm was not mapped as part of that project. The BMD Farm property includes an exemplary natural community of Silver Maple-Wood Nettle-Ostrich Fern floodplain forest (Cornish Conservation Commission 2013, NPS 2013). This community is rated S2 by the NH Natural Heritage Bureau, indicating imperiled status or rarity within the state (Sperduto and Nichols 2004). This small occurrence is found along BMD Brook, straddling the border between SAGA and the adjacent Cornish WMA. The NH Natural Heritage Bureau estimated the size of this occurrence to be 4.5 hectares (11.1 acres; Appendix A of NPS 2013); however only about 1.0 hectares (2.5 acres) lies within SAGA, with the rest lying in the adjacent WMA.

About 7 hectares (16.5 acres) of the BMD Farm property is farmed under an ongoing agricultural lease until 2029, and a 0.6-hectare (1.6-acre) lawn is mowed weekly while another 3 hectares (7 acres) is mowed as needed (about six times per year) to retain open space for special events and to control invasive species (NPS 2013, S. Walasewicz, personal communication).

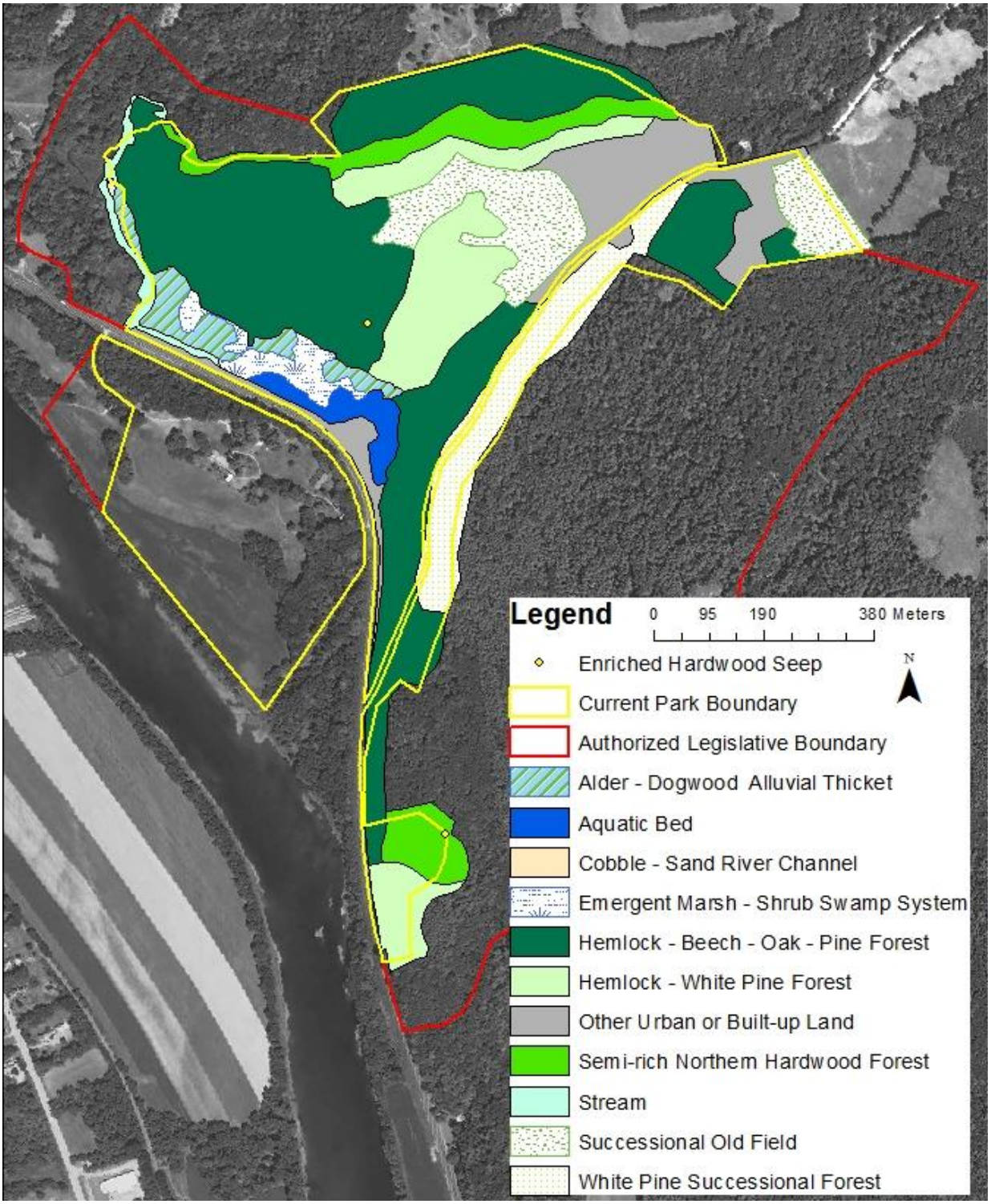

Figure 2-2. Mapped vegetation classes at Saint-Gaudens National Historic Site (from Gawler and Bowman 2012).

Table 2-1. Vegetation associations at Saint-Gaudens National Historic Site. From Gawler and Bowman (2012) except the flood plain forest (described in Appendix A of NPS 2013).

Vegetation Association	Area in park (ha)	Description
Hemlock - Beech - Oak - Pine Forest	27.1	The most common park vegetation, found on drier mid- to upper-slopes, is dominated by American beech (*Fagus grandifolia*), northern red oak (*Quercus rubra*), eastern hemlock (*Tsuga canadensis*), and red maple (*Acer rubrum*). A variant of this type on mesic terraces above the pond is dominated by northern red oak and/or eastern white pine (*Pinus strobus*) with little or no eastern hemlock and American beech.
Hemlock - White Pine Forest	8.3	This coniferous type, occurring on steep slopes, is dominated by eastern hemlock with a super-canopy of eastern white pine.
Semi-rich Northern Hardwood Forest	4.5	Occurring as small patches on low terraces within the matrix forest, this type is dominated by hardwoods including sugar maple (*Acer saccharum*), American basswood (*Tilia americana*), white ash (*Fraxinus americana*), and yellow birch (*Betula alleghaniensis*) with ferns such as ostrich fern (*Matteuccia struthiopteris*) and Christmas fern (*Polystichum acrostichoides*) dominating the herb layer.
White Pine Successional Forest	5.3	This type occurs along the southeast border, with a canopy of eastern white pine above northern red oak and hemlock regeneration.
Successional Old Field	6.0	These open fields lying west and east of Saint-Gaudens home are mowed annually, and contain common grasses such as timothy (*Phleum pretense*) and bentgrass (*Agrostis* sp.) and old-field forbs.
Enriched Hardwood Forest Seep	<0.01	This herbaceous wetland community occurs in two small patches on lower slopes and is characterized by a lush herb layer including northern maidenhair (*Adiantum pedatum*), broadleaf sedge (*Carex platyphylla*), plantainleaf sedge *(C. plantaginea*), and pointedleaf ticktrefoil (*Desmodium glutinosum*).
Silver Maple-Wood Nettle-Ostrich Fern floodplain forest*	1.0	Occurring in a small patch at the confluence of BMD Brook and the CT River, this forest is dominated by silver maple (*Acer saccharinum*) and American elm (*Ulmus americanus*) with ostrich fern (*Matteucia struthiopteris* var. *pensylvanica*) and false nettle (*Boehmeria cylindrica*) in the understory.
Alder - Dogwood Alluvial Thicket	2.0	Bordering BMD Brook and Pond, this type is dominated by silky dogwood (*Cornus amomum*), with gray alder (*Alnus incana*) codominant, and has a diverse herb layer.
Cobble - Sand River Channel	0.04	Occurring on a gravel bar in BMD Brook, this type has a sparse cover of American sycamore (*Platanus occidentalis*) seedlings, and shrubs and herbs.

Table 2-1 (continued). Vegetation associations at Saint-Gaudens National Historic Site. From Gawler and Bowman (2012) except the flood plain forest (described in Appendix A of NPS 2013).

Vegetation Association	Area in park (ha)	Description
Bluejoint Wet Meadow	<1.5*	Occurring in narrow bands along BMD Brook, this type is dominated by bluejoint (*Calamagrostis canadensis*), broadleaf cattail (*Typha latifolia*), common boneset (*Eupatorium perfoliatum*), Canada bluegrass (*Poa compressa*), smallspike false nettle (*Boehmeria cylindrica*), jewelweed (*Impatiens capensis*), and Virginia water horehound *(Lycopus virginicus*).
Medium-depth Emergent Marsh	<1.5*	Occurring in low, wet areas separated from the main stream channel, this marsh is dominated by three species: white grass (*Leersia virginica*), threeway sedge (*Dulichium arundinaceum*), and broadleaf cattail.
Cattail Marsh	<1.5*	Occurring adjacent to BMD Pond and Brook, this marsh is dominated by broadleaf cattail.
Aquatic Bed	1.3	Occupying shallow parts of BMD Pond, this aquatic type is dominated by ribbonleaf pondweed (*Potamogeton epihydrus*), with variegated yellow pond-lily *(Nuphar lutea* ssp. *variegata*) and American white waterlily (*Nymphaea odorata*).

*Gawler and Bowman (2012) combined these three associations into a single mapped class of total area 1.5 ha.

2.2.2. Resource Descriptions

Aquatic habitats in the park include sections of two perennial streams, BMD Pond, two small surface water impoundments and several wetlands. The second-order BMU Brook flows along the park's northern edge, meandering in and out of the Park, and flows into BMD Brook above BMD Pond. A small impoundment on BMU Brook was used historically as a swimming hole. BMD Brook flows along the park's northwestern boundary, widens into BMD Pond above the historic dam, and then continues on to the Connecticut River. The shallow, approximately 1 hectare (2.5 acre) BMD Pond lost surface area during reconfiguration of Route 12A in 1957 and continues to be impacted by sedimentation (NPS 2010a, S. Walasewicz, personal communication). Farm Pond, a small, spring-fed impoundment, occurs in the Saint-Gaudens Farm area, east of the park's historic core, and drains into an intermittent stream flowing into BMU Brook (Ellsworth 2005).

Extensive wetlands surround BMD Pond and Brook, extending beyond the park's current boundary onto neighboring land within the park's legislative boundary (US FWS 1993, Sharpe and Farrell 2016). Further downstream, a small occurrence of the Silver Maple-Wood Nettle-Ostrich Fern floodplain forest is found along BMD Brook (NPS 2013). Two small (<0.01 ha) enriched hardwood forest seeps are shown on the park vegetation map at the base of steep slopes (see Figure 2-2; Gawler and Bowman 2012). The park also contains about 0.4 km (1/4 mi) of Connecticut River shoreline, and about 35% of the BMD Farm property lies within the 100-year flood plain (FEMA 2006). These features are shown in Figure 4-21 in section 4.4.3.

Species documented to be present in the park include 37 mammals (six of which are bat species), 13 amphibians, five reptiles, and more than 90 bird species (Faccio 2003, Faccio and Mitchell 2015,

Gilbert et al. 2008, Cook et al. 2008, Gates and Johnson 2012, NPS 2017a). One park species, the northern long-eared bat (*Myotis septentrionalis*) was included on the federal threatened species list in 2015 (US FWS 2017). Three other bat species present in the park (*Lasiurus borealis*, *Lasiurus cinereus*, and *Perimyotis subflavus*) are designated species of special concern (SC) in NH, as are two park herptiles (*Ambystoma jeffersonianum* and *Glyptemys insculpta*) and a fish species (*Phoxinus eos*; NH FGD 2009).[2] Special concern is assigned to species that could become threatened in the foreseeable future. Several additional species documented in the park are designated as Species of Greatest Conservation Need (SGCN) in NH including moose (*Alces alces*), two bat species (*Myotis lucifugus* and *Eptesicus fuscus*), brook trout (*Salvelinus fontinalis*), eight bird species, and several of the SC species noted above (NH FGD 2015).

2.2.3. Resource Issues Overview

Discussion with Steve Walasewicz identified several natural resource concerns for SAGA, including 1) invasive plants, animals, and diseases, including the hemlock wooly adelgid (HWA), which poses a particular threat to the park's hemlock ravines; 2) sedimentation in the BMD Pond/wetland complex, which has been proposed for dredging; 3) potential data gaps within the park, including the BMD Farm property; 4) management of a population of large brown bats (*Eptesicus fuscus*) nesting in the historic Beaman barn; 5) management of the Silver Maple-Wood Nettle-Ostrich Fern Floodplain Forest, including control of fern poaching and invasive species; 6) vegetation management to preserve historic views; and 7) planning for development of trails and a canoe/kayak landing along the Connecticut River. Additional issues of park concern include erosion and off-site groundwater contamination from agricultural use and development (NPS 2015a).

Stressors of concern acting on SAGA ecosystems include global and regional threats such as climate change, atmospheric deposition, nutrient enrichment, habitat fragmentation, road impacts, and invasive species and forest pests (Mitchell et al. 2006, NPS 2015a). These threats originate from sources outside the park's borders. Climate change is already having measurable impacts on many species across the globe, and is expected to have dramatic impacts over the coming century (IPCC 2007). Atmospheric deposition is a key concern affecting forest health and soil quality across the region (Likens et al. 1996, Driscoll et al. 2001), and the advance of invasive exotic forest pests is a substantial threat to forest resources (Gandhi and Herms 2010).

2.3. Resource Stewardship

In 2004, the NPS Northeast Temperate Network (NETN) identified 19 Vital Signs for monitoring natural resources at SAGA (Table 2-2; Mitchell et al. 2006). These Vital Signs were selected to represent a subset of physical, chemical, and biological elements and processes of park ecosystems representative of the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

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[2] The wood turtle (*Glyptemys insculpta*) and redbelly dace (*Phoxinus eos*) were last seen in the park during the 1980s.

Table 2-2. Vital signs of natural resource condition selected for Saint-Gaudens National Historic Site by the National Park Service Northeast Temperate Network (Mitchell et al. 2006).

Category	Vital Sign
Air and Climate	Ozone
	Acidic deposition & stress
	Contaminants
	Climate
Geology and Soils	Forest soil condition
Water	Water quantity
	Water chemistry
	Streams - macroinvertebrates
Biological Integrity	Invasive exotic plants
	Invasive exotic animals
	Wetland vegetation
	Forest vegetation
	White-tailed deer
	Fishes
	Breeding birds
	Amphibians and reptiles
Human use	Visitor Usage
Landscapes	Landcover / ecosystem cover / connectivity
	Land use

2.3.1. Management Directive and Planning Guidance

SAGA's national significance lies in its historic association with Augustus Saint-Gaudens, his work, and the Cornish Colony (NPS 2015a). The park was established in order to preserve and interpret the historically significant properties associated with the artist and to serve as a "living memorial" (Public Law 88-543). As such, the park's historic core is managed to represent the designated period of significance beginning in 1884, when the property was first purchased by Charles C. Beaman, Jr., and extending until 1950, when the Saint-Gaudens Memorial Group finished improvements to the property (Killion 2013). Park management seeks to balance the sometimes conflicting needs for preservation of the park's cultural and natural resources "unimpaired for the enjoyment of future generations" with the demands of use by the public and as a "living memorial" (NPS 1996, 16 USC 1).

The park's 1996 General Management Plan (GMP) designated four management subzones at SAGA: 1) the historic subzone or core including Saint-Gaudens home, studio and gardens; 2) the natural subzone including peripheral and wooded areas surrounding the historic core, both streams, and the pond/wetland complex, and the wooded hillside along Saint Gaudens Road from Route 12A up the

hill; 3) a development subzone including the utility corridor south of Saint Gaudens Road, the nursery/collections storage building area, the visitor parking area, and the Mill parking area; and 4) a special use subzone comprised of roads traversing the park (Route 12A, Saint-Gaudens Road, and smaller access roads). The GMP further designated that should BMD Farm be acquired, it would be managed similarly with four subzones, including a historic subzone, a natural subzone along the site's northern, eastern and southern perimeters, a development subzone including a maintenance facility on the north side of the site and a parking area, and a special use subzone the lower terrace area along the Connecticut River where farming would continue (NPS 1996). The park's 1991 Resource Management Plan (RMP) states the following management objectives: 1) "the protection of resources while at the same time seeking to augment the park's operating base so that there will be sufficient staffing and funding to maintain the outstanding cultural and natural resources of the park and to provide for visitor use and enjoyment"; and 2) "broaden and continue cooperation with the Trustees and other groups, in order to more effectively achieve a 'living memorial'" (McKay 1991).

The park visitor center and bookstore, constructed in 2002, lie in the park's historic core (NPS 2013). Park management seeks to contain park maintenance functions and new development in specific locations outside of the park's historic core and natural subzones (NPS 1996). In its role as a "living memorial" to Augustus Saint-Gaudens, the park hosts cultural events such as a summer concert series, a Sculptor-in-Residence program, art exhibitions, and special events, including weddings. The lower field north of Saint-Gaudens Road serves as overflow parking for concerts and special events (NPS 1996). Efforts to improve park accessibility to visitors with disabilities are balanced by the park's mandate to preserve historic landscapes (NPS 1996).

The 2010 acquisition of the BMD Farm property increased the park's area by more than 20% and added eight historic structures, many of which are in need of significant rehabilitation (NPS 2013). As of 2017, NPS was seeking partners and tenants interested in operating programs and investing capital to stabilize and rehabilitate historic structures at this site (NPS 2015b). Under phase 1 of the plan for BMD Farm, NPS has sought partners that would bring programs relating directly to the park's purpose and significance in the fields of art, history, or natural resources. If park management goals for BMDF have not been met after seven years of phase 1, beginning in 2021 NPS will "expand acceptable uses of the Farm beyond those which directly support the park's purpose and significance" and "consider any proposal for use (public or private), provided the proposal meets NPS leasing regulations" (NPS 2014a).

Vegetation management is used to maintain lawns and open views from the park's historic core, and along the Connecticut River (NPS 2013). Hazardous trees are removed, and invasive species are controlled using integrated pest management (NPS 2015a, Currie 2006). Dogs are permitted on the grounds but must be leashed. Fishing is permitted, though fish stocking does not occur at SAGA (NPS 1996).

2.3.2. Status of Supporting Science

As part of the NPS I&M program, twelve baseline inventories have been completed (Water quality, Base cartography, Air quality data, Air quality related values, Climate, Geologic resources, Soil resources, Water body location and classification, Vegetation map, Species lists, Species occurrence

and distribution, and Integrated resource management application (IRMA)[3]); five Vital Sign Inventories have been completed (Breeding birds, Amphibians and reptiles, Terrestrial mammals, Fish, and Land cover); and monitoring is underway for five monitoring protocols (Air quality, Breeding landbirds, Climate, Forest health, and Water quality). An additional monitoring protocol (Invasive species – Early detection) was implemented from 2010-2014. These and many other data sources are summarized in Table 2-3.

[3] IRMA is an online portal (irma.nps.gov) providing data and resources related to the national parks.

Table 2-3. Datasets identified for assessing natural resource condition at Saint-Gaudens National Historic Site.

Natural Resource or Issue	Data Type	Year(s) Collected	Source
Air quality	Air quality assessment	Ongoing	NPS Air Resources Division
	Deposition sensitivity assessment	NA	Sullivan et al. 2011a, 2011b
	Ozone sensitivity assessment	NA	NPS 2004
Mercury contamination	Air quality assessment	Ongoing	NPS Air Resources Division
	Hg wet deposition monitoring	2004-present	Mercury Deposition Network
	Hg in dragonfly larvae	2011- present	NPS Dragonfly mercury project
Climate & phenology	Climate inventory	NA	Davey et al. 2006
	Climate trends	1901-2012	Monahan and Fisichelli 2014a and 2014b
	Phenology trends	1901-2012	Monahan et al. 2016
Soundscape	Model predictions	NA	NPS Natural Sounds & Night Skies Division
Lightscape	Model predictions	NA	NPS Natural Sounds & Night Skies Division
Geology	Bedrock map	NA	NPS
Soil	Soil map	NA	USDA NRCS
	Inventory	1980	Cronan et al. 1981
	Forest soil chemistry monitoring	2006-present	NPS NETN
Water quantity and quality	Inventory and sampling	1980	Cronan et al. 1981
	Baseline report	2005	NPS 2005
	Monitoring	2006-present	NPS NETN
	Legacy monitoring	1982-1998	SAGA
	Bathymetry	2013	NPS NETN
Streams-macroinvertebrates	Index	1997-2004	SAGA

Table 2-3 (continued). Datasets identified for assessing natural resource condition at Saint-Gaudens National Historic Site.

Natural Resource or Issue	Data Type	Year(s) Collected	Source
Invasive species	Invasive aquatic plant detection and monitoring	2006-present	NPS NETN
	Invasive species early detection (ISED)	2010-present	NPS NETN
	Forest invasive plant monitoring	2006-present	NPS NETN
	Assessment	2017	Redstart Forestry (Musson et al. 2017)
	Gypsy moth monitoring	1993-2006	USDA Forest Service
Wetlands	Natural Resource Evaluation	1980	Cronan et al. 1981
	Wetland delineation	1992	Schweisberg*
	Wetland study	1998	New England Environmental Associates, Inc.
	Wetland study	2014	Sharpe and Farrell 2016
	National Wetlands Inventory	Ongoing	US FWS
Forest vegetation	Monitoring	2006-present	NPS NETN
	FHM Monitoring	1995 – 2003	Cooke 2003
	Forest vulnerability	NA	Fisichelli et al. 2014
White-tailed deer herbivory	Herbivory impacts monitoring	2006-present	NPS NETN
	Regional density estimates	2006-2015	NH FGD (D. Bergeron, personal communication)
Birds	Inventory	1980	Cronan et al. 1981
	Park bird inventory	2001-2002	Faccio 2003
	Forest bird monitoring	2007 –present	NPS NETN
	Detection	Ongoing	eBird

*The Schweisberg (1992) wetland delineation and Yates et al. (in press) bat surveywere not available for inclusion in this assessment.

Table 2-3 (continued). Datasets identified for assessing natural resource condition at Saint-Gaudens National Historic Site.

Natural Resource or Issue	Data Type	Year(s) Collected	Source
Amphibians and reptiles	Inventory	1985-1986	Cook 1986
	Inventory	2001	Cook et al. 2008
	Coverboard monitoring (salamanders)	2010-2015	SAGA
Fish	Inventory	1980	Cronan et al. 1981
	Inventory	1985-1986	Cook 1986
	Inventory	2000	Mather et al. 2003
Bats	Inventory	2002	Chenger
	Inventory	1010	Gates and Johnson 2012
	Survey	2017	Yates et al.*
Terrestrial mammals	Inventory	1980	Cronan et al. 1981
	Inventory	1985-1986	Cook 1986
	Inventory	2004	Gilbert et al. 2008
Vegetation inventory, classification and mapping	Classification and mapping	2003-2005	Gawler and Bowman 2012
	Inventory	1980	Cronan et al. 1981
Landcover	Landcover change	1973-2002	Wang and Nugranad-Marzilli 2009
	Landcover and land use	Ongoing	NPScape

*The Schweisberg (1992) wetland delineation and Yates et al. (in press) bat surveywere not available for inclusion in this assessment.

3. Study Scoping and Design

3.1. Preliminary Scoping

A scoping meeting, held at the park October 6-7, 2016, was attended by Steve Walasewicz (NPS SAGA), Chris Arnott (NPS Northeast Region), Fred Dieffenbach (NPS NETN) and Geri Tierney (SUNY ESF). Recently, SAGA has merged administrative and some other staff with nearby Marsh-Billings-Rockefeller National Historical Park (MABI).

Chris Arnott described the NRCA program goals and methods. Steve Walasewicz presented natural resource concerns for SAGA, summarized in section 2.2.3 herein. Steve Walasewicz then led a tour around the park, including BMD Farm and Pond. Geri Tierney presented a list of proposed indicators of condition to assess for SAGA, which was edited at the meeting as reported below in section 3.2.1. Geri Tierney also presented a preliminary table of existing natural resource data for SAGA, which the group discussed and updated (Table 2-3). After the meeting, Chris Arnott distributed both the proposed Indicator List and the Table of Data to NPS regional and network staff for additional input. In response, Adam Kozlowski (NPS NETN) provided bathymetry data for BMD Pond, Amanda Babson (NPS) provided links to NPS climate and phenology reports, and Marian Norris (NPS Northeast Region) provided links to additional regional water quality datasets.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

This NRCA used the NPS NETN Vital Signs framework to guide selection and reporting of indicators. Starting from the list of 19 Vital Signs recommended for SAGA (Figure 2-2), one indicator of low importance (Visitor Usage) was removed from consideration, and seven additional indicators of interest at SAGA (Visibility and particulate matter, Soundscape, Lightscape, Viewshed, Mammals, Bats, and Terrestrial invertebrates) were added to reach a total of 25 indicators to be assessed herein (Table 3-1). One or more metrics were used to describe the condition of each indicator selected for inclusion.

Table 3-1: Indicators of natural resource condition to be assessed at Saint-Gaudens National Historic Site.

Category	Indicator	Metrics
Air and Climate	Ozone	Ozone concentration, injury to sensitive species
	Acidic deposition & stress	Total N and S wet deposition rates, dry deposition rates
	Visibility & particulate matter	Haze index
	Mercury contamination	Hg concentration in wet deposition
	Climate & phenology	Monthly temperature and precipitation
	Soundscape	Anthropogenic sound pressure level
	Lightscape	Anthropogenic light ratio
	Viewshed	Visual impact
Geology and Soils	Forest soil condition	Nutrient ratios, base saturation
Water	Water quantity	Pond water level and stream discharge
	Water chemistry	Temperature, pH, DO, specific conductance, N, P, ANC
	Streams-macroinvertebrates	Diversity of community
Biological Integrity	Invasive exotic plants	Presence and relative abundance of key species
	Invasive exotic animals	Detections of key pests
	Wetland vegetation	Extent, width and condition of buffer, % cover of invasive plants, qualitative assessment of disturbance and alteration
	Forest vegetation	Forest structural stage, snag abundance, coarse woody debris, tree regeneration, tree condition and forest pests, tree growth and mortality rates
	White-tailed deer	Regional deer population density, browse vegetation impacts
	Fish	Guild species richness, population trends
	Birds	Guild species richness, population trends
	Amphibians and reptiles	Amphibian index of biotic integrity, population trends
	Bats	Guild species richness, population trends
	Mammals	Guild species richness, population trends
	Terrestrial invertebrates	Guild species richness, population trends
Landscapes	Landcover /connectivity	Land cover change, forest patch size distribution
	Land use	Anthropogenic land use, impervious cover

3.2.3. Reporting Areas

The reporting area for this assessment is land lying within the SAGA boundary, excluding agricultural areas, gardens, buildings, roads, and parking areas. Relevant data from areas surrounding the park are included in the assessment of some Vital Signs, but the surrounding land itself is not assessed herein.

3.2.4. General Approach and Methods

Assessment points (also known as reference values) are used to distinguish expected or acceptable condition (i.e., *good condition*) from undesired conditions that warrant concern, further evaluation or management action (Bennetts et al. 2007). Herein, assessment points were drawn from knowledge of ecological integrity, as well as from regulatory or program standards, park management goals, historical data, data from relatively undisturbed sites, predictive models, or expert opinion. When warranted by available information from one or more of these categories, a second assessment point was set to attempt to distinguish conditions that warrant *moderate concern* from *significant concern*. For example, the scientific literature on white-tailed deer browsing impacts on native vegetation in the eastern U.S. suggests that negative impacts on vegetation may be measurable at deer density levels as low as 8 deer/km^2 but that severe impacts are documented at deer densities at or above 20 deer/km^2 (Section 4.4.5). In this case, two assessment points were used.

In a National Historical Site such as SAGA, expected or acceptable condition for ecological integrity may conflict with desired condition for preservation or interpretation of a historical landscape; this potential conflict is evident in Vital Signs such as Land use and Forest vegetation. In these cases, assessment of ecological integrity benchmarks is valuable because it provides a deeper understanding of park condition, as well as a consistent baseline to assess management goals. However, in cases such as these, ratings of *moderate concern* or *significant concern* may not warrant management action. Additional condition reporting based on park management goals may become possible as NETN and park staff progress in development of scorecards that track progress towards park resource management goals.

Trends in condition were determined by a statistical test of significance if sufficient data were available. Unless otherwise specified, an alpha value of 0.10 was used to determine statistical significance.[4]

Confidence in condition status was assigned by considering the quality and depth of the available data, as well as the justification for the assessment points used to determine condition. High confidence was assigned to assessments based on abundant, quantitative data from multiple sites reflecting the range of variation in the park resource, and which relied on well-justified assessment points. Medium confidence was assigned to assessments based on sufficient, quantitative or qualitative data from at least one representative site in or near the park, and which relied on well-justified assessment points. Low confidence was assigned to assessments based on preliminary or

[4] An alpha level of 0.10 is used to balance the competing objectives to 1) avoid type 1 errors and 2) maximize the power to detect trends.

incomplete data, or preliminary or incomplete assessment points. Confidence in trends was based on the length and quality of the dataset and the level of significance of the trend. High confidence in a trend was reserved for datasets containing at least 10 years of quantitative data, while medium confidence in a trend required a dataset that contains at least 8 years of quantitative or qualitative data.

Summary Indicator Symbols

NPS stoplight reporting categories and symbology (Table 3-2) were used to report condition status, trends in condition, and confidence in assessment (see Appendix A). Table 3-3 shows examples for interpreting NPS stoplight symbols. For cases in which confidence in condition status differed from confidence in a trend, confidence in condition status was symbolically presented.

Table 3-2. Indicator symbols used to indicate condition, trend, and confidence in the assessment.

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

Table 3-3. Example indicator symbols and descriptions of how to interpret them.

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

4. Natural Resource Conditions

4.1. Air and Climate

To better understand status and trends in air quality affecting national parks, the NPS Air Resources Division (ARD) compiles air quality data from monitoring stations across the nation, and uses these data to estimate air quality metrics and associated condition ratings for all parks within the contiguous U.S. (NPS ARD 2017). Many small parks, such as SAGA, do not contain on-site air monitoring stations; status metrics for these parks are interpolated using data from nearby monitoring stations.

Eight indicators were included to assess condition and trend for Air and Climate:

- Ozone
- Acidic deposition and stress
- Visibility and particulate matter
- Mercury contamination
- Climate
- Soundscape
- Lightscape
- Viewshed

4.1.1. *Ozone*

Description

Ground level ozone is a hazard to human health and to vegetation, particularly to ozone-sensitive species. Ozone is produced by a chemical reaction of nitrogen oxides and volatile organic compounds, from industrial and automobile emissions, in the presence of sunlight during hot summer months. As a result of stricter air pollution control resulting from the Clean Air Act amendments of 1990, ozone levels have been decreasing both nation-wide, and in the northeastern U.S. since 1990 (US EPA 2017). In 2015, the US EPA strengthened ozone pollution control by lowering the national ozone standard to 70 ppb, in recognition of increasing scientific evidence that damage to both human health and ecosystems was occurring at ozone levels below the previous standard (75 ppb).

A vegetation risk assessment of ozone injury at SAGA determined a low risk due to low regional ozone exposure (NPS 2004). Ozone-sensitive plant species present at SAGA are shown in Table 4-1. Thirteen of these species are considered bio-indicator species, in which leaf damage from ambient ozone concentrations can be easily recognized.

Table 4-1. Ozone-sensitive plant species at Saint-Gaudens National Historic Site, including bio-indicator species (NPS 2017a). Dashes indicate that the species is not a bio-indicator.

Common name	Latin name	Bio-indicator species
Boxelder	*Acer negundo*	Yes
Red maple	*Acer rubrum*	–
Groundnut	*Apios americana*	Yes
Spreading dogbane	*Apocynum androsaemifolium*	Yes
Hemp dogbane	*Apocynum cannabinum*	–
Wild sarsaparilla	*Aralia nudicaulis*	–
Poke milkweed	*Asclepias exaltata*	Yes
Swamp milkweed	*Asclepias incarnata*	–
Common milkweed	*Asclepias syriaca*	Yes
Yellow birch	*Betula alleghaniensis*	–
Paper birch	*Betula papyrifera*	–
Devil's darning needles	*Clematis virginiana*	–
Beaked hazelnut	*Corylus cornuta*	Yes
White ash	*Fraxinus americana*	Yes
Black ash	*Fraxinus nigra*	–
Eastern white pine	*Pinus strobus*	–
Sycamore	*Platanus occidentalis*	Yes
Bigtooth aspen	*Populus grandidentata*	–
Quaking aspen	*Populus tremuloides*	Yes
Pin cherry	*Prunus pensylvanica*	Yes
Black cherry	*Prunus serotina*	Yes
Chokecherry	*Prunus virginiana*	–
Allegheny blackberry	*Rubus allegheniensis*	Yes
Bramble	*Rubus cuneifolius*	–
Pussy willow	*Salix discolor*	–
Basket willow	*Salix purpurea*	–
Silky willow	*Salix sericea*	–
Canada goldenrod	*Solidago canadensis*	–

Data and Methods

NPS ARD compiles ozone data to assess condition based on five-year average concentrations for protection of both human health and vegetation, and to assess ten-year trends (NPS ARD 2013, NPS ARD 2017). The ozone monitoring station nearest to SAGA is located at Lebanon Airport in Grafton County, NH, 16 km (10 miles) north of the park. This status assessment was based on interpolated

NPS ARD estimates of average ozone concentrations at SAGA for the five-year period 2011-2015 (NPS ARD 2017).

Assessment Points

NPS ARD assesses ozone condition in national park units separately for protection of human health and for protection of vegetation (Table 4-2; NPS ARD 2015, NPS ARD 2017). For the former, the assessment points shown in Table 4-2 are tied to the primary National Ambient Air Quality Standard for ground-level ozone set by the US Environmental Protection Agency (US EPA) based on human health effects. To better assess ozone condition relevant to ozone-sensitive vegetation, NPS ARD has developed the W126 metric, a biologically based cumulative exposure index. This metric sums weighted ozone concentrations over daylight hours during the growing season. Assessment points for the W126 metric are derived from recorded impacts to sensitive vegetation (US EPA 2014). An ozone risk assessment for NETN suggested a W126 assessment point of 5.9 ppm-hrs to protect highly sensitive species in the network (NPS 2004), which is slightly lower than the current NPS ARD assessment point.

Table 4-2. Ozone condition assessment points rating developed by NPS Air Resources Division (2015).

Metric	***Good Condition***	***Moderate Concern***	***Significant Concern***
Human health: Ozone concentration* (ppb)	<= 60	61 - 75	>= 76
Vegetation: W126** (ppm-hrs)	< 7	7 - 13	> 13

*Estimated five-year average of annual 4th-highest daily maximum 8-hour concentration.

**Estimated five-year average of the maximum 3-month 12-hour W126.

Condition and Trend

Interpolated average five-year (2011-2015) ozone concentration at SAGA warranted *moderate concern* for human health, and showed *good condition* for vegetation health (Table 4-3, NPS ARD 2017). NPS ARD did not determine trends for SAGA; ten-year (2000-2009) trends in the W126 metric at nearby national park units range from unchanging to significantly improving (Figure 4-1; NPS ARD 2013).

Table 4-3. Five-year (2011-2015) average values and ratings for ozone condition at Saint-Gaudens National Historic Site (NPS Air Resources Division 2017).

Metric	**5-yr average**	**Rating**
Human health: O_3 concentration (ppb)	60.4	Moderate concern (61-75)
Vegetation: W126 metric (ppm-hrs)	3.5	Good condition (<7)

Level of Confidence and Data Gaps

Confidence in status assessment based on long-term quantitative data interpolated from off-site ozone monitors is medium. Park trends were not determined, and confidence in regional trend is medium.

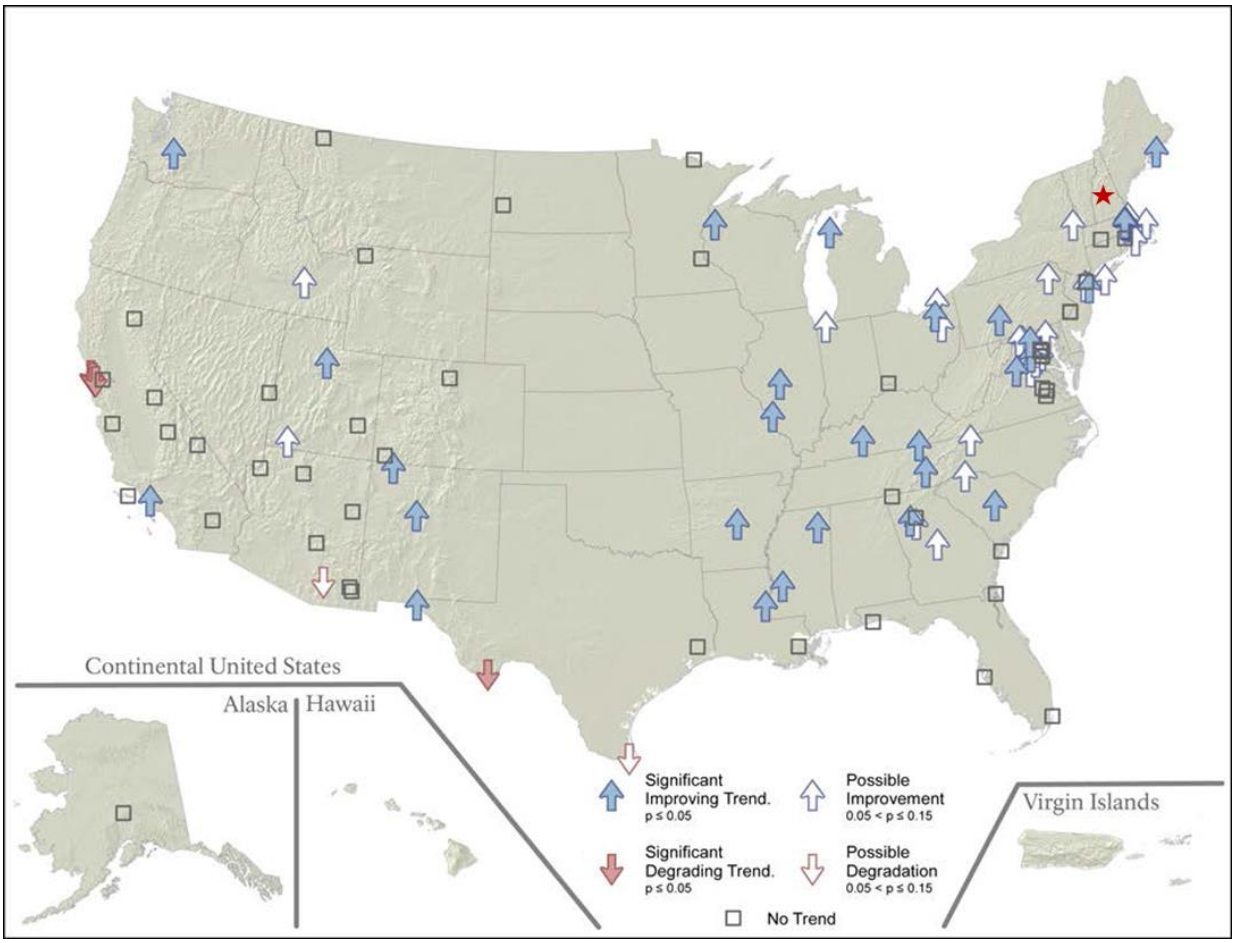

Figure 4-1. National trends in the ozone W126 metric, 2000–2009 (excerpted from NPS Air Resources Division 2013). Red star shows approximate location of Saint-Gaudens National Historic Site.

4.1.2. Acidic Deposition & Stress

Description and Relevance

Emissions of sulfur (S) and nitrogen (N) from power plants, factories, automobiles and other sources have dramatically altered precipitation chemistry in many regions, particularly the northeastern U.S. (Driscoll et al. 2001). Atmospheric deposition of S and N has contributed to acidification of soils and surface waters, export of nutrient cations (Ca, Mg, etc.), and mobilization of aluminum (Al; a toxin) in soils (Likens et al. 1996, Ruess and Johnson 1985). In addition, S deposition can stimulate microbes to transform mercury (Hg) into a toxic, bioavailable compound (methyl mercury, MeHg; US EPA 2008). N is a limiting nutrient necessary for plant growth that has historically been retained within northeastern forested ecosystems. As atmospheric deposition has increased N inputs by five- or ten-fold in the northeastern U.S., concern has arisen that excess N may “saturate” forested

ecosystems, causing excess nitrification and N leaching which in turn would exacerbate the effects of acidification (Aber et al. 1998).

Broad-scale patterns of wet deposition across the northeast are well characterized and are most substantial at high elevations and in the southern and western parts of the northeast region (US EPA 2008). Substantial additional acidity can result from dry and occult deposition, and these patterns of deposition are not well characterized (NPS ARD 2013). Since passage of the 1990 Clean Air Act Amendments, wet deposition of S has decreased 35% or more across the eastern U.S., while wet deposition of N changed little in the 1990s, but generally has decreased since 2000 (US EPA 2008).

Sullivan et al. (2011a) assessed ecosystem sensitivity to acidification for NPS I&M park units based on vegetation, lakes and streams within the park. SAGA was found to have very high ecosystem sensitivity, moderate pollutant exposure and moderate park protection yielding an overall **high risk from acidic deposition**. Sullivan et al. (2011b) also assessed sensitivity to nutrient N enrichment for park units based on sensitive vegetation and lakes. SAGA was found to have very low ecosystem sensitivity and moderate pollutant exposure, yielding an overall **very low risk from N enrichment**.

Data and Methods

NPS ARD assesses condition of wet deposition from National Atmospheric Deposition Program (NADP) data as an indicator of acidic deposition and stress on natural ecosystems in national park units across the nation, including SAGA (NPS ARD 2017). Condition is calculated using normalized 30-year precipitation values in order to reduce the influence of yearly variations in precipitation on results. For parks without onsite monitoring stations, park values are interpolated from nearby stations. The closest NADP sites for monitoring wet deposition are located 90 km (55 miles) northeast of SAGA at Hubbard Brook, NH (NH02), and 100 km (60 miles) southwest of SAGA in Bennington, VT (VT01). NPS ARD has determined trends in wet deposition for a subset of park units which did not include SAGA (NPS ARD 2013).

NPS ARD has not assessed dry deposition since data availability is more limited (NPS ARD 2013). The closest Clean Air Status and Trends Network (CASTNET) monitoring sites for monitoring dry deposition are located about 75 km (50 miles) southwest of the park at Lye Brook in Bennington County, VT, and at Hubbard Brook, NH.

Assessment Points

NPS ARD has set condition assessment points for N and S wet deposition as shown in Table 4-4. However, if park ecosystems are ranked “very high” in sensitivity to acidification or nutrient enrichment, wet deposition condition ratings are adjusted up to the next worse category (NPS ARD 2015). SAGA was found to have very high ecosystem sensitivity to acidification and very low ecosystem sensitivity to nutrient enrichment. Accordingly, condition ratings for total S wet deposition were adjusted one category higher from those assigned based on concentration, while condition ratings for total N wet deposition were not adjusted (Sullivan et al. 2011a and 2011b).

Table 4-4. Wet deposition condition assessment points and rating developed by NPS Air Resources Division (2015).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Total N wet deposition (kg/ha/yr)	< 1	1 - 3	> 3
Total S wet deposition (kg/ha/yr)	< 1	1 - 3	> 3

Condition and Trend

NPS ARD has interpolated average five-year (2011-2015) wet deposition rates for SAGA to be 3.0 kg/ha/yr total N (warranting *moderate concern*) and 1.7 kg/ha/yr total S (warranting *significant concern* due to the adjustment based on the park's very high ecosystem sensitivity to acidification; NPS ARD 2017). NPS ARD did not determine trends in wet deposition for SAGA. Ten-year (2000-2009) trends in S and N (combined nitrate and ammonium) wet deposition for other park units of the northeastern U.S. show significantly improving trends (Figures 4-2 and 4-3; NPS ARD 2013) and regional trends are likely to be representative of SAGA.

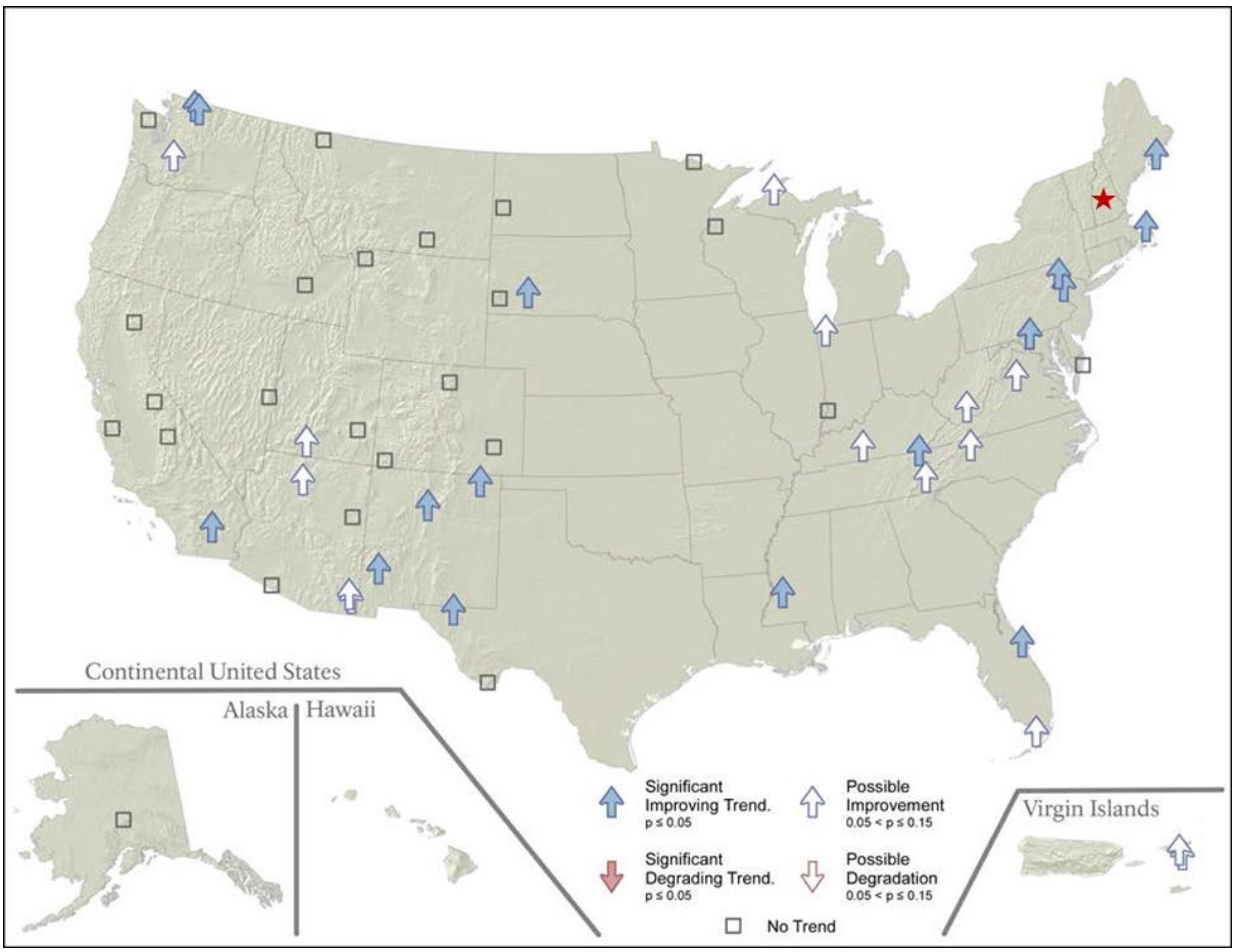

Figure 4-2. National trends in sulfate concentrations in precipitation, 2000–2009 (excerpted from NPS Air Resources Division 2013). Red star shows approximate location of Saint-Gaudens National Historic Site.

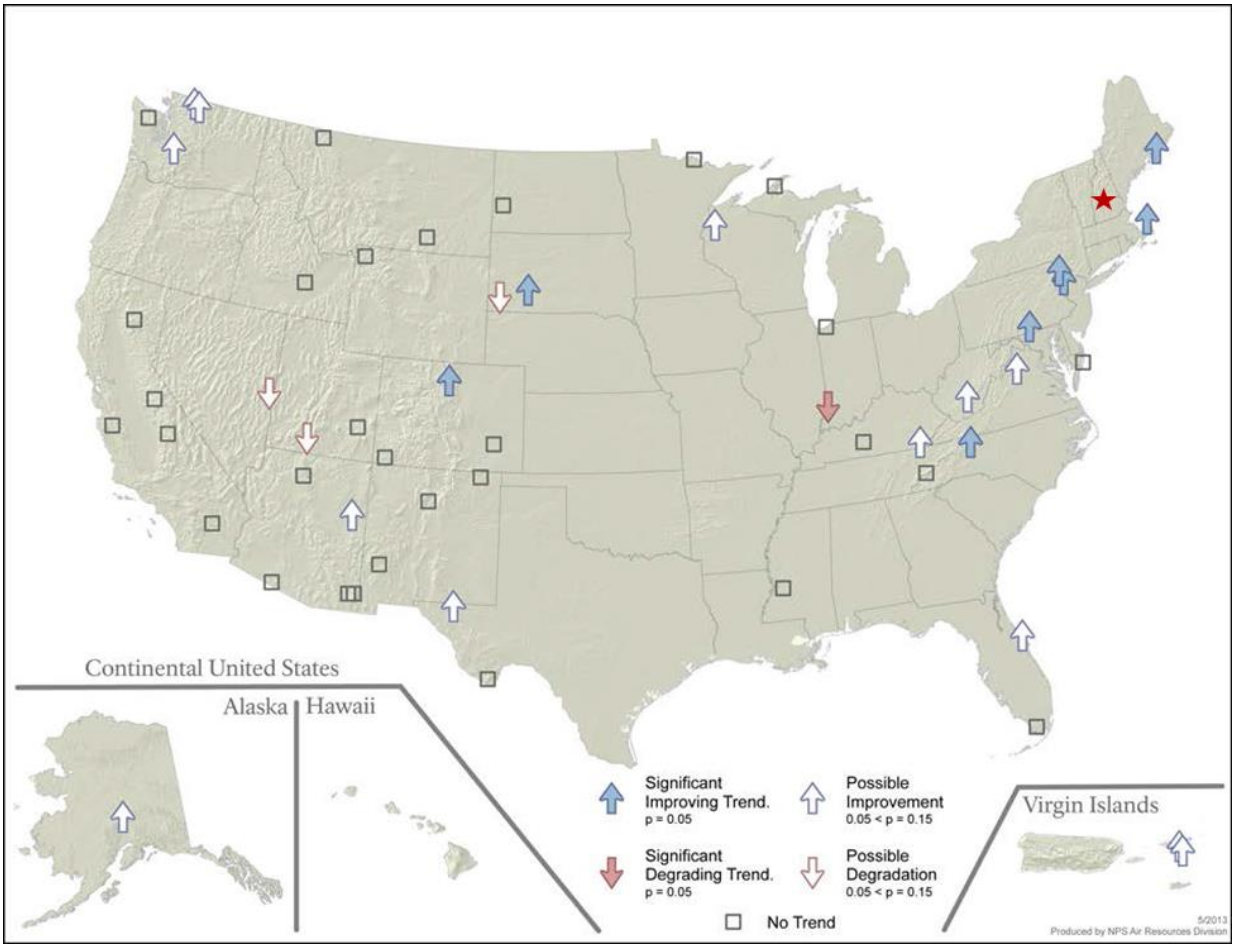

Figure 4-3. National trends in nitrogen concentrations in precipitation, 2000–2009 (excerpted from NPS Air Resources Division 2013). Red star shows approximate location of Saint-Gaudens National Historic Site.

Level of Confidence and Data Gaps

Confidence in status assessment is medium. Data was interpolated from sites more than 75 km (50 miles) away, and complement onsite forest soil and water sampling to increase understanding of acidic deposition stress on park ecosystems. Confidence in regional trends is high.

4.1.3. Visibility and Particulate Matter

Description and Relevance

The ability to clearly see landscape features is important to national park visitors. NPS actively seeks to "protect clean, clear air and spectacular scenery now and for future generations" (Action 37 in NPS 2012). At SAGA, many visitors come to view the park landscape, and appreciate crisp, clear days for landscape viewing. Visibility is a complex concept and is "closely associated with conditions that allow appreciation of the inherent beauty of landscape features" (Malm 1999). Perception of visibility is affected by many factors which can be grouped into four main categories: 1) the optical characteristics of illumination (including sun angle and cloud cover); 2) the physical interaction of light with particles in the atmosphere (via scattering and absorption); 3) characteristics

of the viewed scene or target (color, texture, form and brightness); and 4) psychological processes and value judgments of the observer (Malm 1999).

Regional haze can impair the view by obscuring the color, texture and lines of the viewed landscape. Haze is caused by small (< 10 micron) particles (sulfates, nitrates, organic material, elemental carbon or soot, and soil) suspended in the atmosphere. Fine particulate matter (< 2.5 microns; PM-2.5) have a bigger impact on visibility and human health than coarser particles (2.5 - 10 microns). Particles may originate from natural sources (such as windblown dust or soot from wildfires) or from anthropogenic sources (including farming, traffic, and industry). Some particles are emitted directly into the atmosphere, while others form from chemical reactions in the atmosphere. In recent times, sulfates have been found to contribute 60 to 90% of the visibility degradation in the eastern U.S.; atmospheric concentrations of sulfates are highest during the summer months due to chemical reactions of atmospheric sulfate in the presence of sunlight (Malm 1999).

Data and Methods

Visibility is monitored at a network of sites across the nation by the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring network, including 50 national parks. NPS ARD interpolates visibility estimates for additional national park units, such as SAGA, that do not contain an IMPROVE site. The closest IMPROVE monitoring site is located 75 km (50 miles) southwest of SAGA at Lye Brook in Bennington County, VT.

Three types of measurements are made at IMPROVE sites: view, optical and particle. The visual appearance of a view is qualitatively documented with automatic photographic or video imagery. At some IMPROVE sites, optical monitors measure the ability of the atmosphere to scatter or absorb light. A particle monitor measures the mass and chemical composition of fine (PM-2.5) and coarse (PM-10) atmospheric particles.

NPS ARD has assessed ten-year (2000-2009) trends in visibility at a subset of national park units as the trend in Haze Index on the 20% clearest days and 20% haziest days (NPS ARD 2013). This Haze Index is expressed as deciviews (dv), which represent a linear scale of human-perceived changes in air quality, analogous to the decibel scale for sound. The Haze Index is near 0 dv for a pristine environment, and an increase of 1 dv represents a small but perceptible change in condition regardless of baseline visibility (Pitchford and Malm 1994).

Assessment Points

NPS ARD assesses condition for visibility at national park units using a Haze Index, as the deviation of current estimates of five-year average visibility from estimated average natural visibility in the absence of anthropogenic visibility impairment (Table 4-5; NPS ARD 2015). Interpolated estimates are used to assess condition within the contiguous U.S., and are less accurate in the eastern U.S. due to the scarcity of IMPROVE sites. In the eastern U.S., estimated natural background particulate concentrations yield visual ranges of 100 – 130 km (60 – 80 miles); this range varies across the landscape with topography, vegetation and other landscape features (Malm 1999).

Table 4-5. Visibility assessment points and rating developed by NPS Air Resources Division (2015).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Haze Index (dv)	< 2	2 - 8	> 8

Condition and Trend

At SAGA, NPS ARD estimated the average five-year (2011-2015) Haze Index to be 4.9 dv above natural condition, warranting *moderate concern* (NPS ARD 2017).

NPS ARD did not determine the trend in visibility for SAGA; ten-year (2000-2009) trends in visibility at national park units in New England show significant improving trends (Figure 4-4; NPS ARD 2013). Reductions in sulfur dioxide and nitrogen oxide emissions from electric utilities and industrial boilers, required by the Clean Air Act, have contributed to this improving trend (NPS ARD 2013).

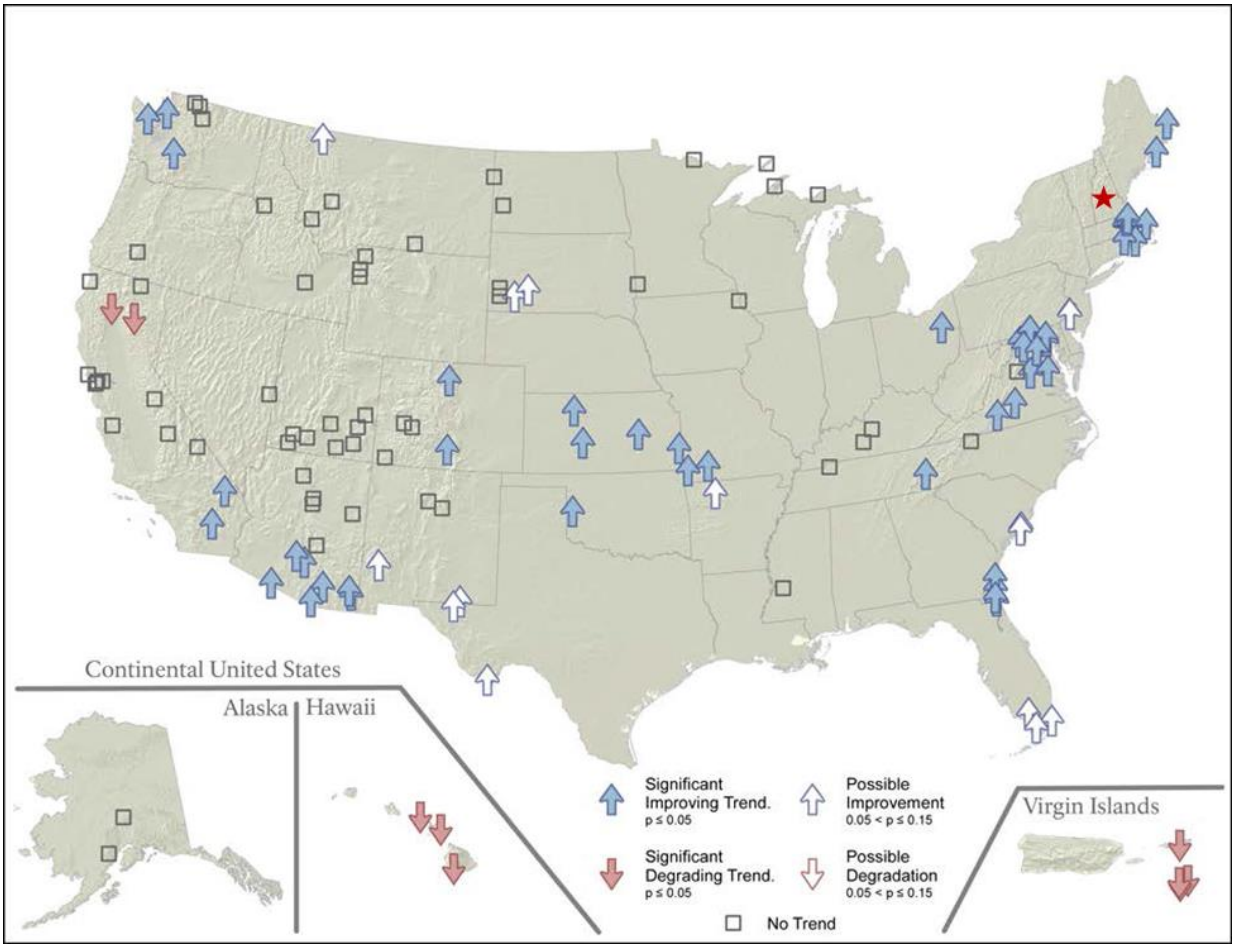

Figure 4-4. National trends in Haze Index on haziest days, 2000–2009 (excerpted from NPS Air Resources Division (2013)). Red star shows approximate location of Saint-Gaudens National Historic Site.

Level of Confidence and Data Gaps

Confidence in visibility condition at SAGA, interpolated from data collected at least 75 km (50 miles) away, is low. Confidence in regional ten-year trends is high. If desired, park staff could use automated, time-lapse photographic monitoring to monitor key landscape scenes at SAGA.

4.1.4. Mercury Contamination

Description

Deposition of heavy metal contaminants was identified as a Vital Sign for NETN parks (Mitchell et al. 2006). Of particular interest is mercury (Hg), an environmental contaminant of concern in aquatic and, more recently, terrestrial ecosystems (Evers et al. 2005, Rimmer et al. 2009). Hg is emitted by coal-burning power plants, solid waste incineration, and other sources. Once in the atmosphere, Hg is widely disseminated and is deposited in both wet and dry form. Atmospheric deposition (both wet and dry) transfers Hg to surface water bodies, where it is transformed by microorganisms in wetland sediments or forest soil into an organic form (methyl mercury, MeHg), a process which can be stimulated by S deposition (US EPA 2008). MeHg is a neurotoxin which bioaccumulates up the food chain, affecting the reproduction, growth, development, and behavior of a variety of organisms including mammals, fish, salamanders, birds, plants, invertebrates and soil microflora.

Data and Methods

Two national networks monitor Hg deposition, both operating under the framework of the NADP: the Mercury Deposition Network (MDN) monitors wet deposition of Hg, and the Atmospheric Mercury Network (AMNet) measures dry and total deposition of Hg. The active MDN site nearest to SAGA is located approximately 120 km (75 mi) northwest in Underhill VT (site VT 99), where Hg wet deposition has been monitored since August 2004. Dry deposition of Hg was also collected at this site from 2008 to 2016. In forest ecosystems, total deposition of Hg is substantially higher than that received from wet deposition alone (Risch et al. 2017).

In order to better understand Hg condition at national parks, NPS has estimated three-year average Hg wet deposition rates at national park units from NADP-MDN data, and has predicted MeHg concentration in surface waters at national park units from relevant surface water characteristics and wetland abundance (NPS ARD 2015). NPS has also determined ten-year trends in Hg deposition at a subset of national park units which did not include SAGA (NPS ARD 2013).

In addition, NPS has developed a citizen scientist monitoring program to develop dragonfly nymphs as biosentinels for Hg in aquatic food webs in parks across the nation. Dragonfly larvae are useful indicators of Hg contamination for two reasons: they bioaccumulate Hg from their prey, and they are an important food source for many species of fish. Since 2011, dragonfly larvae have been collected in BMD Brook and analyzed for Hg concentration (Figure 4-5; Nelson and Flanagan 2013).

Finally, the NPS Hydrographic and Impairment Statistics (HIS) database summarizes information on park hydrologic impairment, including Hg and heavy metal contamination, from state management agencies.

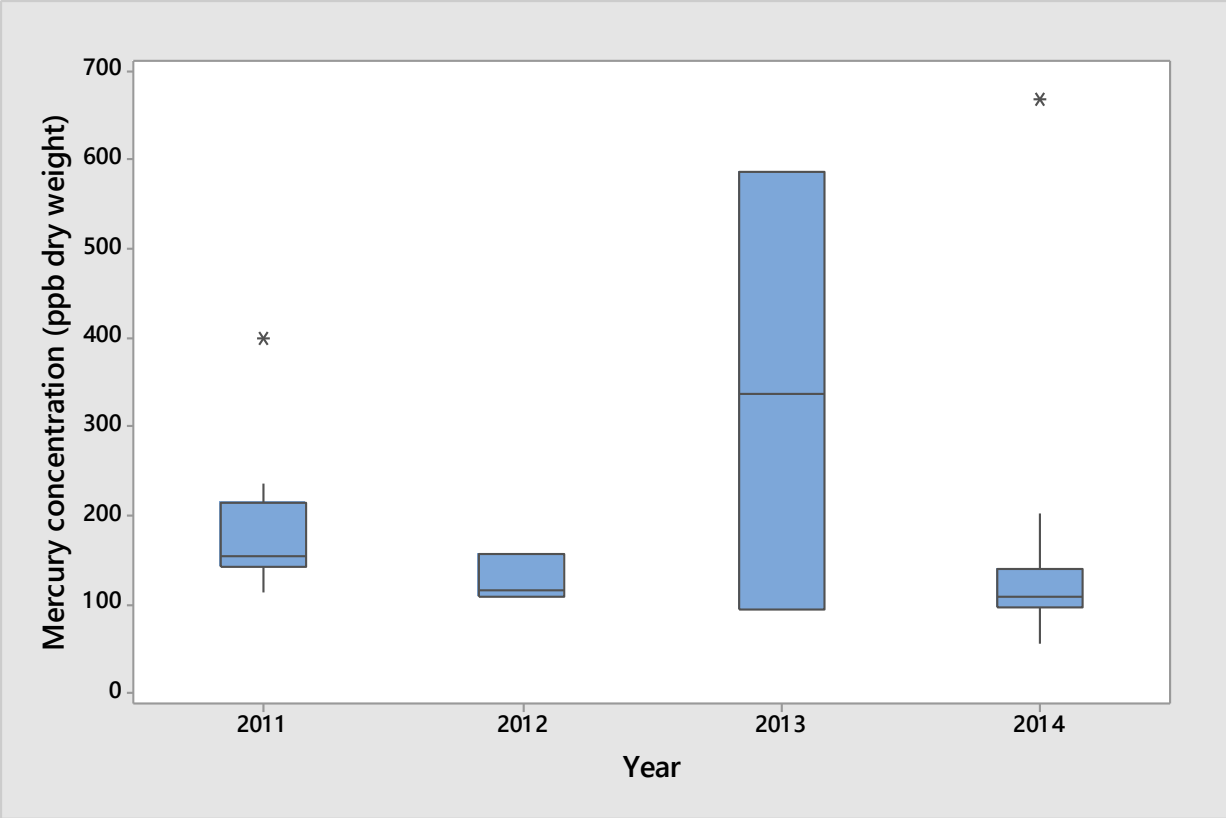

Figure 4-5. Box plot of mercury concentration in dragonfly larvae collected in Saint-Gaudens National Historic Site. The box shows the middle 50% of the data with a line across the box marking the median. Lines extend above and below the box to show the range of the data, with extreme values designated *.

Assessment Points

NPS ARD (2015) has developed draft condition ratings for Hg deposition. The draft Hg status condition assessment is based on two factors: 1) estimated 3-year average Hg wet deposition ($\mu g/m^2/yr$); and 2) predicted surface water meHg concentrations (ng/L) in park surface waters. The combination of these two factors leads to condition ratings of *good condition*, *moderate concern* or *significant concern* as shown in Table 4-6.

Table 4-6. Mercury status assessment matrix developed by NPS Air Resources Division (2015). Green, yellow and red circles indicate, respectively, good condition, moderate concern or significant concern.

Predicted methylmercury concentration rating (ng/L)	**Mercury wet deposition rating (μg/m²/yr)**				
	Very Low < 3	**Low ≥ 3 and < 6**	**Moderate ≥ 6 and < 9**	**High ≥ 6 and < 9**	**Very High > 12**
Very Low **< 0.038**	🟢	🟢	🟢	🟡	🟡
Low **≥ 0.038 and < 0.053**	🟢	🟢	🟡	🟡	🟡
Moderate **≥ 0.053 and < 0.075**	🟢	🟡	🟡	🟡	🔴
High **≥ 0.075 and < 0.12**	🟡	🟡	🟡	🔴	🔴
Very High **>0.12**	🟡	🟡	🔴	🔴	🔴

Condition and Trend

NPS ARD has estimated three-year (2013–2015) wet Hg deposition at SAGA to be low at 5.4 μg/m^2/yr, and has predicted MeHg concentration in park surface waters to be medium at 0.1 ng/L (K. Taylor, personal communication). This combination of values corresponds to a condition rating of *moderate concern* (Table 4-6; NPS ARD 2015). Ten-year (2000-2009) trends in Hg concentration in precipitation are possibly improving at assessed national park units in the northeastern U.S. (Figure 4-6, NPS ARD 2013). Four year trend in Hg concentration in dragonfly larva collected at SAGA is unchanging. In addition, the NPS HIS database reported Hg and Al contamination in BMD Brook in 2014.

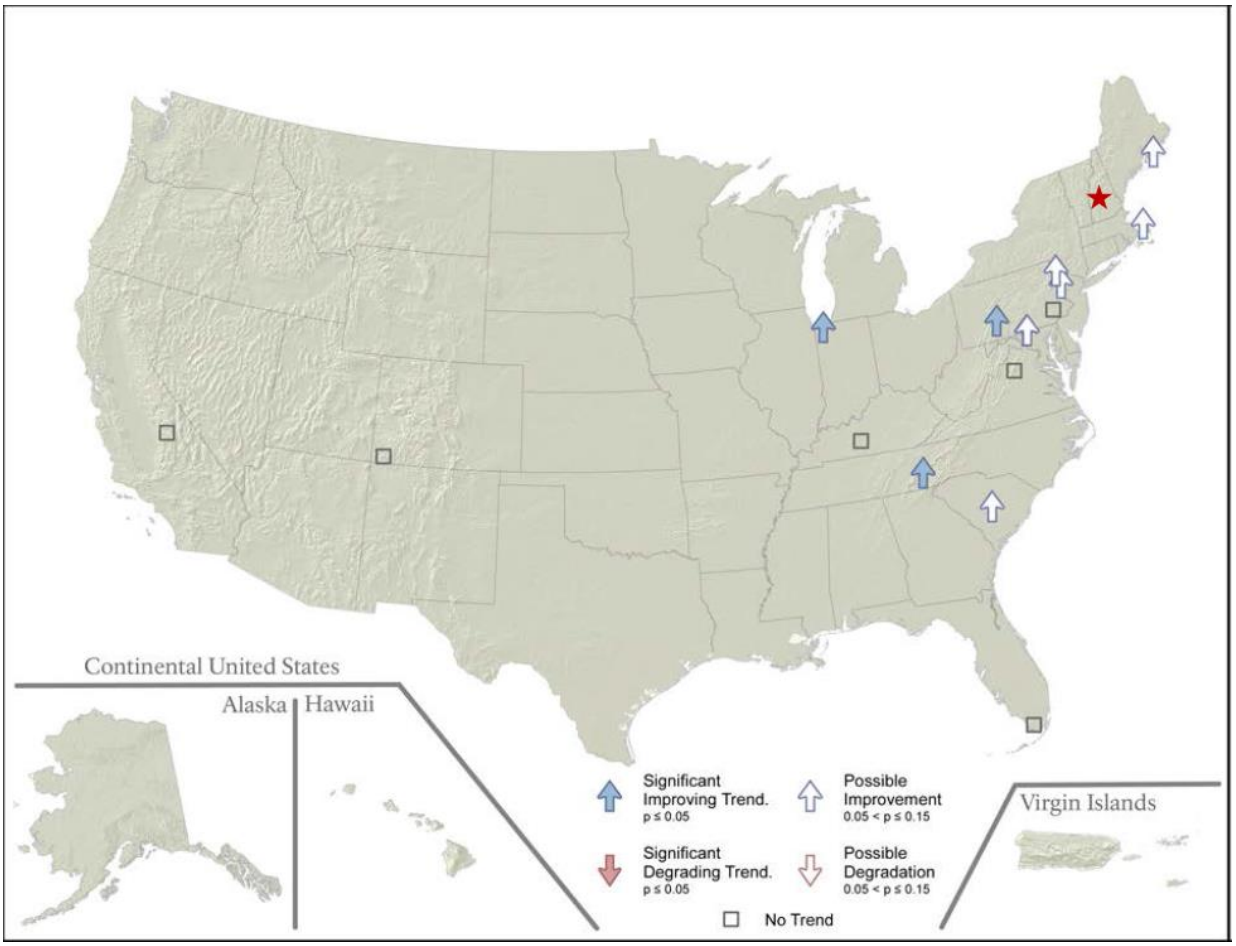

Figure 4-6. National trends in mercury concentrations in precipitation (ng/liter/yr), 2000–2009 (excerpted from NPS Air Resources Division (2013)). Red star shows approximate location of Saint-Gaudens National Historic Site.

Level of Confidence and Data Gaps

Confidence in Hg condition based on interpolated data, models and dragonfly data collected onsite is medium. Confidence in four year trend in Hg concentration in dragonfly larva is low.

4.1.5. Climate

Description and Relevance

Climate is a dominant driver of ecological structure, composition and functional relationships. Anthropogenic climate change is expected to cause "major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity" (IPCC 2007). Former NPS Director Jonathan B. Jarvis stated that "climate change continues to be the most far-reaching and consequential challenge ever faced by our national parks" (NPS 2014b).

It is clear that global warming is occurring (IPCC 2013). Many observed physical and biological changes have already been linked to human-induced warming, including the rise in global average

temperature and changes in phenology of many species (Parmesan and Yohe 2003, IPCC 2007).[5] Modeled future climate scenarios suggest that temperatures across much of the globe, including much of the U.S., will shift outside the range of historical variability by mid-century (Mora et al. 2013).

Data and Methods

Monahan and Fisichelli (2014a) used gridded climate data from the Climatic Research Unit's high-resolution time series to examine 25 climate-related variables over 112 years (1901-2012) at 289 parks across the nation, including SAGA. For each park, the study area included a 30-km (18.6-mi) buffer surrounding the park. They used a moving window analysis at three scales (10-, 20-, and 30-year windows) to characterize each park's historical range of variability (HRV; Figure 4-7), and to compare recent averages to historical conditions, noting extreme current condition (i.e., <5% or >95% percentile compared to HRV).

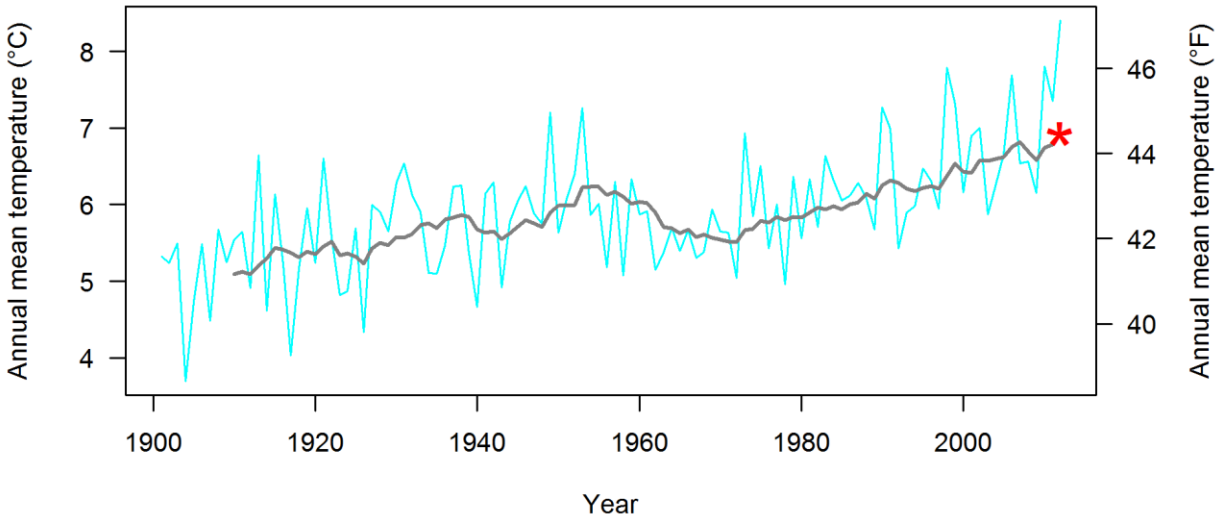

Figure 4-7. Time series used to characterize the historical range of variability and most recent percentile for annual mean temperature at Saint-Gaudens National Historic Site. The blue line shows temperature for each year, the gray line shows temperature averaged over progressive ten-year intervals, and the red asterisk shows the average temperature of the most recent ten-year window (2003–2012).Excerpted from Monahan and Fisichelli (2014b).

Current conditions at SAGA were "extreme warm" for 5 of 7 temperature variables, and "extreme wet" for 6 of 7 precipitation variables (Figure 4-8). No variables showed current condition of "extreme cold" or "extreme dry" (Monahan and Fisichelli 2014a).

[5] Phenology is the study of the timing of recurrent biological events, such as flowering, leaf-out, migration, and hibernation, and provides a simple and straightforward process in which to track changes in the ecology of species in response to climate change.

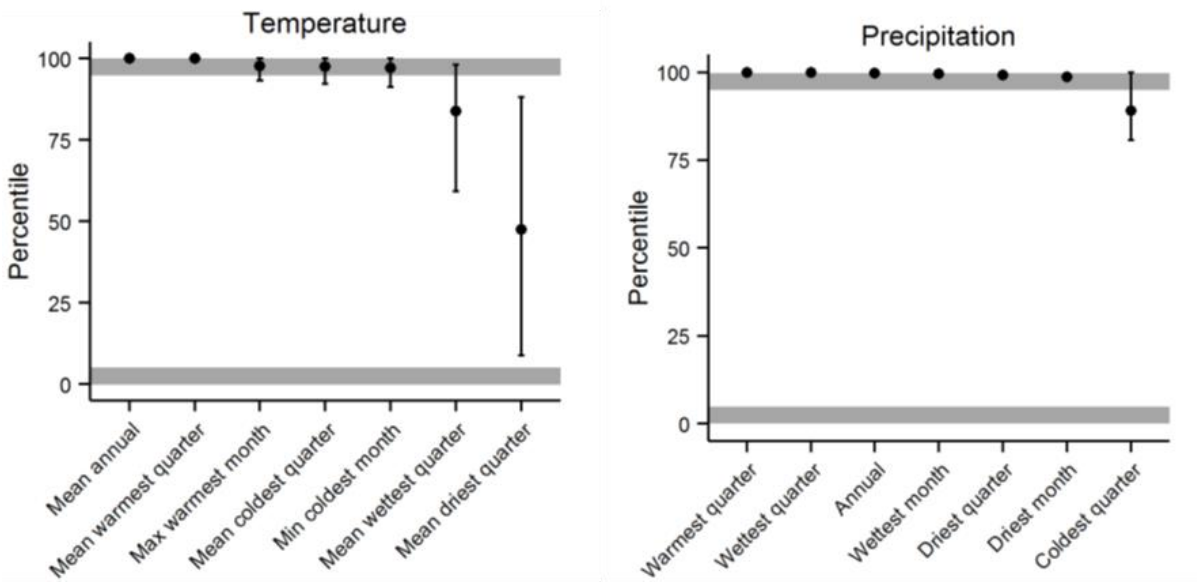

Figure 4-8. Recent temperature and precipitation percentiles at Saint-Gaudens National Historic Site. Black dots indicate average recent percentiles across the 10, 20, and 30-year intervals (moving windows). Variables were considered "extreme" if the mean percentiles were <5th percentile or >95th percentile (i.e., the gray zones). Black bars indicate the range of recent percentiles across 10, 20, and 30-year moving windows. Excerpted from Monahan and Fisichelli 2014b.

Using a similar moving window analysis, Monahan et al. (2016) examined changes in the phenology of spring onset at 276 national parks, including SAGA. They used the "Berkeley Earth" surface temperature dataset to estimate changes in two phenology variables (first leaf and first bloom) for indicator plant species over 112 years (1901-2012). Their analysis indicated that the timing of spring onset was advancing in about three-quarters of national parks considered. In parks lying in the northeast US (from NY to Maine), estimates of both indices (first leaf and first bloom) are "extreme early" (defined as <5% compared to HRV) for almost all parks, including SAGA. The analysis suggested that at SAGA, the first leaf and first bloom indices have been advancing by 1.0 and 0.7 days/decade, respectively.

Fisichelli et al. (2014) investigated potential forest change over the 21st century in response to climate change at 121 national parks, including SAGA. They examined potential changes in tree habitat suitability and uncertainty in potential change under two possible future climate scenarios ("least change" and "major change"). The two scenarios represented an increase in mean annual temperature of 1.9–6.7° C (3.5–12.1° F) and increased precipitation (12 to 21%) at the park over baseline conditions (1961 – 1990). They further examined present levels of nonnative biotic stressors (exotic plants and forest insect pests and diseases). For SAGA, this analysis predicted high levels of forest change, with most (66%) modeled tree species undergoing large change[6] in habitat suitability, and high uncertainty (a 57% difference in the number of tree species undergoing high change

[6] Large change is defined as >50% decrease or >100% increase in habitat suitability.

between the two climate scenarios). Levels of predicted forest change and uncertainty were similar for other parks in the region. Quantification of current biotic stress from nonnative species at SAGA indicated that 16% of plant species found at the park were nonnative, and a high number (43) of exotic forest insects and diseases were present in the park or nearby region. Many forest trees are foundation species, which have a strong role in creating or maintaining habitat for other species, so impacts to these trees will ramify through park ecosystems.

One additional source of data comes from *Connect the Connecticut*, a collaborative effort in sustainable landscape planning spearheaded by the North Atlantic Landscape Conservation Cooperative (NALCC). This project has developed natural resource datasets and planning tools for the Connecticut River watershed with the goal of sustaining ecosystems and populations of native species (see http://connecttheconnecticut.org/). Using a model developed by the anadromous fish lab of the US Geological Survey, they projected persistence of brook trout in headwater streams in response to climate change[7]. In BMU Brook, they projected a probability of 0.48 (out of 1) that brook trout (*Salvelinus fontinalis*) would persist until 2080 under a climate change scenario (McGarigal et al. 2017).

Assessment Points

Assessment points for climate condition have not been determined.

Condition and Trend

Although assessment points for climate condition have not yet been determined, the extent and magnitude of ecosystem impacts expected over the next century under current warming projections warrant *significant concern*.

Level of Confidence and Data Gaps

Confidence in status assessment is low because understanding of ecosystem changes in response to climate change is poor and because assessment points have not been established. Continued monitoring of species phenology in the park will be informative.

4.1.6. Soundscape

Description

Most visitors to national parks seek an experience undisturbed by man-made noise (Haas and Wakefield 1998). Noise can have significant impacts on wildlife, influencing communication, courtship and mating, predation and predator avoidance, and effective use of habitat (NPS 1994, Barber et al. 2010). The natural soundscape is an inherent component of "the scenery and the natural and historic objects and the wildlife" protected by the NPS Organic Act of 1916 (16 USC 1). NPS Management Policies require the NPS to "restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise)," "protect natural soundscapes from unacceptable impacts," and preserve the cultural soundscape "for appropriate

[7] Future climate conditions were an average of the Representative Concentration Pathways 4.5 and 8.5 (IPCC 2013).

transmission of cultural and historic sounds that are fundamental components of the purposes and values for which the parks were established" (§ 4.9 and 5.3.1.7 in NPS 2006). Director's Order 47 (NPS 2000) directs park managers to monitor the park soundscape and manage noise. Parks may be affected by noise sources originating both within the park (due to park equipment and management) as well as outside the park (such as airplane and automobile traffic, and nearby land uses and development).

To understand soundscape condition, it is useful to distinguish between acoustic resources (physical sound sources such as wildlife, waterfalls, wind, rain, and cultural or historical sounds), the soundscape (the human perception of physical sound sources), and the acoustic environment (all acoustic resources, including anthropogenic noise). Clarifying this distinction allows managers to create objectives for safeguarding both the acoustic environment and the visitor experience (NPS NSNSD 2014).

Data and Methods

Soundscape data have not been collected at SAGA. However, using acoustic data collected at 244 sites, the NPS Natural Sounds & Night Skies Division (NSNSD) has developed a geospatial model which predicts both natural and existing ambient sound levels with 270 meter resolution using 109 spatial explanatory layers from seven categories (location, climatic, landcover, hydrological, anthropogenic, temporal, and equipment; Mennitt et al. 2014). Anthropogenic explanatory variables included road density, distance to all roads and major roads, flight frequency observation data, and a naturalness index based upon land use, housing density and traffic. Natural ambient sound level is the acoustical conditions that exists in the absence of human-caused noise and represents the level from which the NPS measures impacts to the acoustic environment (Figure 4-9). Existing ambient sound level is the current sound level in an area, including both natural and human-caused sounds. In addition, the model calculates the difference between these two metrics, providing a measure of impact to the natural acoustic environment from anthropogenic sources. The resulting impact metric indicates how much anthropogenic noise has raised the existing sound pressure levels in a given location (Figure 4-10). Sound pressure levels (SPL) are shown as L_{50} dBA, where L_{50} represents the level that is exceeded 50 percent of the time during a summer day, and dBA is the sound pressure level (amplitude) in decibels (dB) adjusted (weighted) to reflect human hearing sensitivity to frequencies from 1,000 to 6,000 Hz (Turina et al. 2013).

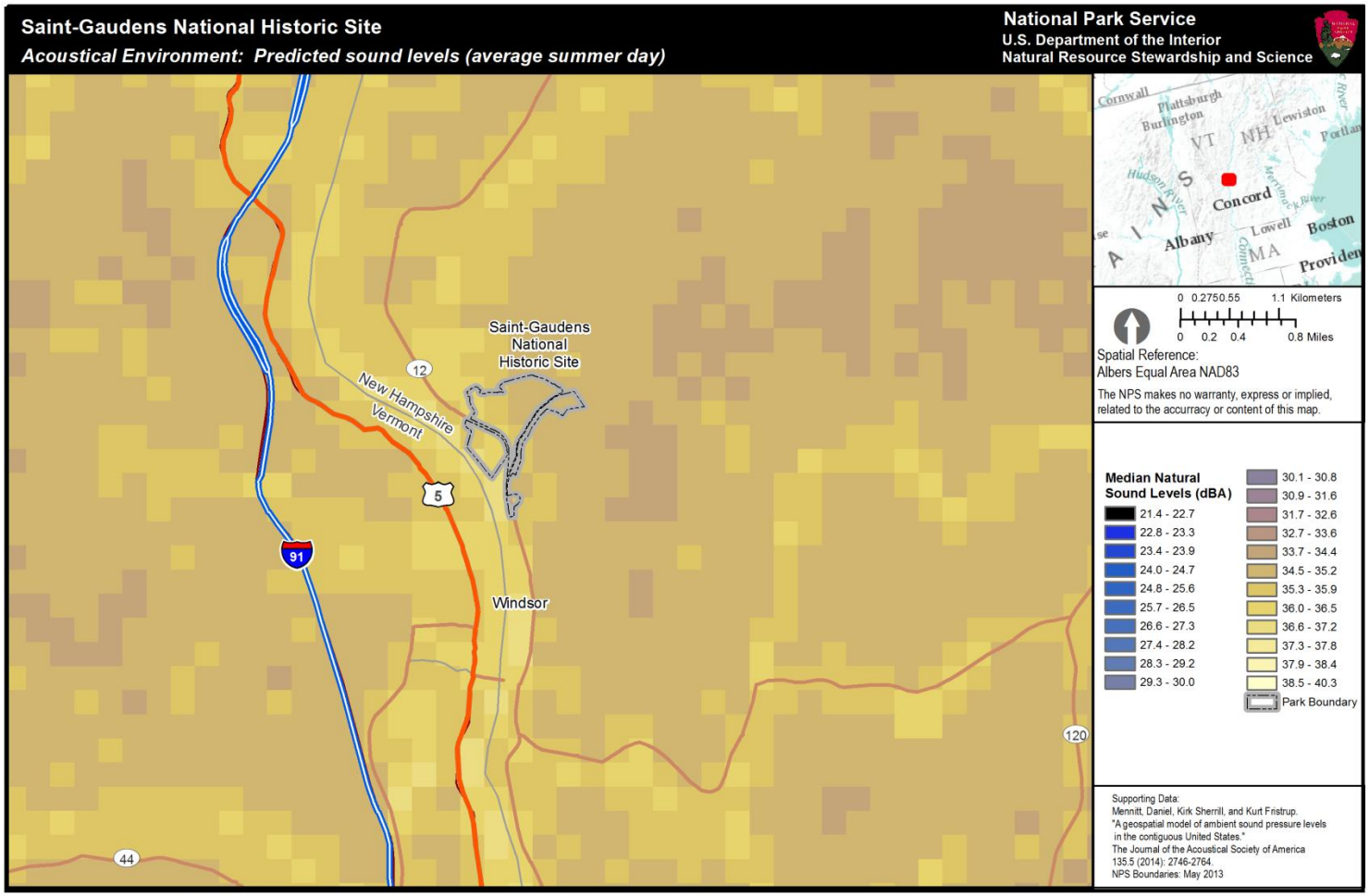

Figure 4-9. Modeled natural ambient sound levels (L_{50} dBA) at Saint-Gaudens National Historic Site range from 34.8 to 36.5 (Figure provided by NPS Natural Sounds and Night Skies Division).

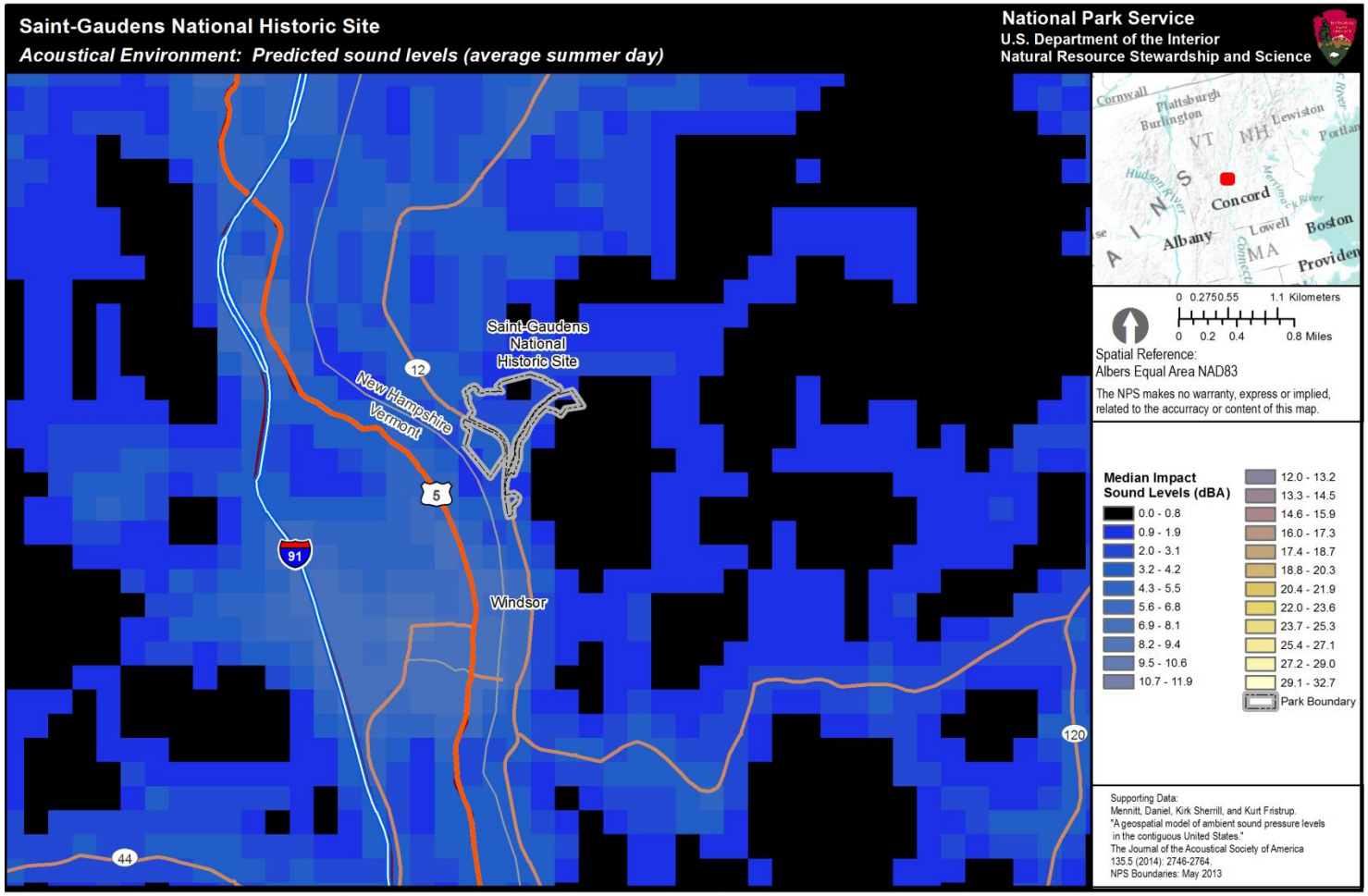

Figure 4-10. Modeled impact sound levels (L_{50} dBA) at Saint-Gaudens National Historic Site range from 0.2 to 3.9 (Figure provided by NPS Natural Sounds and Night Skies Division). Impact sound levels represent alteration to the natural acoustic environment from anthropogenic sources (i.e., noise).

Assessment Points

Soundscape assessment points should address the effects of noise on human health and physiology, wildlife, the quality of the visitor experience, and finally, the inherent value of the acoustic environment (NPS NSNSD 2014). Various characteristics of sound can contribute to how noise affects the acoustic environment. These characteristics include rate of occurrence, duration, amplitude (loudness), pitch, and whether the sound occurs consistently or sporadically. In order to capture these aspects, the quality of the acoustic environment should be assessed using a number of different metrics including existing ambient sound level (measured in decibels), percent time human-caused noise is audible, and noise free interval. Functional effects produced by increases in sound level should also be considered. For example, the *listening area* (the area in which a sound can be perceived by an organism) is reduced when background sound levels increase due to sound masking (Barber et al. 2010).

NPS NSNSD has developed interim guidance to assist parks in assessing soundscape condition (Turina et al. 2013). The suggested assessment points for non-urban parks (Table 4-7) are applicable to SAGA, but may be adjusted to accommodate management objectives and functional effects specific to SAGA. Since each 3 dB increase in background sound level will reduce a given listening area by half, the assessment point between *moderate concern* and *significant concern* corresponds to a 50% reduction in listening area (Turina et al. 2013). This means that a rating of *significant concern* is applied to a park in which anthropogenic noise has increased sound levels enough to reduce by half the area over which a park visitor can perceive sounds.

Table 4-7. Suggested assessment points for Soundscape condition in non-urban parks (Turina et al. 2013).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Mean Impact SPL (L_{50} dBA)	≤ 1.5	1.5 -3.0	≥ 3.0
Corresponding Reduction in Listening Area	≤ 30%	30 – 50 %	≥ 50%

Condition and Trend

Soundscape condition was assessed for SAGA by NPS NSNSD using a modeled dataset (Mennitt et al. 2014). Predicted impact SPL for the park showed an interquartile range (2.3 - 3.2 L_{50} dBA) corresponding to a reduction in listening area within the range of 30 - 50 % and warranting moderate concern. The trend in soundscape condition was not assessed. Nationwide trends indicate that prominent sources of noise in parks (namely vehicular traffic and aircraft) are increasing (US DOT FHWA 2013, US DOT FAA 2010). However, conditions in specific parks may differ from national trends.

Level of Confidence and Data Gaps

Confidence in status assessment is low because this assessment did not incorporate onsite monitoring. Trend was not assessed. Confidence in soundscape assessment could be increased by onsite monitoring. NPS has developed an Acoustical Monitoring Training Manual (NPS NSNSD

2013) which provides guidance to park managers seeking to define park acoustical zones, select sounds and sites of interest for monitoring, deploy and maintain automated recorders and meteorological instruments, collect data, conduct on-site listening sessions, and analyze acoustical data. A useful first step is to develop an inventory of audible sounds to better understand what sounds presently contribute to the acoustic environment, which are the most common, and which could possibly threaten the quality of the acoustic environment. Inventory data can be collected simply by a single, focused listener in calm weather conditions during a series of listening sessions in several different locations and across different times of day to capture spatial and temporal variation in acoustic conditions (Lynch et al. 2011).

4.1.7. Lightscape

Description

Visitors to the national parks are able to enjoy star-gazing amid the natural darkness protected within the parks. In addition to having a substantial impact on the quality of the visitor experience, natural darkness has ecological value to many species, including those which use darkness to evade predators or which navigate using patterns of light and dark. NPS uses the term "natural lightscape" to describe resources and values that exist in the absence of anthropogenic light at night. The natural lightscape can be compromised by light pollution from sources both within and outside the national parks. NPS management policies require the NPS to “preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light” (§ 4.10 in NPS 2006). The Springfield Telescope Makers, a club of telescope and astronomy enthusiasts, has met at SAGA annually in recent years for star-gazing.

Data and Methods

Lightscape data has not been collected at SAGA; however, modeled data were provided by the NPS NSNSD (Figure 4-11). Using data from the 2001 World Atlas of Night Sky Brightness (Cinzano et al. 2001), NSNSD scientists have modeled a measure of anthropogenic light pollution across the contiguous U.S. This measure, called the anthropogenic light ratio (ALR), is a measure of how much total nighttime sky brightness is elevated over natural nighttime light levels across the entire sky. ALR is calibrated such that a ratio of 0.0 indicates pristine conditions of natural light, while a ratio of 1.0 indicates a sky 100% brighter than a natural sky. Average natural sky luminance is 78 nL (nanolamberts; Moore et al. 2013).

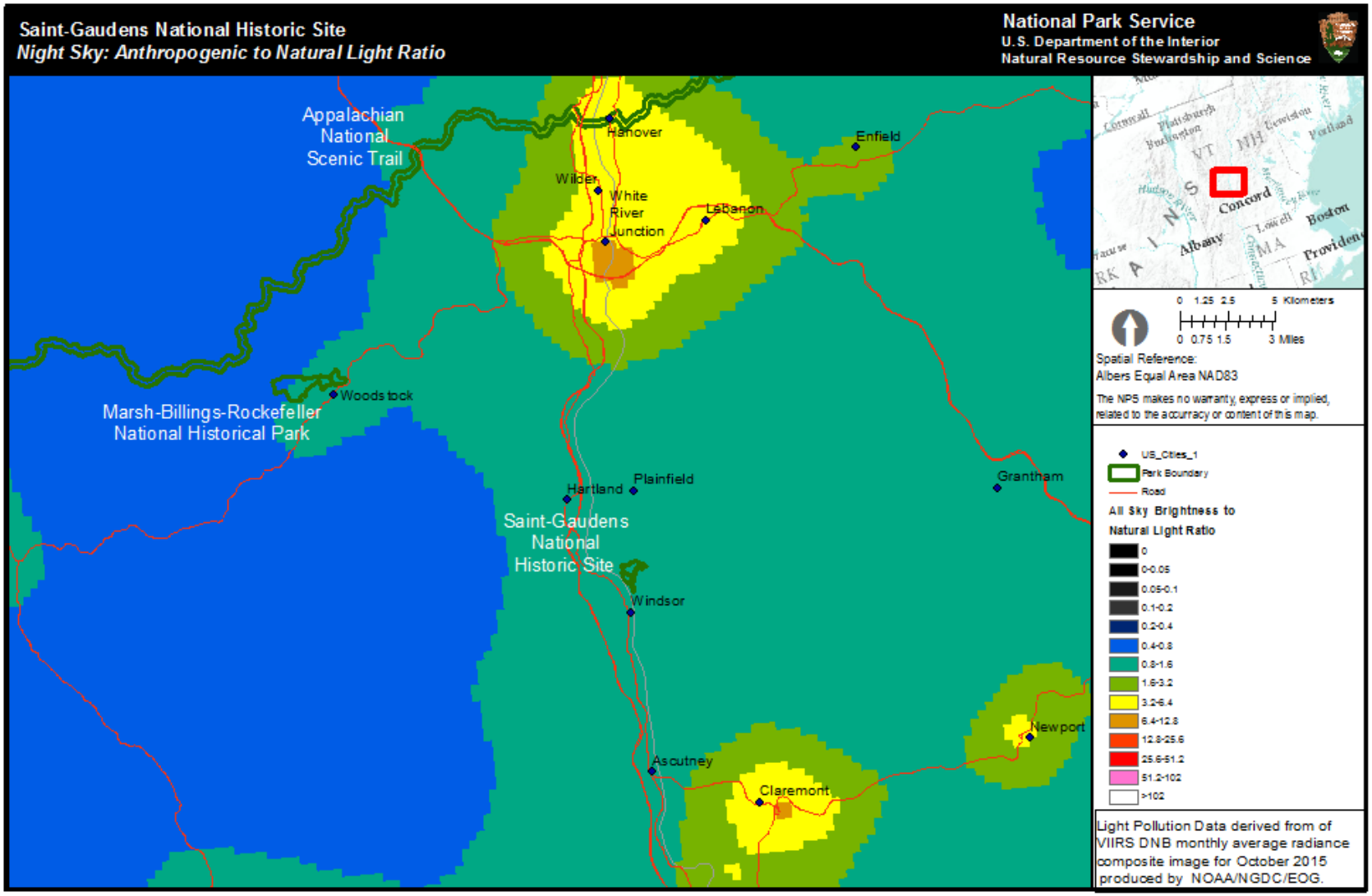

Figure 4-11. Local view of anthropogenic light near SAGA. Warmer colors represents more environmental influence from artificial lights, while cooler colors represent less artificial light (Figure provided by NPS NSNSD).

Assessment Points

Lightscape assessment points should consider park management objectives and wilderness status and the impact of light pollution on sensitive species or species of concern. Ideally, condition would be assessed from several lightscape metrics such as maximum vertical illuminance, horizontal illuminance, spectral characteristics, and impacts to wildlife species of concern (Moore et al. 2013).

NPS NSNSD has developed interim guidance to assist Park units in assessing lightscape condition using a single metric (ALR). The suggested assessment points for non-urban parks are applicable to SAGA (Table 4-8). The assessment point between *good condition* and *moderate concern* represents a 33% increase in luminance over a natural sky, and corresponds to a threshold at which the human eye is unable to fully adapt to the dark and some visual sensitivity is lost. The assessment point between *moderate concern* and *significant concern* represents a 200% increase in luminance over a natural sky, and corresponds to a level at which the Milky Way is not fully visible, and full adaptation to darkness is no longer possible by the human eye (Moore et al. 2013).

Table 4-8. Suggested assessment points for lightscape condition in non-urban parks (Moore et al. 2013).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Median ALR	≤ 0.33	0.33 - 2.0	≥ 2.0

Condition and Trend

The modeled median ALR value at SAGA was 1.05, indicating that anthropogenic light was more than 100% brighter than the natural light from the night sky (NPS NSNSD, unpublished data). This corresponds to a rating of *moderate concern.* At these light levels, the Milky Way is visible but has typically lost some of its detail and is not visible as a complete band. Zodiacal light (or "false dawn" which is faint glow at the horizon just before dawn or just after dusk) is rarely seen. Anthropogenic light likely dominates light from natural celestial features and shadows from distant lights may be seen. The trend in lightscape was not assessed.

Level of Confidence and Data Gaps

Confidence in lightscape condition at SAGA is low, because assessment was made from modeled data and did not incorporate onsite monitoring. Trend was not assessed. Confidence could be increased by onsite monitoring of lightscape parameters, including maximum vertical illuminance, horizontal illuminance, spectral characteristics, impacts to wildlife species of concern, measures in certain quadrants of the sky, and qualitative indices (Moore et al. 2013). NPS has developed a protocol for monitoring park lightscape using automated digital photography (Duriscoe et al. 2007). Alternatively, citizen scientist monitors may be engaged to monitor lightscape using simple star counts, such as in the Globe at Night Program (www.globeatnight.org).

4.1.8. Viewshed

Description

NPS is mandated to preserve parks unimpaired for the enjoyment of future generations, and this mandate includes the conservation of scenery (NPS Organic Act). Indeed, visitors to national parks

overwhelmingly report that scenic views are an important component of the visitor experience (Kulesza et al. 2013). Viewshed provides a useful concept for understanding, and is defined simply as the areas visible from a given observation point.

At SAGA, the site's significance is enhanced by the rural character of the surrounding land that attracted and inspired Saint-Gaudens and the artists of the Cornish Colony. Spectacular views from park's historic core extend west across the Connecticut River to Mt. Ascutney in Vermont, and views east from the historic core to adjacent farm land contribute to the rural character of the site (NPS 2013). These views provided great inspiration to Saint-Gaudens and other artists of the Cornish colony and are considered crucial elements of the site's landscape and history (NPS 1996, NPS 2010b). Part of Mt. Ascutney is protected from development as Vermont's Mount Ascutney State Park. However, the construction of television towers and U.S. Route 91 have altered the landscape viewed from SAGA. It is NPS policy to work collaboratively with state and local partners to protect this viewshed, including opposing construction of any structure visible along the ridgeline west or south of the park that significantly affects views from the park (NPS 1996). Within SAGA, the growth of trees on the south side of Saint Gaudens Road and west of the park's historic core since the 1950s have blocked views of the lower slopes of Mt. Ascutney and the VT ridgeline extending north (NPS 2010b).

Data and Methods

Data were not available to assess Viewshed at SAGA.

Assessment Points

Viewshed reference conditions have not been determined. However, materials from the NPS Visual Resources Program (VRP) may provide guidance in determining impacts to park viewsheds. Assessment of viewshed impacts involves understanding both the important visual qualities and character of the landscape within the project viewshed, and the visual experience of visitors observing the viewshed from key observation points (Sullivan and Meyer 2014).

Condition and Trend

Data were not available to determine condition and trend of Viewshed at SAGA.

Level of Confidence and Data Gaps

Viewshed at SAGA is a data gap that could be filled using methods provided by the NPS VRP. [8] A first step would be to conduct an inventory of important views from key observation points within the park, including a systematic description of the visual elements of important views both within and outside the park boundary, and assessments of their scenic quality and importance. Once views are inventoried, park staff could set appropriate resource management objectives, and use automated, time-lapse photographic monitoring to monitor key views. This dataset would provide a useful baseline to evaluate future risks or threats to the resource and to promote protection of the viewshed.

[8] NPS VRP resources are found at http://blmwyomingvisual.anl.gov/vr-overview/nps/

4.2. Geology and Soils

One indicator was included to assess condition and trend for Geology and Soils:

- Forest soil condition

4.2.1. Forest Soil Condition

Description and Relevance

Soil provides the foundation upon which forest ecosystems exist, providing physical structure for anchorage and fine root growth, as well as nutrients and water for tree growth and maintenance. Forest soil condition is affected by physical disturbance from timber harvest, fire, or trampling, as well as by atmospheric deposition of acidic inputs and other contaminants (Driscoll et al. 2001, Aber et al. 2003). Soil nutrient cycling is also affected by prior land use, weathering of parent material, and by tree species growing on the site, and by interaction of these factors. Tree species vary in their influence on soil nutrient cycling, particularly with respect to N cycling (Finzi et al. 1998, Lovett and Mitchell 2004). The impacts of atmospheric deposition are of particular concern in the northeastern U.S., affecting both terrestrial and aquatic ecosystems. Al leached from forest soils by atmospheric inputs enters lakes and streams where it causes toxic impacts to fish and other aquatic organisms.

Data and Methods

Since 2006, NETN has collected composite soil samples from 21 permanent forest plots at SAGA (Miller et al. 2014). Soil samples were separated by horizon (O and A) if possible, dried and analyzed for pH, organic matter (as loss on ignition; % LOI), percent total N (% TN) and total carbon (% TC) by combustion, exchangeable acidity in potassium chloride, and exchangeable cations in ammonium chloride (see Miller et al. [2014] for detailed methods). Percent base saturation (% BS) was calculated from milliequivalent levels of base cations and acidity.

Condition was determined from the recent full data cycle collected (2010-2012), using either the A horizon or the upper 10 cm collected if horizons were not evident, except for C/N and Ca/Al ratios which considered the minimum ratios obtained from any horizon. Trends were not determined due to differences in soil collection methods between the recent and initial (2006-2008) data cycles. Since 2014, the NETN soil sampling schedule has been spread out over a longer (12-year) return interval (K. Miller, personal communication).

Assessment Points

NETN rated soil chemistry based on the ratio of exchangeable calcium to aluminum (Ca:Al), developed as an indicator of acid stress on forest soils, and the ratio of total C to total N (C:N), a primary indicator of nitrogen status as shown in Table 4-10 (Cronan and Grigal 1995, Aber et al. 2003, Miller et al. 2014). Percent base saturation (%BS) is considered here as a complementary indicator of acid stress (Cronan and Schofield 1990). The US Department of Agriculture Forest Service (USDA FS) has developed a detailed Soil Quality Index (SQI) that integrates multiple physical and chemical properties of forest soils for use in interpreting Forest Inventory and Analysis (FIA) data (Amacher et al. 2007). SQI assessment points were considered to interpret condition for soil characteristics in addition to those rated in Table 4-9.

Table 4-9. Assessment points for forest soil condition. See text for description.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Calcium : Aluminum	> 4	1 - 4	< 1
Carbon : Nitrogen	> 25	20 - 25	< 20
% Base saturation	>15%	10-15%	<10%

Condition and Trend

Analysis of soil pH showed that most forest plots at SAGA had moderately acid soil (Table 4-10). TN was adequate for plant nutrition, and TC was adequate to excellent. Low C:N ratio indicated forest soils at SAGA warranted *significant concern* for vulnerability to N saturation (Table 4-11), though N deposition rates at SAGA (reported in section 4.1.2 herein) fell below threshold rates for predicted onset of N saturation (5-18 kg N/ha/yr; Aber et al. 2003). Base cation status was low for potassium (K), magnesium (Mg), manganese (Mn), and zinc (Zn) indicating possible deficiencies. Al toxicity may be a problem to sensitive vegetation at most plots, and to a wider range of plants at plots with the highest Al values. Ca:Al ratios indicated *moderate concern* for acidification. Percentage of forested plots invaded by earthworms (57%) in the most recent available data (2014-2016) increased over the initial data cycle (21% in 2006-2008). Notably, *Amynthas agrestis* (crazy snake worm or Asian jumping worm) was detected in the park in 2017 (K. Jones, personal communication).

Table 4-10. Soil chemistry data from 21 permanent forested Northeast Temperate Network plots at Saint-Gaudens National Historic Site sampled 2010-2012. Interpretation follows the USDA FS Soil Quality Index (Amacher et al. 2007), unless otherwise cited. Cation values are g/kg sample.

Characteristic	Min	Median	Max	Interpretation
pH	3.7	4.8	6.6	Moderately acid (4.01 to 5.5)
% TN	0.06	0.14	0.69	Moderate (0.1 to 0.5)
% TC	1.2	2.5	11	Moderate (1-5) to high
Ca	18	139	4450	Moderate (101 - 1000), with some low and high values
K	11	30	97	Low (<100) – possible deficiencies
Mg	3	19	140	Low to moderate (50 - 500) – possible deficiencies
Al	3.8	114	559	High (> 100) – adverse effects more likely
Fe	2.1	7.1	81	Moderate (0.1 – 10) to high
Mn	5.3	19	112	Low to moderate (11 - 100)
Zn	< 0.2	1.5	5.1	Low to moderate (1 - 10)
% BS	11%	25%	74%	Good condition (>15%)

Table 4-11. Forest soil chemistry ratings for the 2010-2012 sampling cycle at Saint-Gaudens National Historic Site. See text for details.

Soil chemistry parameter	Median value	Rating
Calcium:Aluminum ratio	1.3	*Moderate concern*
Carbon:Nitrogen ratio	19.7	*Significant concern*

Level of Confidence and Data Gaps

Confidence in status assessment from 21 forested plots is moderate. Trends were not assessed.

4.3. Water

Water quantity and quality are monitored behind the impoundment on BMD Pond, and at one location each along BMU Brook and BMD Brook for a total of three sites in the park (Figure 4-12, Gawley and Dieffenbach 2016). BMU Brook is considered a cold-water fishery, capable of supporting brook trout (*Salvelinus fontinalis*).

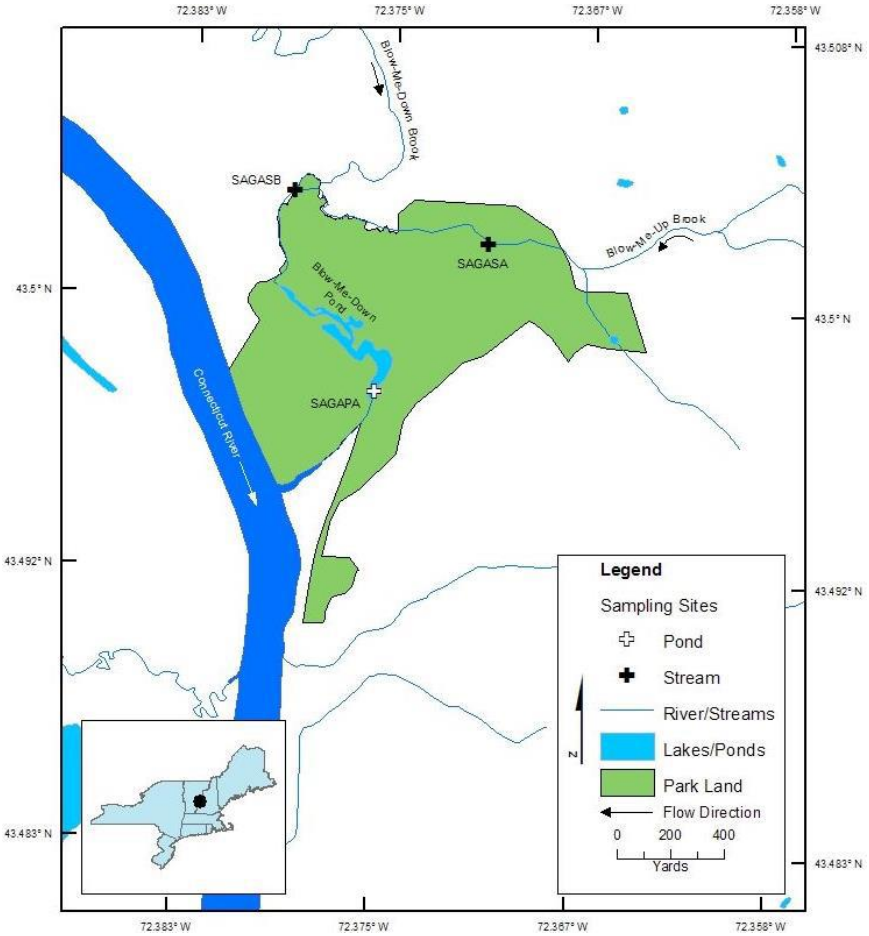

Figure 4-12. Northeast Temperate Network water monitoring sites at Saint-Gaudens National Historic Site.

Three indicators were included to assess condition and trends for Water:

- Water quantity
- Water quality
- Streams - Macroinvertebrates

4.3.1. Water Quantity

Description and Relevance

Climate is a primary driver of hydrology, and variation in the timing and magnitude of precipitation and snowmelt are important drivers of change in water quantity. Low streamflows can create adverse conditions for aquatic life, such as high temperatures and low dissolved oxygen.

Data and Methods

NETN has monitored water quantity at three park sampling locations (one pond and two streams) approximately monthly (May to October) since 2006 with some missed values (Gawley et al. 2014). Procedures for measuring pond stage using a staff gage were standardized in 2013, and reliable conversion standards for data collected prior to that year were not available for this analysis (B. Gawley, personal communication). Thus, only pond stage data collected after standardization in 2013 are included herein. NETN stream discharge measurements were made using a current meter. Additional stream discharge measurements from 1997-1998 were available from a legacy park dataset. Ten-year trends (2007-2016) were assessed for spring (high flow) and late summer (low flow) stream discharge in BMU Brook and BMD Brook using regression analysis.

Assessment Points

Assessment points for water quantity at SAGA have not been set. Minimum values for pond water height and streamflow may be set in comparison to mean values measured onsite, and with consideration of ecological functioning.

Condition and Trend

Measured pond stage values in BMD Pond remained stable with little seasonal variation from 2013-2016 with occasional high water outliers (Figure 4-13). Measured values for 2016 were mostly lower than previous values since 2013 but not enough to be outliers. Stream discharge in both brooks varied seasonally as expected (Figures 4-14 and 4-15), and values for 2016 were within the ranges of previously measured values. Water quantity condition was not determined due to the lack of established assessment points. Regression analysis of ten-year (2007-2016) datasets showed that year of study was not a significant predictor of spring or late summer stream discharge in either brook, indicating that trends were unchanging.

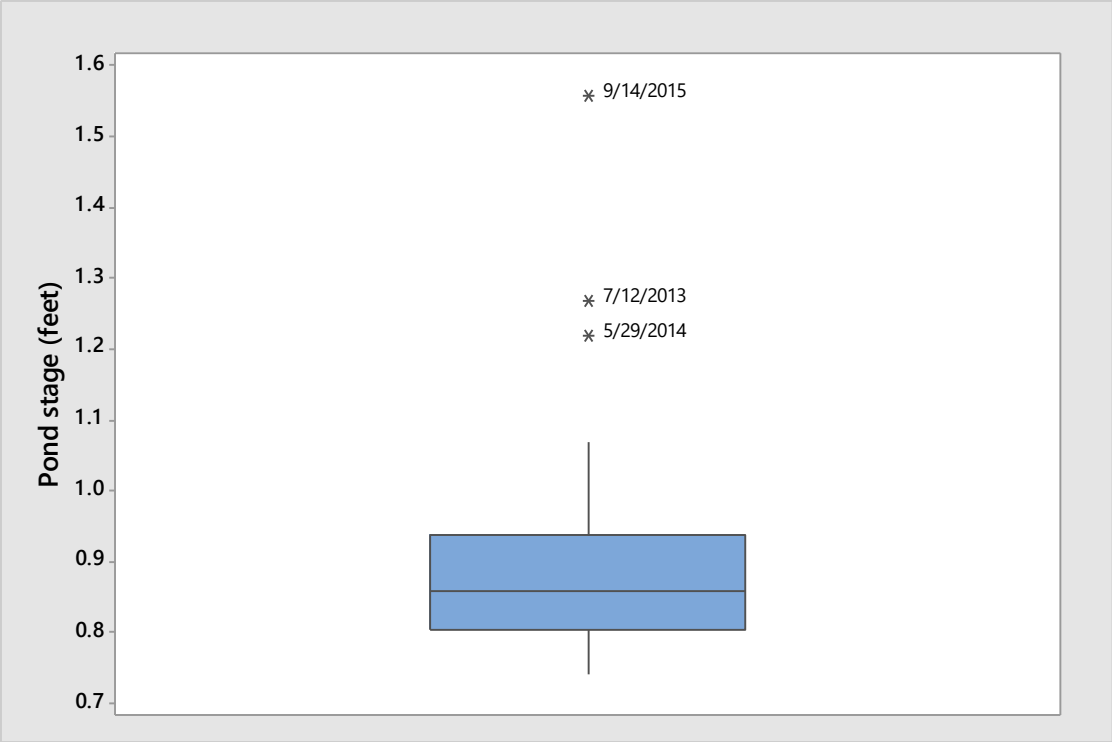

Figure 4-13. Boxplot of pond height in Blow-me-down Pond at Saint-Gaudens National Historic Site from 2013-2016.

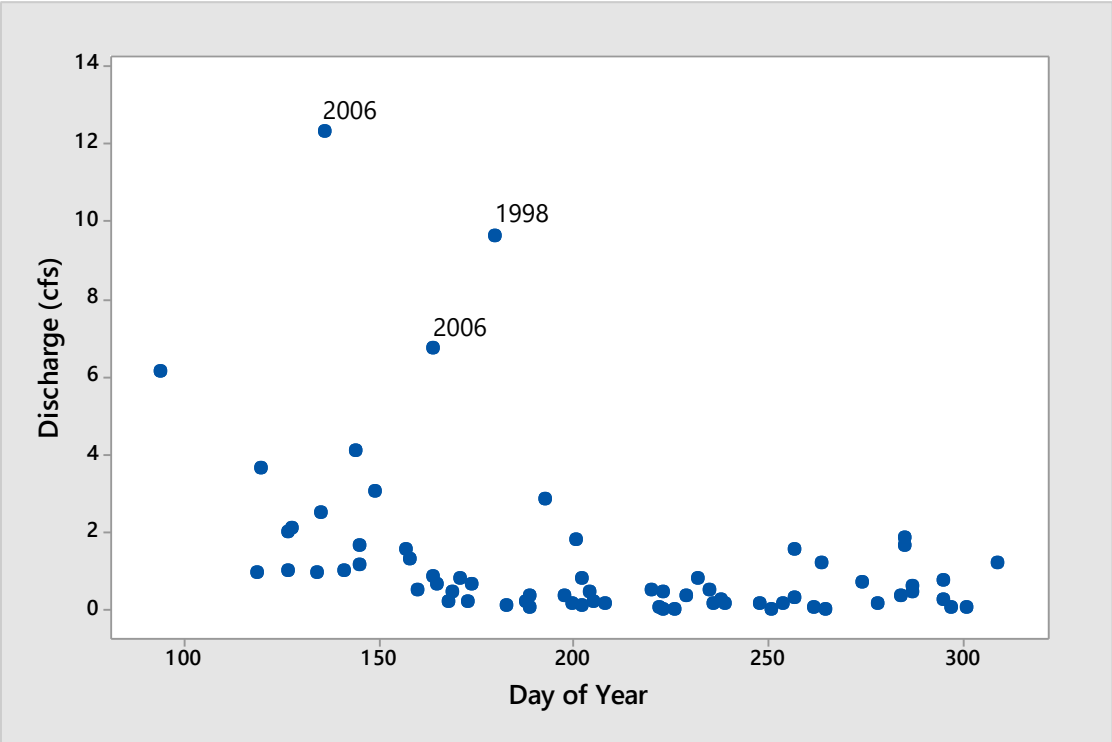

Figure 4-14. Stream discharge in Blow-me-up Brook at Saint-Gaudens National Historic Site from 1997-1998 and 2006-2016.

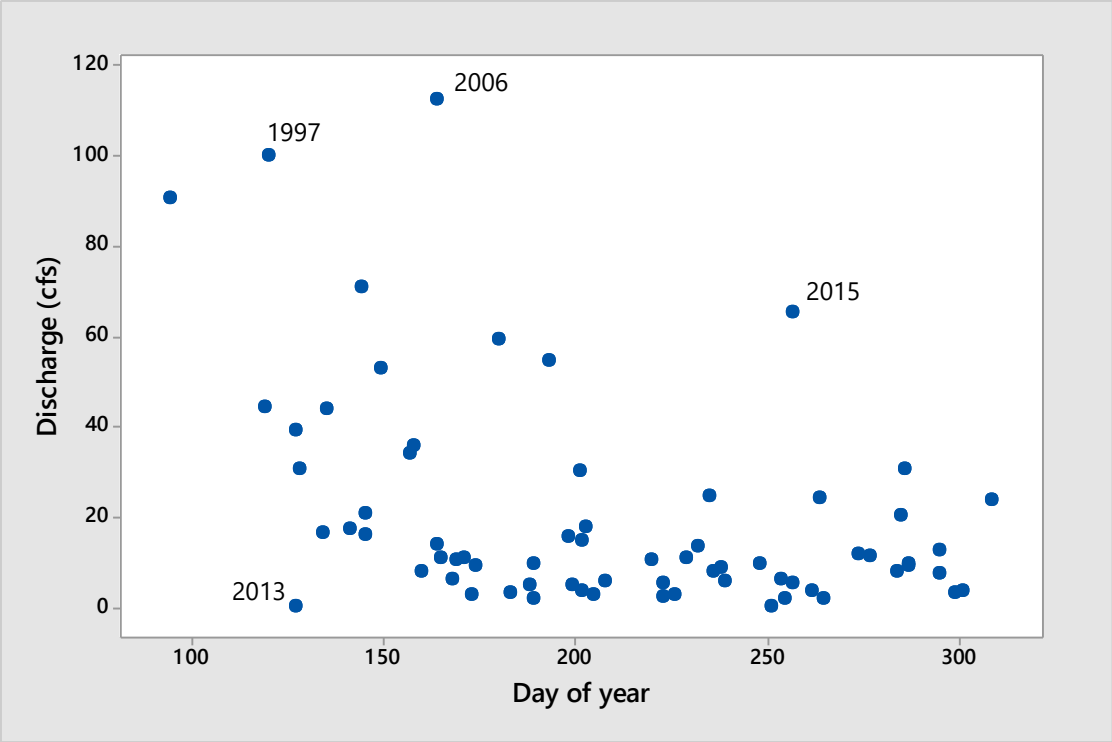

Figure 4-15. Stream discharge in Blow-me-down Brook at Saint-Gaudens National Historic Site from 1997-1998 and 2006-2016.

Level of Confidence and Data Gaps

Determination of appropriate assessment points will allow assessment of condition. Level of confidence in unchanging ten-year trends is high.

4.3.2. Water Quality

Description and Relevance

Water chemistry is an essential indicator for determining condition of aquatic resources, providing fundamental information about the quality of the resource and its ability to support aquatic life. pH measures the availability of hydrogen ion, which determines acidity, a fundamental property of the sample which is influenced by pollution. Temperature affects water chemistry and biology, and temperature is inversely correlated with dissolved oxygen (DO). DO is a critical indicator of water quality because low oxygen levels can kill or stress most aquatic life. A marked increase in specific conductance (a measure of the level of dissolved ions in water) can be an indicator of pollution. Naturally occurring values of specific conductivity cover a wide range (less than 20 to more than 1,000 microsiemens per centimeter; µS/cm). N is an essential plant element and is often the limiting nutrient in terrestrial systems and marine waters, though it can also be limiting in some freshwater systems. Phosphorus (P) is a major plant nutrient which is typically limiting to plant growth in streams and ponds.

Data and Methods

The NPS Hydrographic and Impairment Statistics (HIS) database summarizes information on park hydrologic impairment from state management agencies.

NETN has monitored water chemistry at three park sampling locations (one pond and two streams) approximately monthly from May through October since 2006 (Gawley and Dieffenbach 2016). Pond samples were collected from set depths, standardized in 2012. In-situ sampling includes the following: pH, specific conductance, temperature, and DO. Acid neutralizing capacity (ANC) and nutrients (several forms of N and total P [TP]) are monitored twice yearly, once in June and once in August. Reporting of total N (TN) includes all forms of nitrogen (organic and inorganic). Beginning in 2012, monthly light penetration profiles, and twice-yearly chlorophyll *a*, chloride and sulfate measurements were incorporated into the sampling process. Detailed methods can be found in Gawley et al. (2014).

Water quality condition was assessed from the most recent three-year data available (2014-6). Trends in July water quality values were assessed using regression analysis, as were ANC and nutrient values from both June and August samplings. For the two streams, trends were assessed for the eleven-year (2006-20016) dataset. In BMD Pond, where sampling depths were standardized in 2012, five-year trends (2012-2016) were assessed.

Assessment Points

Gawley and Dieffenbach (2016) assessed water quality in BMD Pond using water quality assessment points from the State of New Hampshire and the US EPA. (Tables 4-12 and 4-13). US EPA criteria provide assessment points for TN, TP and chlorophyll *a* developed specifically for Ecoregion VIII (including the states of Vermont, NH and Maine) and represent nutrient conditions that are minimally impacted by human activities (US EPA 2000, US EPA 2001). The EPA criteria are not regulatory values. Assessment points for specific conductance have not been established; however an increasing trend in specific conductance would warrant concern. For ANC, a minimum assessment point of 100 μeq/L is suggested for adequate buffering (Stoddard et al. 2003). For chloride, the US EPA national criteria for chronic exposure to aquatic life is 230 mg/l (US EPA 1988).

Table 4-12. Water quality assessment points for Blow-me-down Pond in Saint-Gaudens National Historic Site. ND indicates not determined.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*	Source
DO (mg/L)	≥ 5.0	< 5.0	ND	NH
pH (standard units)	6.5 – 8.0	< 6.5 or > 8.0	ND	NH
TN (mg/L)	as naturally occurs	> 0.24, unless natural	ND	NH, US EPA
TP (µg/L)	as naturally occurs	> 8, unless natural	ND	NH, US EPA
Chlorophyll a (µg/L)	≤ 2.43	> 2.43	ND	US EPA
ANC (µeq/L)	≥100	< 100	ND	Stoddard et al. 2003
Chloride (mg/L)	≤ 230	> 230	ND	US EPA

Table 4-13. Water quality assessment points for streams in Saint-Gaudens National Historic Site. ND indicates not determined.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*	Source
DO (mg/L)	≥ 6.0	< 6.0	ND	NH
pH (standard units)	6.5 – 8.0	< 6.5 or > 8.0	ND	NH
TN (mg/L)	as naturally occurs	> 0.38, unless natural	ND	NH, US EPA
TP (µg/L)	as naturally occurs	> 10, unless natural	ND	NH, US EPA
ANC (µeq/L)	≥100	< 100	ND	Stoddard et al. 2003
Chloride (mg/L)	≤ 230	> 230	ND	US EPA

Condition and Trend

Water temperature, DO, and specific conductivity varied seasonally in BMD Pond and both streams (Figures 4-16 and 4-17). Water quality showed *good condition* in the upper water column[9] of BMD Pond and in both streams for temperature, pH and DO during the 2014-2016 period assessed. For the September 2016 measurement only, DO values in BMD Pond fell below the 5 mg/L assessment point; and pH in BMD Brook occasionally fell just above the 8.0 upper pH assessment point. In both BMD Pond and BMU Brook, July pH values significantly declined across the time period assessed (five years in BMD Pond and eleven years in BMU Brook). No other significant trends in July pH, temp, DO and specific conductivity were seen.

[9] At the 0.5 m standard measurement mark.

Analysis for ANC showed that the pond and both streams were adequately buffered, with all measurements falling above the 100 μeq/L assessment point indicating *good condition* (Figure 4-18). ANC varied seasonally, as expected, with June values typically lower than August values. The eleven-year (2006-2016) trend in ANC was improving for summer values in BMU Brook ($p=0.04$) and suggested improvement for spring values in both BMU Brook and BMD Pond ($p=0.12$ and $p=0.103$, respectively). Sullivan et al. (2011a and 2011b) found SAGA to have very high ecosystem sensitivity to acidification and very low sensitivity to N enrichment, while deposition rates of N and S were moderate (section 4.1.2). C:N and Ca:Al ratios in forest soil warrant *significant concern* and *moderate concern*, respectively (section 4.2.1). The pH and ANC values reported here indicate adequate buffering for now.

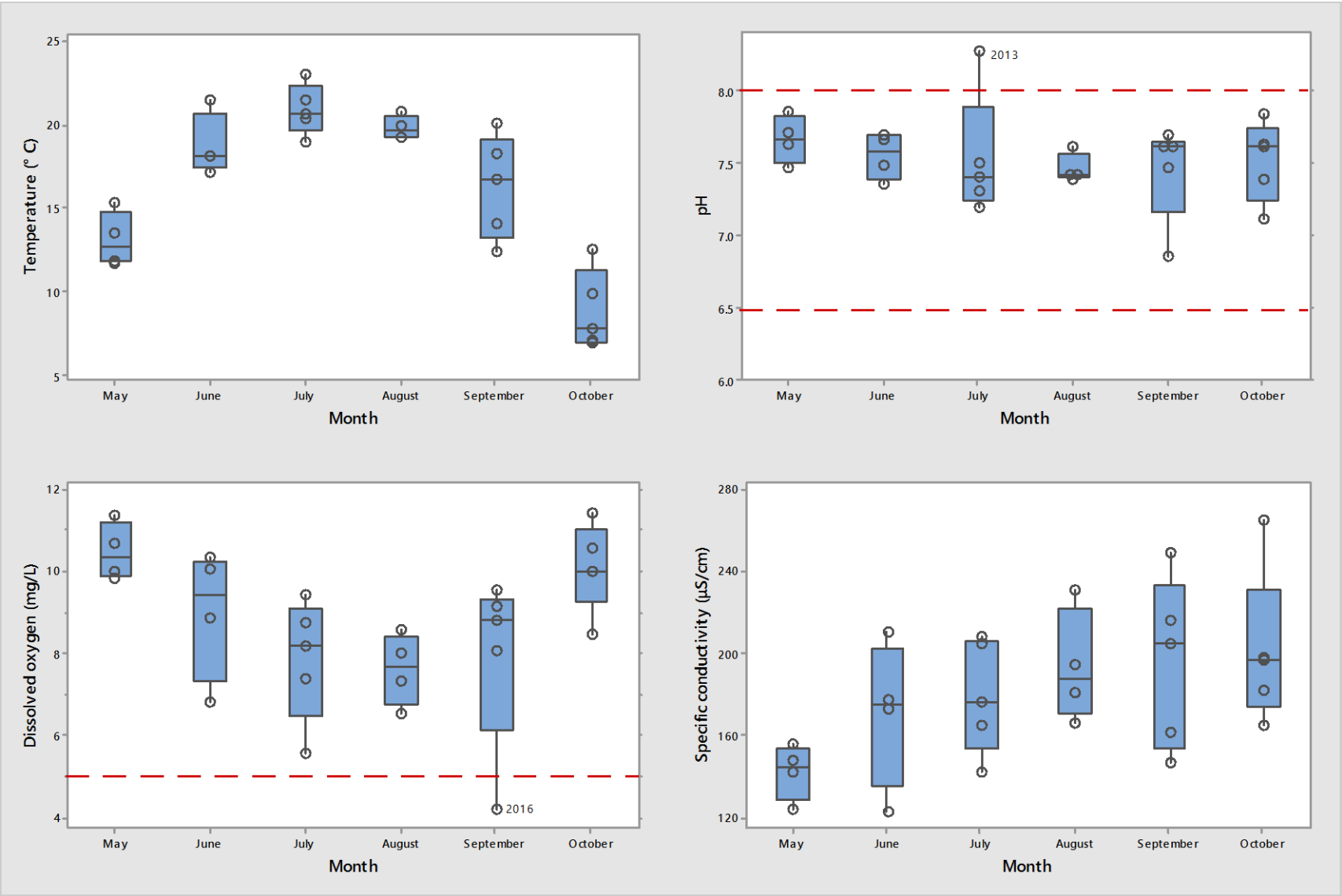

Figure 4-16. Boxplots of monthly temperature, pH, DO, and specific conductance in Blow-me-down Pond in Saint-Gaudens National Historic Site from 2012-2016. Reference lines show assessment points.

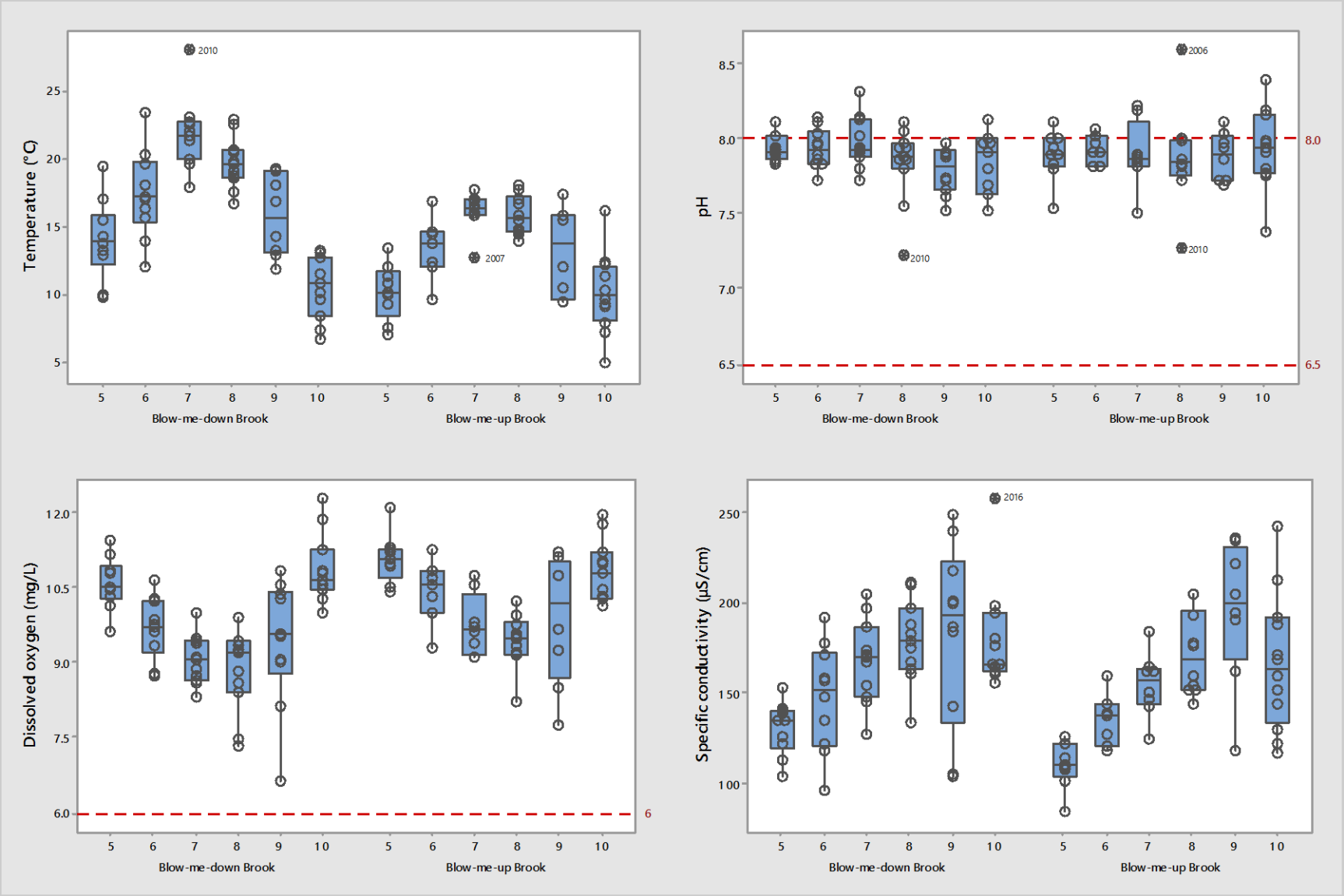

Figure 4-17. Boxplots of monthly temperature, pH, DO, and specific conductance in Saint-Gaudens National Historic Site streams from 2006-2016. Reference lines show assessment points.

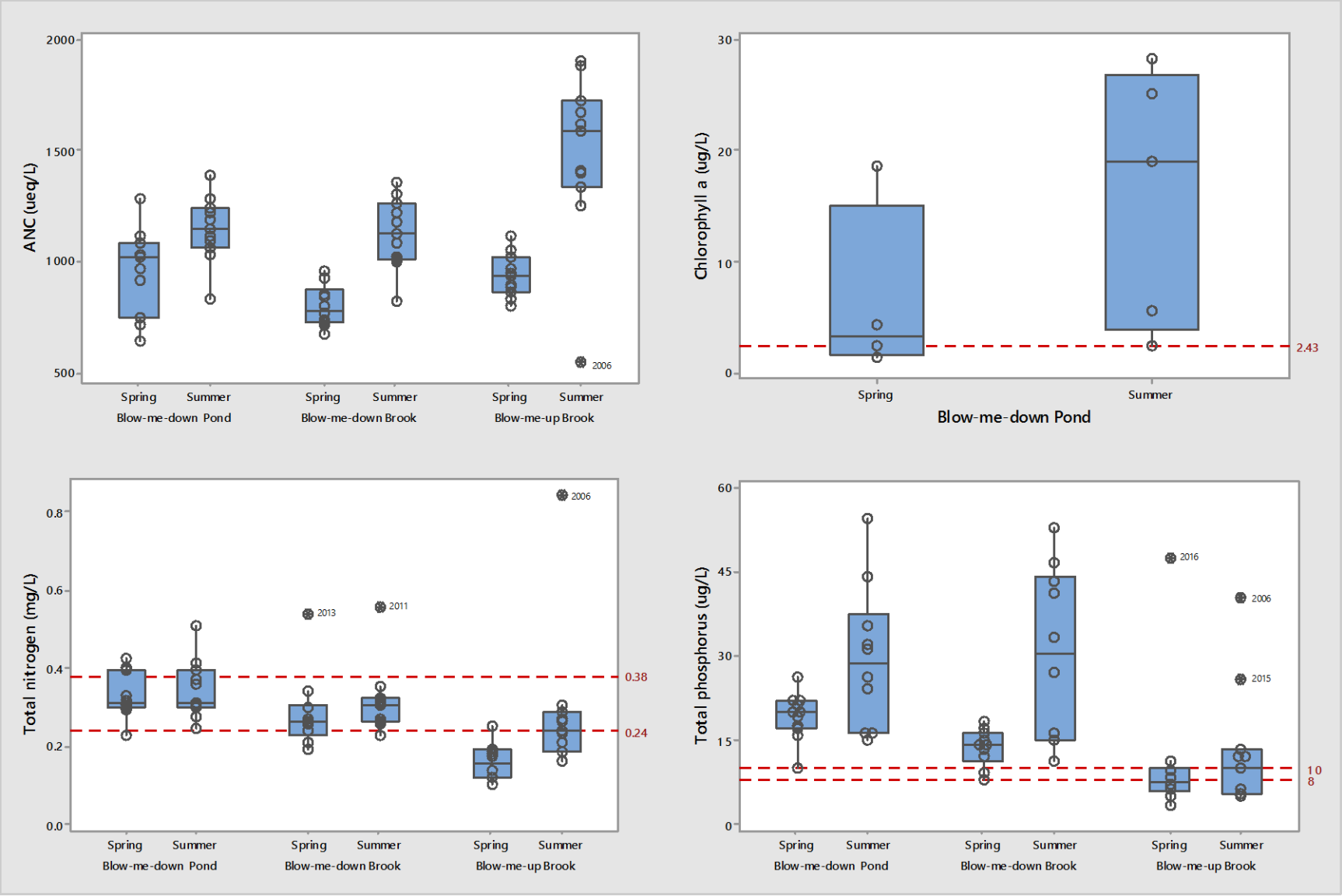

Figure 4-18. Boxplots of ANC, total nitrogen and total phosphorus in surface water in Saint-Gaudens National Historic Site from 2006-2016, and chlorophyll a from 2012-2016. Reference lines show assessment points.

Nutrient (TN and TP) and chlorophyll *a* levels in BMD Pond routinely exceeded the US EPA ecoregional criteria corresponding to minimally-impacted condition during the assessment period (2014-2016; Figure 4-18), warranting *moderate concern*, though these values do not have regulatory meaning. TN levels in both streams fell within the US EPA ecoregional criteria, indicating *good condition*, while TP levels in both streams exceeded the US EPA ecoregional criteria corresponding to minimally-impacted condition, warranting *moderate concern*. In BMD Pond, the eleven-year trend (2006-2016) in August TP levels showed significant deteriorating condition ($p=0.06$). Similarly, 2016 values for chlorophyll *a* in BMD Pond were the highest yet recorded; however, the five-year trend (2012-2016) for chlorophyll *a* did not show statistically significant change. In BMU Brook, the eleven-year trend (2006-2016) in May TP levels suggested deteriorating condition ($p=0.13$).

Sulfate and chloride were assessed beginning in 2012 to better understand water quality (Figure 4-19). Sulfate fell at the lower end of the usual range of sulfate concentration in natural water (104 - 695 μeq/L; Wetzel 1983). However, continued S inputs from current levels of atmospheric deposition warrant concern (section 4.2.1). Chloride values in both BMD Pond and BMD Brook fell above the US EPA freshwater assessment point of 230 mg/L, warranting *moderate concern*, while chloride levels in BMU Brook fell well below this assessment point, warranting *good condition*. June chloride values in BMD Pond showed highly significant ($p<0.01$) deterioration over the five years monitored (2012-2016), while August values in BMU Brook suggested deterioration over this period ($p=0.13$). Contamination from NH Route 12A is an obvious source of chloride into BMD Brook and Pond, while contamination from local roads, agriculture, and residential water-softening systems may be affecting BMU Brook. Continued monitoring of chloride will be important to confirm this trend and inform park managers.

In addition, the NPS HIS database reported Hg and Al contamination in BMD Brook in 2014. Overall, water chemistry in BMD Pond and the two streams showed *good condition* for many metrics, but warranted *moderate concern* for high P levels, for Hg and Al contamination, and for increasing trends in chloride and TP.

Level of Confidence and Data Gaps

Confidence in water quality condition status from a variety of metrics from three park water bodies using established state assessment points is high. Confidence in five-year trends is low, while confidence in eleven-year trends is high. Continued monitoring will allow determination of trends for these important water quality metrics.

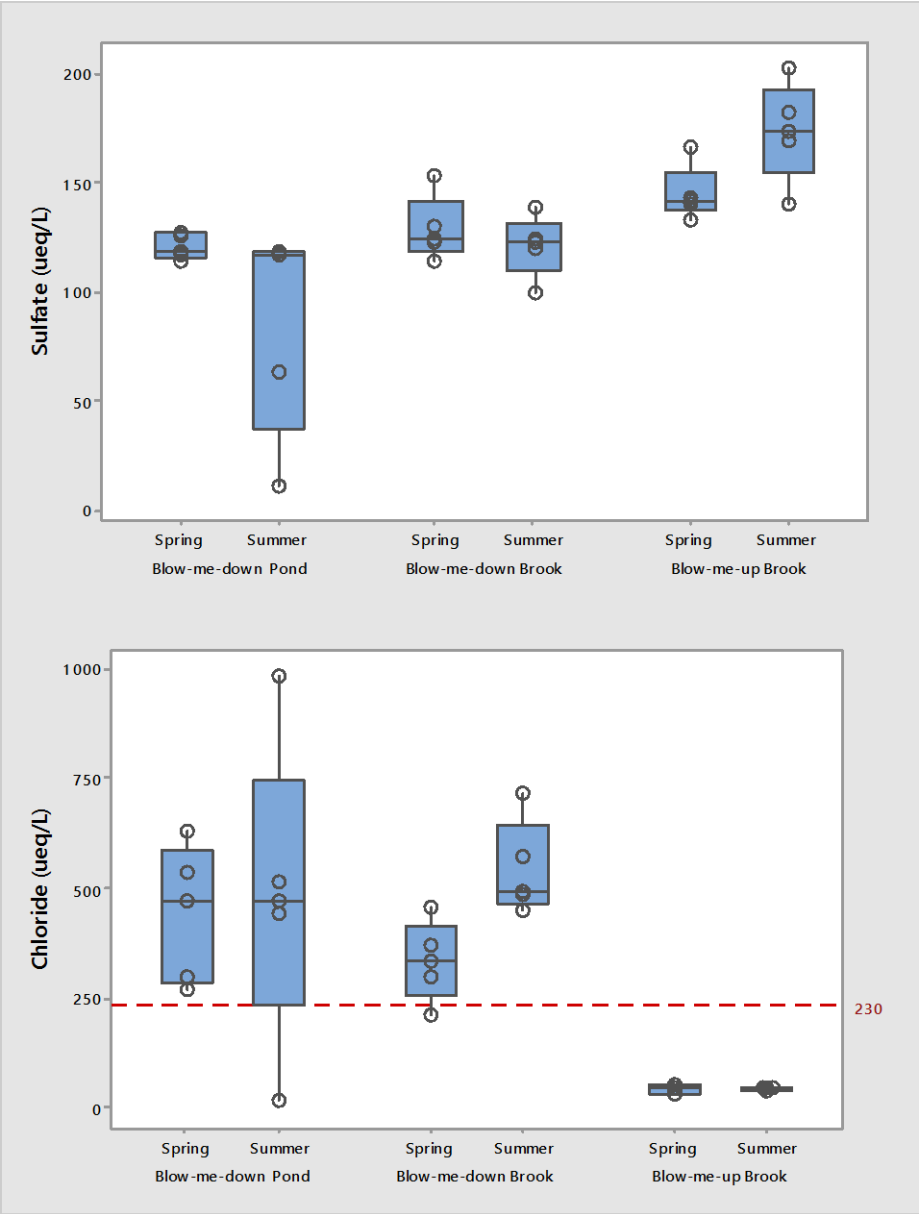

Figure 4-19. Boxplots of sulfate and chloride in surface water in Saint-Gaudens National Historic Site from 2012-2016. Reference lines show assessment points.

4.3.3. Streams – Macroinvertebrates

Description

Stream macroinvertebrates, such as insect larvae, snails and worms, were identified as a Vital Sign to be monitored at SAGA (Mitchell et al. 2006). The richness and composition of macroinvertebrate taxa in streams respond rapidly to changes in the physical and chemical environment, and provides a useful indicator of stream condition.

Data and Methods

Currently, macroinvertebrates are not monitored at this park. However, park staff collected macroinvertebrate taxa presence data at one location along BMU Brook and three locations along BMD Brook three times per year (typically spring, summer, and fall) from 1997-2004. Using methodology of the Izaak Walton League's Save our Streams Program, stream substrate samples were examined for the presence of macroinvertebrate taxa. Data from three macroinvertebrate categories (sensitive, less sensitive, and tolerant) were summed into an index value. While not reflective of current condition, summer index values (representative of low-flow conditions potentially stressful to macroinvertebrates) averaged over three years (2002-2004) were assessed, and regression analysis was used to determine trend in summer index values from 1997-2004.

Assessment Points

The Izaak Walton League's Save our Streams Program methodology assigned water quality ratings of excellent for index values >22, good for values 17-22, fair for values 11-16 and poor for values <11. This translates into ratings of *good condition* for index values >= 17, *moderate concern* for values 11-16, and *significant concern* for values <11.

The Vermont Department of Environmental Conservation (VT DEC) has set reference condition for evaluating macroinvertebrate communities of three types of streams: 1) small, high gradient streams, 2) medium-size high gradient streams, and 3) warm water medium gradient streams and rivers (VT DEC 2004). It may be possible to adapt these criteria for use in determining macroinvertebrate condition at SAGA and nearby Marsh-Billings-Rockefeller NHP in VT. These criteria include macroinvertebrate density, species richness overall, species richness of sensitive species (mayflies, stoneflies and caddisflies), abundance of tolerant organisms (i.e., Chironomidae), and the similarity of species distribution compared to minimally-impacted reference streams.

Condition and Trend

Current data are not available to determine condition and trend. Looking at the older dataset, average 3-year (2002-2004), summer index values for locations along BMD Brook warranted *moderate concern*. Average index values for a single location along BMU Brook were lower. Eight year trend in index values (1997-2004) showed no significant change.

Level of Confidence and Data Gaps

To fill this data gap, park staff could collect macro-invertebrate data using the methods provided by the VT DEC or a NPS I&M protocol such as the Southern Colorado Plateau Network (SCPN) Aquatic Macroinvertebrate Monitoring Protocol (Brasher et al 2011).

4.4. Biological Integrity

Eleven indicators were included to assess condition and trend for Biological Integrity:

- Invasive exotic plants
- Invasive exotic animals
- Wetland vegetation

- Forest vegetation
- White-tailed deer
- Fish
- Birds
- Amphibians and reptiles
- Bats
- Mammals
- Terrestrial invertebrates

4.4.1. Invasive Exotic Plants

Description and Relevance

Invasive exotic species pose a serious threat to native biodiversity across the globe (Mooney et al. 2005). NPS is mandated to preserve native species, and it is NPS policy to manage or eradicate invasive exotic species (NPS 2006). In addition, native species can also exhibit increases in biomass accumulation, reproduction or ecological influence in their native habitat to the point that they are considered invasive.

Data and Methods

Invasive exotic plants have been surveyed at SAGA using several methods. First, the littoral zone of BMD Pond was surveyed annually from 2006-2016 for invasive aquatic plants on a high priority list which included 14 species (Gawley and Roy 2014). Second, the NETN forest monitoring crew collects tree, shrub and understory plant data from permanent forests plots at SAGA on a four-year revisit interval (Section 4.4.4 herein). These data are assessed for frequency and percent cover of 22 key exotic plant species known to be highly invasive in northeastern forest, woodland and successional habitats (Miller et al. 2014). Third, the NETN Invasive Species Early Detection (ISED) program, underway from 2010 to 2014, relied on opportunistic surveys in SAGA to detect priority pests and plants at early stages of establishment. This program provided park staff, cooperators and others with information describing priority species of concern, and procedures for reporting detections. The ISED target list for SAGA included 19 terrestrial plant species and eight aquatic plants, including one (didymo) now considered to be native (Table 4-14; C. Seirup personal communication). ISED data provided useful information to park managers, but was not used herein to determine condition and trends due to the opportunistic nature of the sampling.

Table 4-14. Invasive Species Early Detection (ISED) target species watch list for Saint-Gaudens National Historic Site. ND indicates not detected.

Lifeform	Species	Common Name	SAGA Status
Herb	*Alliaria petioloata*	garlic mustard	In park at low levels
	Cardamine impatiens	narrowleaf bittercress	Sullivan County
	Fallopia japonica	Japanese knotweed	In park at low levels
	Microstegium vimineum	Japanese stiltgrass	ND
	Oplismenus hirtellus ssp. undulatifolius	wavyleaf basketgrass	ND
	Phragmites australis	common reed	Sullivan County
	Ranunculus ficaria	lesser celandine	ND
Vine	*Ampelopsis brevipedunculata*	porcelainberry	ND
	Dioscorea oppositifolia	Chinese yam	ND
	Persicaria perfoliata	mile-a-minute	Nearby county
Shrub	*Elaeagnus umbellata*	autumn olive	In park at low levels
	Euonymus alatus	winged burning bush	In park at low levels
	Ligustrum spp.	privet	In park at low levels
	Rhamnus cathartica	buckthorn	In park at low levels
	Rhamnus frangula	glossy buckthorn	In park at low levels
	Rosa multiflora	multiflora rose	In park at low levels
	Rubus phoenicolasius	wine raspberry	Sullivan County
Tree	*Ailanthus altissima*	tree of heaven	Nearby county
	Paulownia tomentosa	princess tree	Nearby county
Aquatic	*Didymosphenia geminata*[3]	didymo (alga)	ND
	Hydrilla verticillata	hydrilla	ND
	Hydrocharis morsus-ranae	common frogbit	ND
	Myriophyllum heterophyllum	variable watermilfoil	ND
	Myriophyllum spicatum	Eurasian watermilfoil	Sullivan County
	Najas minor	brittle waternymph	ND
	Potamogeton crispus	curly pondweed	Sullivan County
	Trapa natans	water chestnut	ND

[3]Didymo is now known to be native to this area.

Additionally, a park-wide survey for invasive plants was undertaken in August 2017 by Redstart Forestry (Musson et al. 2017). Walking transects throughout the park, this survey mapped occurrences of invasive plants in four categories (minimal, light, moderate and heavy; Figure 4-20) and prioritized areas for treatment. This survey found 17 invasive species in the park, including species on the park ISED watch list (Table 4-15). Priority species for treatment include goutweed, black swallow-wort and exotic honeysuckle as well as species on the ISED list. Areas with the heaviest infestations were found west of Route 12A, along the Connecticut River shoreline, and east of the BMD wetland complex.

Table 4-15. Non-native invasive plants detected in Saint-Gaudens National Historic Site (from Musson et al. 2017). Dashes indicate that the species is not on the ISED watch list.

Lifeform	Species	Common name	ISED Watch List
Herb	Aegopodium podagraria	Goutweed	–
	Alliaria petioloata	garlic mustard	Yes
	Fallopia japonica (*Polygonum cuspidatum)*	Japanese knotweed	Yes
	Lythrum salicaria	purple loosestrife	–
Vine	*Celastrus orbiculatus*	Asiatic bittersweet	–
	Cynanchum louiseae (Vincetoxicum nigrum)	black swallow-wort	–
Shrub	*Berberis thunbergii*	Japanese barberry	–
	Elaeagnus umbellata	autumn olive	Yes
	Euonymus alatus	winged burning bush	Yes
	Euonymus europaeus	spindle tree	–
	Lonicera spp.	honeysuckle	–
	Rhamnus cathartica	Buckthorn	Yes
	Rhamnus frangula (Frangula Alnus)	glossy buckthorn	Yes
	Rosa multiflora	multiflora rose	Yes
	*Syringa reticulate**	Japanese tree lilac	–
Tree	*Acer platanoides*	Norway maple	–
	Robinia pseudoacacia	black locust	–

*A small area of mature plants in the landscaped area between the cut-flower garden and Aspet (Saint-Gaudens' home) are to be preserved (Musson et al. 2017).

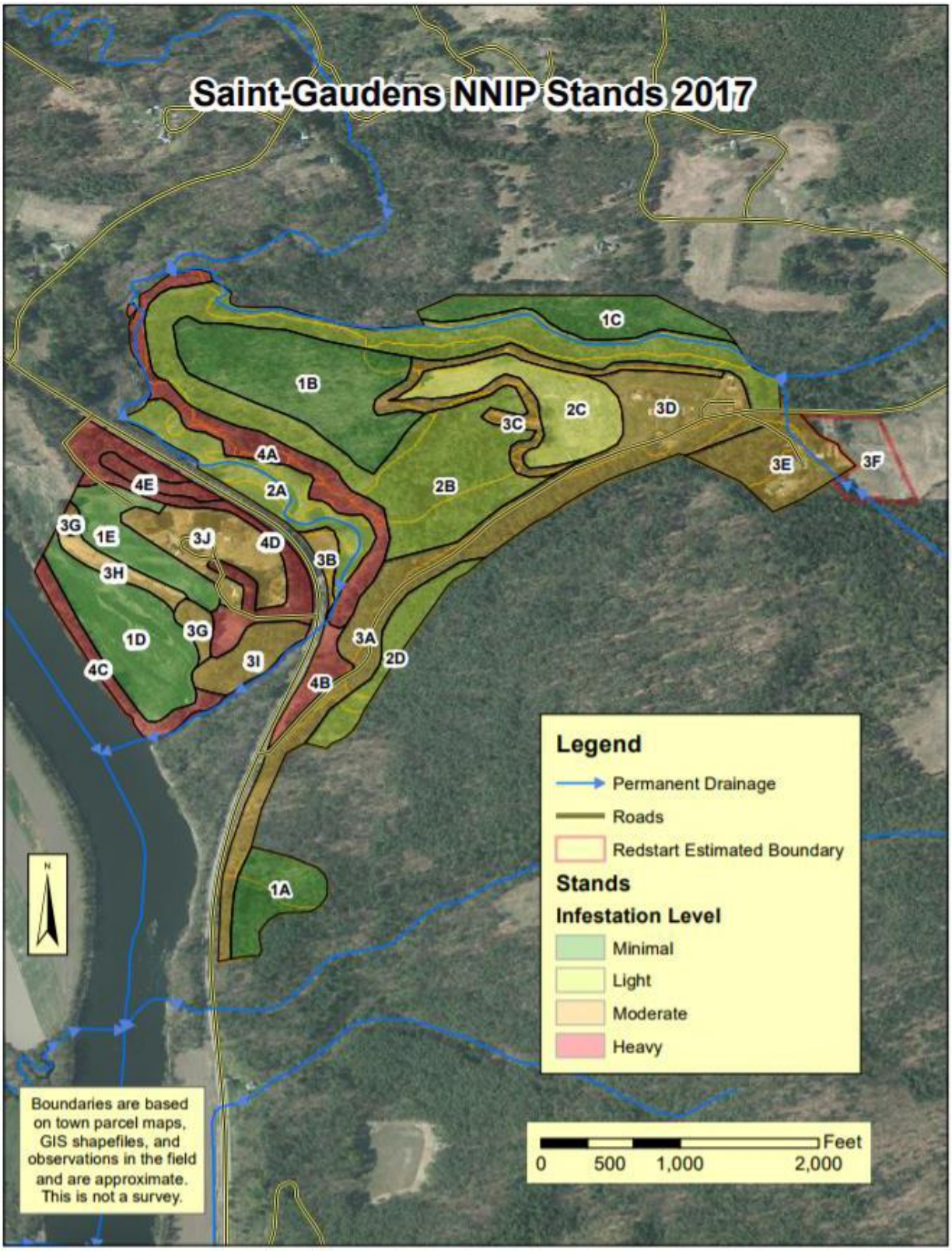

Figure 4-20. Map showing non-native invasive species status at Saint-Gaudens National Historic Site from 2017 survey. Areas are labeled according to infestation level as follows: minimal (1A-1D); light (2A-2D); moderate (3A-3J), and heavy (4A-4E). Reproduced from Musson et al. 2017.

Assessment Points

NETN has established condition categories for key invasive exotic plant species found in forest plots (Table 4-16).

Table 4-16. Assessment points for key invasive exotic plant species (Miller et al. 2014).

Metric	*Good Condition*	*Moderate Concern*	Significant Concern
Detections	< 0.5 key species / plot	0.5 to < 3.5 key species / plot	3.5 or more key species / plot

Condition and Trend

Populations of purple loosestrife (*Lythrum salicaria*) and yellow iris (*Iris pseudacorus*) have been established in BMD Pond for many years and have resisted eradication efforts by park staff (S. Walasewicz, personal communication). Annual surveys in BMD Pond detected no additional invasive aquatic plants of concern during annual surveys from 2006-2016 (Gawley and Roy 2014; B. Gawley, personal communication). This represents *moderate concern*. In forest plots, the most recent cycle of data collection (2014-2016) found 0.8 +/- 0.3 invasive indicator species per plot, also warranting *moderate concern*. The number of invasive indicator species per plot showed a small but significant increase in the current cycle (2014-2016) compared to the first data cycle collected (2006-2008; p=0.07).

Level of Confidence and Data Gaps

Confidence in status assessment is medium. Level of confidence in the increasing trend in forest plots is low, while confidence in the eight-year unchanging trend in BMD Pond is medium. Continued surveillance for new infestations will provide high-value information to park staff.

4.4.2. Invasive Exotic Animals

Description and Relevance

Several exotic forest pest species could cause dramatic changes in forest composition if they invade forests at SAGA. Most notably, the hemlock woolly adelgid (*Adelges tsugae*; HWA) has caused widespread and rapid mortality of hemlock across the eastern U.S. since introduction in the 1950s, and threatens to rapidly and substantially reduce or eliminate eastern hemlock (*Tsuga canadensi*s) throughout much of its range (Orwig et al. 2002). HWA has been present in New Hampshire since 2000 and continues to approach SAGA; HWA was detected in Sullivan County in 2014 (in Charlestown), in 2016 (in Langdon) and again in 2017 (in Washington; Wiemer 2017); this pest is also present in neighboring Windsor County, Vermont. Eastern hemlock is a critical species at SAGA; this long-lived, climax tree provides vital shading in steep ravines, maintaining cool stream temperatures and stable flows in park streams. Machin et al. (2005) undertook a HWA risk assessment for nearby MABI and they recommended early detection and rapid response to this serious threat.

The emerald ash borer (*Agrilus planipennis*; EAB) is a destructive pest that quickly kills all native species of ash (*Fraxinus* spp.). EAB was detected in Concord NH in 2013 and is spreading in

southern NH (NHBugs 2017); in 2018, EAB was detected in Vermont, northwest of SAGA, at the intersection of Orange, Caledonia and Washington Counties (VTinvasives.org 2018). Also present in southern NH is the winter moth (*Operophtera brumata*; NH DFL 2015). First detected in Massachusetts in the 1990s, the winter moth feeds on many species of deciduous trees and shrubs, and can completely defoliate hardwood stands.

The Asian longhorned beetle (*Anoplophora glabripennis*; ALB) poses an enormous threat to maples (*Acer* spp.) and other species as it spreads from its current documented occurrences in Worcester, MA (since 2008) and Boston, MA (since 2010; NHBugs 2017). The Sirex woodwasp (*Sirex noctilio;* SIR) is an exotic wood-boring insect known to attack several pine species (*Pinus* spp.). First identified in NY in 2004, this insect has been detected in northern Vermont (USDA FS 2017). Early detection of all these species is crucial to management of impacts.

The exotic scale insect (*Cryptococcus fagisuga*) that contributes to beech bark disease (BBD) has been established across Vermont and New Hampshire since the 1960s.

Exotic worms are also of concern, including *Amynthas agrestis*, (crazy snake worm or Asian jumping worm), a species which was detected in SAGA in 2017 (K. Jones, personal communication). Invasive earthworms cause dramatic changes in forest ecosystems are very difficult to eradicate.

Data and Methods

From 2010 – 2014, The NETN Invasive Species Early Detection (ISED) program maintained a list of high priority forest pests and provided support to facilitate detection of priority pests and exotic plants in parks at early stages of establishment. The ISED target list for SAGA included five forest insect pests: HWA, ALB, EAB, sirex wood wasp, and winter moth. Alien forest pests are tracked nation-wide by the USDA FS Alien Forest Pest Explorer (https://www.nrs.fs.fed.us/tools/afpe/).

Assessment Points

Assessment points are suggested based on proximity of high priority forest pests to SAGA (Table 4-17).

Table 4-17. Suggested assessment points for high priority forest pests. An assessment point for moderate concern has not been identified.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Detections	No high priority pests in Sullivan County NH or adjacent counties*	Not defined	Detection of high priority pest in Sullivan County NH or adjacent counties.

*Adjacent to Sullivan County, NH are the New Hampshire counties of Cheshire (to the south), Hillsborough (southeast), Merrimack (east), Grafton (north) and the Vermont counties of Windsor (west) and Windham (southwest).

Condition and Trend

HWA has been observed in Sullivan County, NH (since 2014), and most of the neighboring counties. EAB has been observed in the neighboring counties of Merrimack and Hillsborough, NH, as well as in Vermont. The winter moth has been observed in neighboring Cheshire and Hillsborough counties, NH. The proximity of these three high priority pests to the park warrants significant concern. In addition, the detection of *Amynthas agrestis* in SAGA represents a *significant concern*. Trends were not determined.

Level of Confidence and Data Gaps

Confidence in status assessment is low due to the qualitative dataset and preliminary assessment points. An annual monitoring program for high priority pests including HWA is warranted. A simple, rapid, annual monitoring program, such as outlined in Costa and Onken (2006) is recommended to enable early detection of HWA at SAGA. This method involves examination of two low branches per tree for white wooly masses on up to 100 hemlock trees per stand, annually, by staff, interns or volunteers. In addition, the development of a Forest Pest Action Plan now, in advance of detection, would help ensure readiness for rapid response. Such a plan would include some combination of: cultivation of resistant trees; treatment; and post-mortality management of dead trees. Both chemical and biological control methods for HWA currently are being used in national parks, such as Great Smoky Mountains NP and Delaware Water Gap NRA.

4.4.3. Wetland Vegetation

Description and Relevance

Freshwater wetlands provide many valuable ecosystem services including surface water detention, sediment retention, and nutrient transformation, in addition to providing critical habitat for many species of plants, insects, amphibians, fish and mammals.

The National Wetlands Inventory (NWI) uses remotely sensed data to identify likely wetland locations across the U.S. Available NWI wetland data in this area were identified from small-scale (1:40,000 to 1:58,000) color infrared images from the 1980s and 1990s (US FWS 1993). NWI shows a complex of wetlands surrounding BMD Pond and BMD Brook, extending beyond the park's current boundary onto neighboring land within park's legislative authorized boundary (Figure 4-21; US FWS 1993). Sharpe and Farrell (2016) delineated wetlands along BMD Brook in the immediate vicinity of BMD Dam; they mapped three palustrine wetlands occupying 2.9 ha (7.2 ac) of land (Figure 4-21). Further downstream, a small occurrence of the Silver Maple-Wood Nettle-Ostrich Fern Floodplain Forest is found along BMD Brook, straddling the border between SAGA and the adjacent Cornish Wildlife Management area (NPS 2013). Also, two small (<0.01 ha) enriched hardwood forest seeps are shown on the park vegetation map at the base of steep slopes (Gawler and Bowman 2012).

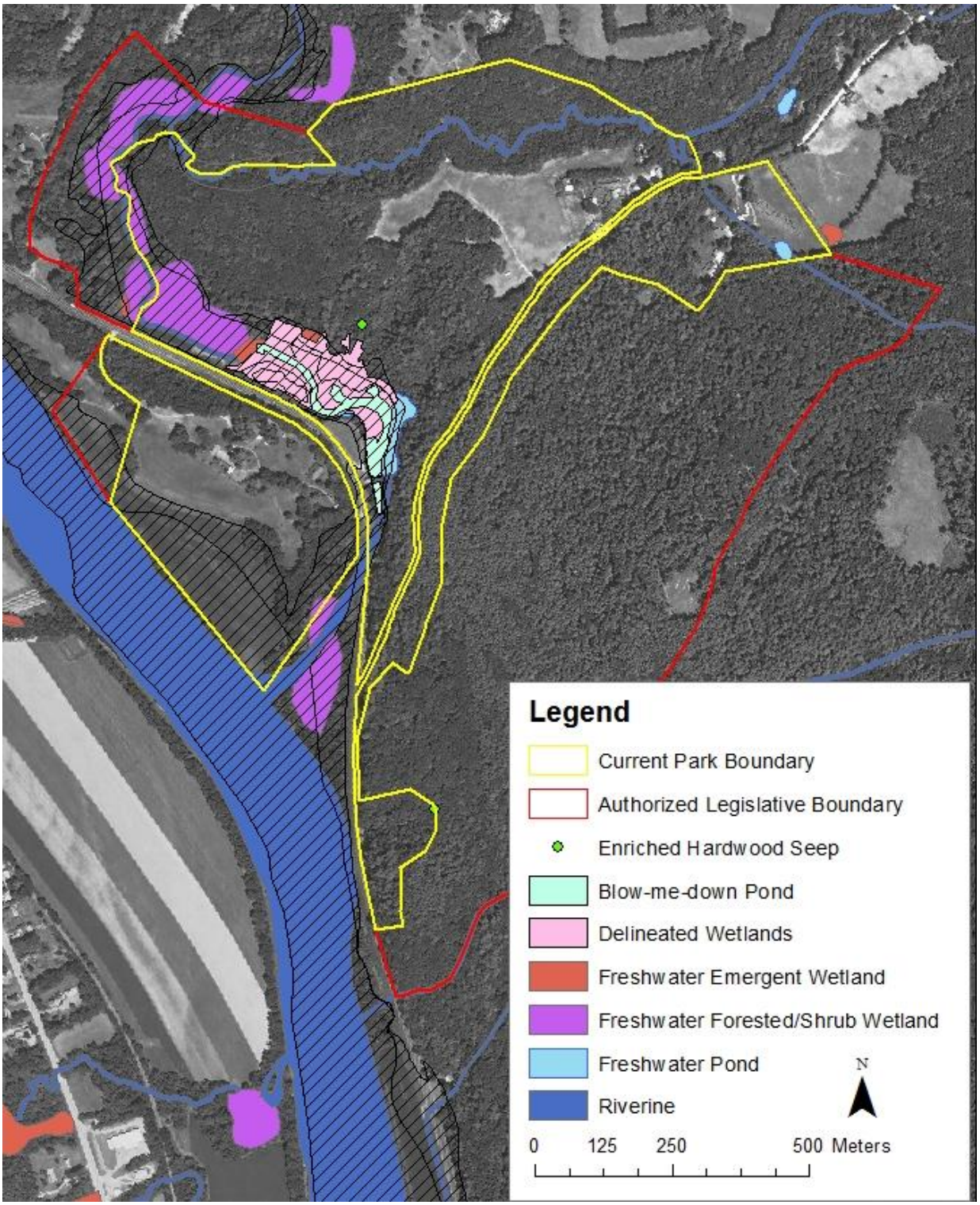

Figure 4-21. Approximate location of wetlands at Saint-Gaudens National Historic Site (US Fish & Wildlife Service 1993, Gawler and Bowman 2012, Sharpe and Farrell 2016). Hatched areas show the 100-year flood zone (Federal Emergency Management Agency 2006).

Data and Methods

Status and trends in wetland vegetation are not currently monitored at this park, however, several sources provided insight into wetland condition. First, several wetland areas (temporary pools labeled Pond 2, A', B', B, C, DE, and FGHI on Figure 4-22) were sampled for amphibians and reptiles during the park Amphibian and Reptile Inventory (Cook et al. 2008).

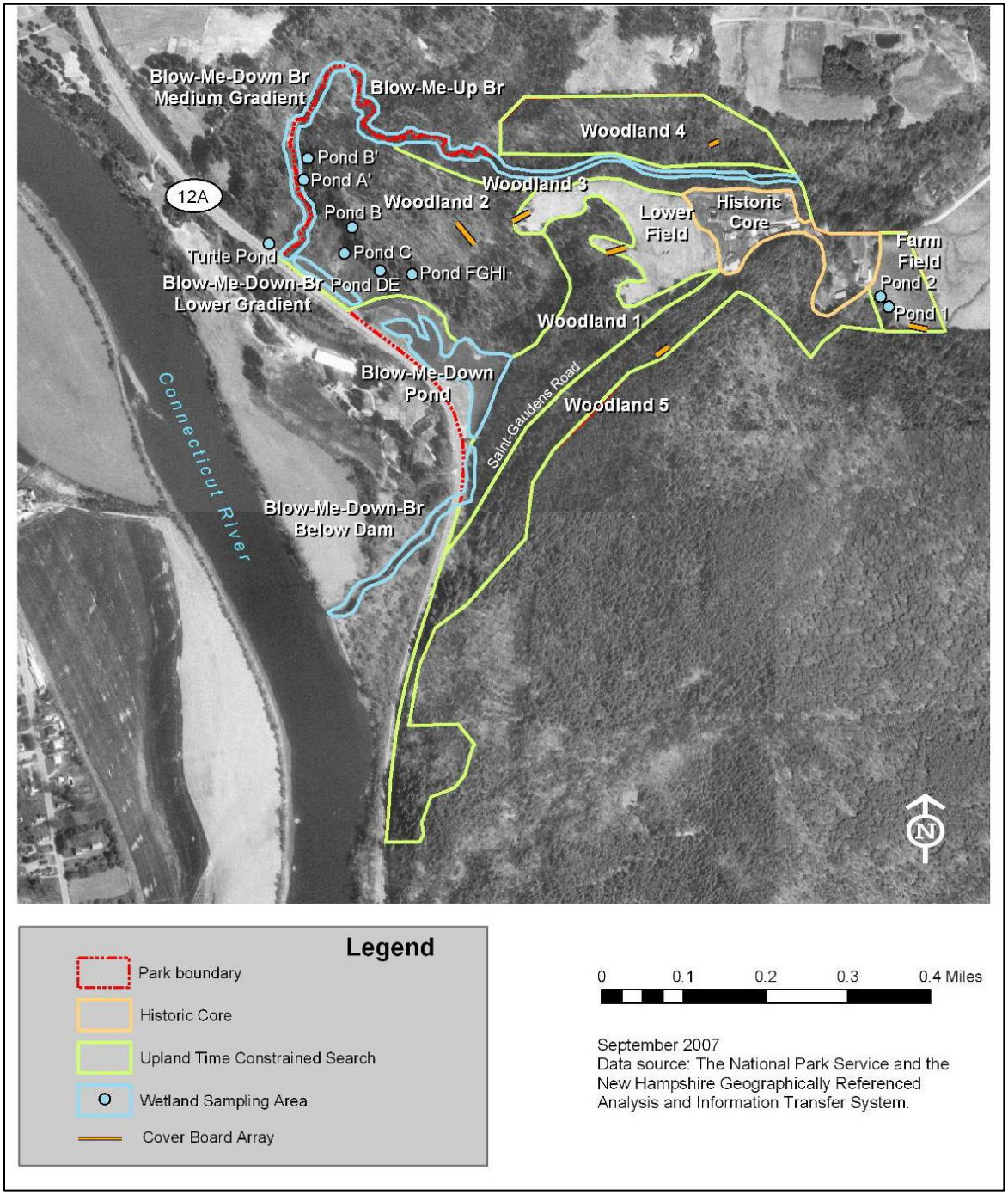

Figure 4-22. Temporary pools and other features sampled at Saint-Gaudens National Historic Site during the park amphibian and reptile inventory (Cook et al. 2008).

Second, preliminary assessment of the condition of wetland buffers was assessed from ortho-imagery using the US EPA Rapid Assessment Method (USA-RAM; US EPA 2011). USA-RAM methodology assesses wetland condition and stress based on four components: buffer, hydrology, physical structure and biological structure. NETN draws upon the RAM and other methods for assessment of wetland vegetation at Acadia National Park (Miller and Mitchell 2013). While most of these components require a site visit, preliminary assessment of the condition of wetland buffers can be assessed using ortho-imagery, and ideally would be confirmed by ground-truthing during a subsequent site visit.

In the present assessment, the wetland complex mapped by Sharpe was assessed for the condition of wetland buffer from NAIP 2016 ortho-imagery and the SAGA vegetation map, using USA-RAM methods as summarized here (US EPA 2011). The wetlands assessment area corresponded to the wetland boundary, and the assessed buffer zone extended 100 m from the wetland boundary. To qualify as wetland buffer, a land cover patch must meet a minimum size requirement (at least 5 m wide and extending at least 10 m along the boundary) and be a natural land cover type. Anthropogenic cover types such as built structures, highways and parking lots, agricultural fields, lawns, and ATV trails do not qualify as wetland buffer. The percent of assessment area having a buffer was visually estimated to the nearest 5%. To estimate buffer width, a central point was selected within the wetland complex and eight transects were drawn in the 4 cardinal directions (N, S, E, and W) and 4 ordinal directions (NE, SE, SW, and NW). Then, buffer width was measured to the nearest 5 m along each transect, up to a distance of 100 m. The eight measurements were averaged for this wetland complex. This condition assessment for wetland buffers is considered preliminary because a subsequent site visit for ground-truthing was not part of this assessment.

Assessment Points

Suggested assessment points for determining condition of wetlands from selected USA-RAM metrics are shown in Table 4-18.

Table 4-18. Suggested metrics and assessment points for determining condition of wetlands (adapted from US EPA 2011 and Faber-Langendoen 2009).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Percent of assessment area having a buffer	> 50 – 100%	25-49%	<25 %
Buffer width (average)	>= 100 m	50 – 99 m	< 50 m
Stress to buffer zone	No stressors affecting >= 1/3 of buffer	At least 1 stressor affecting >= 1/3 of buffer	At least 1 stressor affecting >= 2/3 buffer
Alterations to hydroperiod	Hydroperiod alterations are not severe	At least 1 moderately severe alteration impacting hydroperiod	At least 1 severe alteration impacting hydroperiod
Stress to water quality	Water quality stressors are not severe	At least 1 moderately severe stressor impacting condition	At least 1 severe stressor impacting condition
Habitat/substrate alterations	Substrate alterations are not severe	At least 1 moderately severe alteration impacting substrate	At least 1 severe alteration impacting substrate
Percent cover of invasive plants	0 %	< 5 % in any strata	>= 5 % in any strata
Vegetation disturbance	Vegetation disturbance are not severe	At least 1 moderately severe vegetation disturbance noted	At least 1 severe vegetation disturbance noted

Condition and Trend

Preliminary assessment of the condition of wetland buffer for the mapped wetland complex surrounding BMD Pond showed *good condition* (> 50 to 100%) for percent of assessment area having a buffer, and *moderate concern* (50 – 99 m) for buffer width. Trends were not assessed. The SAGA Amphibian and Reptile Inventory showed that amphibian species sensitive to disturbance and pond-breeding salamanders were represented in the amphibian community at SAGA in 2000 (Cook et al. 2008; see Section 4.4.8 herein), indicating that park wetlands and vernal pools provide good quality habitat. Cook et al. (2008) noted that the string of temporary pools adjacent to BMD Pond, particularly ponds A', B, C, DE and FGHI, are important breeding grounds for wood frogs and spotted salamanders.

Level of Confidence and Data Gaps

Level of confidence in preliminary assessment of wetland buffer condition is low because assessment relied on imagery without ground-truthing. Status and trends in wetland vegetation is a data gap that could be filled by collecting rapid assessment data using USA-RAM (US EPA 2011).

4.4.4. Forest Vegetation

Roughly half of this 77-ha (191-acre) park is forested. The matrix forest is Hemlock - Beech - Oak - Pine Forest found on drier mid- to upper-slopes, and dominated American beech (*Fagus grandifolia*), northern red oak (*Quercus rubra*), eastern hemlock (*Tsuga canadensis*), and by red maple (*Acer rubrum*). Steeper slopes are covered by a Hemlock - White Pine Forest, with eastern white pine (*Pinus strobus*) forming a super-canopy above the hemlock. Lower terraces support a semi-rich

Northern Hardwood Forest dominated by hardwoods including sugar maple (*Acer saccharum*), American basswood (*Tilia americana*), white ash (*Fraxinus americana*), and yellow birch (*Betula alleghaniensis*). The southern border of the park, south of Saint-Gaudens Rd, supports a White Pine Successional Forest, with a canopy of eastern white pine above northern red oak and eastern hemlock regeneration (Gawler and Bowman 2012).

Data and Methods

The USDA FS has monitored 16 forest plots along four transects at SAGA for forest health and pest status, using methods found in the North American Maple Project Cooperative Field Manual and the Forest Health Monitoring Field Methods Guide (Cooke 2003). Temporary plots were monitored during the first cycle, and subsequently permanent forest plot were installed near the original temporary plots. A total of four transects were placed in white-pine successional forest (1 transect), white pine-hemlock forest (1 transect), and the matrix hemlock-beech-oak-pine forest (2 transects). Plots were monitored on a four-year return interval in 1995, 1999 and 2003.

Since 2006, NETN has monitored 21 permanent forest plots at SAGA for a suite of stand, tree and understory metrics (Wheeler et al. 2015). Half the plots are monitored during each biennial collection, yielding three cycles of data separated by a 4-year revisit interval. From this dataset, NETN assesses metrics of forest structure, composition and function. Stand structure assesses the percentage of plots in mature and old-growth structural stages and is indicative of the habitat value of the landscape. Coarse woody debris (CWD) refers to downed trees and large branches on the ground, while snags are standing dead trees. Measuring the abundance of these features provides an indicator of wildlife habitat availability. Tree regeneration assesses the success of tree seedling and sapling establishment and is an early-warning indicator of changes in canopy vegetation. Tree condition qualitatively assesses tree health to identify specific health problems, and tree mortality rates indicate health problems within specific tree species.

For the data reported herein, the current dataset consists of data collected from 2014-2016, while the initial dataset consists of data collected from 2006-2008. For metrics with sufficient data, trends over the eight-year interval were assessed by comparing the recent with the initial dataset using a paired t-test for normally distributed data, or a Wilcoxon test for data which was not normally distributed.

Assessment of exotic plant species, deer-browse impacts, and forest soil chemistry were considered, respectively, in Sections 4.4.1 (Invasive exotic plants), 4.4.5 (White-tailed deer herbivory) and 4.2.1 (Forest soil condition). In addition to the plot measurements, NETN periodically calculates two landscape metrics associated with forest integrity (Forest patch size and Anthropogenic land use). These are reported herein in Section 4.6.1 (Landcover / Connectivity) and 4.6.2 (Land use).

Assessment Points

NETN has established assessment points for metrics of forest structure, composition and function as shown in Table 4-19 (adapted from Wheeler et al. 2015).

Table 4-19. Assessment points and ratings for six metrics of forest integrity (adapted from Wheeler et al. 2015). Medium to large trees are trees >= 30 cm diameter-at-breast-height (dbh). BBD indicates beech bark disease, ND indicates not determined.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Structural stage	≥ 70% late successional structure	< 70% late successional structure	< 70% combined mature and late successional structure
Snag abundance	≥ 10% standing trees are snags **and** ≥ 10% medium to large trees are snags	< 10% standing trees are snags **or** < 10% medium to large trees are snags	< 5 medium to large snags/ha
Coarse woody debris ratio	> 15% live tree volume	5 - 15% live tree volume	< 5% live tree volume
Tree regeneration	Seedling ratio ≥ 0	Seedling ratio < 0	Stocking index < 25
Tree condition and forest pests	Foliar problem < 10% **and** no Priority 1 or 2 pests **and** BBD ≤ 2	Foliar problem 10 - 50% **or** Priority 2 pest **or** BBD > 2	Foliar problem > 50% **or** Priority 1 pest
Tree mortality rates	≤ 1.6%	> 1.6%	ND

Condition and Trend

Current NETN data from 21 forest plots at SAGA showed mixed results for forest structural characteristics (Table 4-20). In the current cycle, SAGA forest was comprised of stands with more mature than late-successional structural stage, falling short of the 70% assessment point for late-successional forest structure based on stand distributions under natural disturbance regimes for the Hemlock hardwoods forest type predominant at this park, and considered *moderate concern*. Levels of standing dead trees (snags) in the park were lower than desired, warranting *moderate concern*, but were sufficient to provide the minimum of 5 medium-large snags/ha based on wildlife needs. CWD volume remained lower than desired, also warranting *moderate concern* (5 – 15% live tree volume; Table 4-20). While CWD and medium-to-large snag values suggested increases in the current cycle over the initial cycle, neither trend was significant.

Table 4-20. Status of structural characteristics of forest integrity measured in 21 Northeast Temperate Network plots at Saint-Gaudens National Historic Site during two time periods.

Cycle	Stand Structure		Snags		Coarse Woody Debris	
	% late successional	% mature	% Med-large snags	Med-large snags/ha	Volume (m^3/ha)	Volume (ft^3/ac)
2014-2016	43	57	7.1%	14.3	51.7	739
2006-2008	38	48	5.3%	10.7	37.7	539

Looking at tree regeneration, just over half of SAGA plots had desired levels, which is considered *good condition*. Visual inspection of tree foliage condition showed that most plots had foliar damage

(10-50% of tree foliage affected) in the current data cycles, warranting *moderate concern*; species most affected were red oak, red maple, white ash, and eastern white pine. Tree mortality rates were below the 1.6% annual assessment point, showing *good condition*. Average severity of BBD in forest plots remained at level two, indicating "scale insect present, some cracks in bark, 75% canopy remains" during all sampling cycles.

USDA FS forest monitoring (1995-2003) found the forest to be generally in good health, though affected by beech bark disease, ash yellows, and the bronze birch borer (which particularly affected the Birch Allee landscape feature; Cooke et al. 2003).

Level of Confidence and Data Gaps

Confidence in condition estimates from quantitative data from 21 NETN plots is medium. Confidence in trend estimates from two cycles of data is low.

4.4.5. White-tailed Deer

Description

White-tailed deer are a "keystone" species in the northeastern U.S., having a profound effect on the composition, structure and function of the ecosystems they inhabit. Sustained, selective browsing by a historically high population of white-tailed deer is currently impacting understory species composition and tree regeneration in parts of the northeast U.S. (Russell et al. 2001, Rooney and Waller 2003, Cote et al. 2004, Kain et al. 2011). Sustained browsing pressure can result in population reduction or loss of species preferred by deer (such as native perennial forbs) and increases in browse-resistant or non-preferred species (such as grasses and sedges, ferns, and exotic species; Augustine and deCalesta 2003, Balgooyen and Waller 1995, Rooney 2009).

Data and Methods

Local deer population size and the amount of browse available determine browse pressure on vegetation. The NH Fish and Game Department (NH FGD) estimates the size of the deer population annually within state wildlife management units (WMU) using harvest data (Bergeron 2014). Status and trend of white-tailed deer population was determined from estimates for WMU H1, extending along the state's western border the Connecticut River) from Interstate 89 east to Route 10 and south to Route 123, encompassing most of Sullivan County together with smaller parts of neighboring counties (Figure 4-23). Population status was assessed from density estimates averaged over three years (2013-2015). Regression analysis was used to determine trend in density from 2005-2015.

In addition, data on browsing impacts has been collected by NETN as part of the Long-term Forest Monitoring Program (see Section 4.4.4 herein). NETN has monitored frequency of deer-browse indicator species since 2006 in 1-m^2 quadrats within 21 permanent forest plots; these indicator species are plant species known to be preferentially browsed or alternatively avoided by deer.

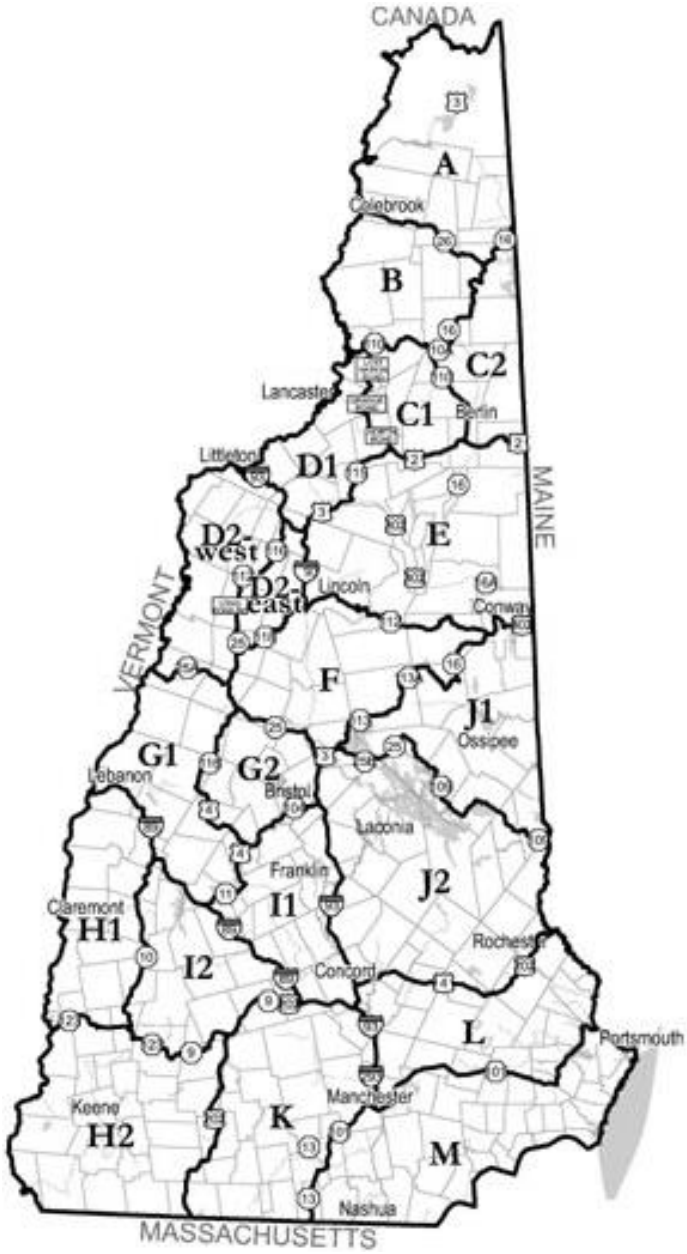

Figure 4-23. Map of New Hampsire Wildlife Management Units.

Assessment Points

Historical densities of white-tailed deer in the eastern U.S. are estimated at 3-4 deer per km^2 (McCabe and McCabe 1997). Negative browse impacts have been documented where deer densities exceed 8 deer per km^2 for 10 or more years, and severe impacts have been observed with deer densities $\geq$ 20 per km^2 (Horsley et al. 2003, Augustine and deCalesta 2003).

Condition ratings for white-tailed deer are shown in Table 4-21. For assessing deer-browse impacts on vegetation, NETN assigns ratings based on change over time in browse-sensitive and browse-avoided species as shown (Miller et al. 2014).

Table 4-21. Condition ratings for white-tailed deer population density and browse impacts (Miller et al. 2014).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Deer population density (deer per km^2)	< 8	8 - 20	≥ 20
Deer-browse impacts	No decrease in frequency of most browse-sensitive species	Decrease in frequency of most browsed species **or** increase in frequency of browse-avoided species	Decrease in frequency of most browsed species **and** increase in frequency of browse-avoided species

Condition and Trend

Mean deer density estimates in WMU H1 averaged across last three years (2013- 2015) was 6.6 deer/km^2 (17.1 deer/mi^2; D. Bergeron, personal communication) indicating *good condition*. Regression analysis of deer density estimates from 2005 to 2015 showed no significant trend. Assessment of deer-browse indicator species in forest plots between the current cycle (2014-2016) and the previous cycle (2010-2012) showed that 2/3 of forest plots did not display negative trends in key browse-preferred species nor increasing trends in key browse-avoided species, indicating *good condition*.

Level of Confidence and Data Gaps

Level of confidence in condition estimate from two metrics with established assessment points is medium. Confidence in regional ten-year population trend from modeled data is medium.

4.4.6. Fish

Description

Fish communities are useful indicators of physical, chemical and biological conditions in aquatic systems. They are also of high interest to outdoor enthusiasts, particularly to recreational fishers. Fishing is permitted within SAGA, but fish are not stocked. BMU Brook is notable as a cold-water fishery that can support brook trout.

Data and Methods

The park freshwater fish inventory surveyed two park streams (BMD Brook and BMU Brook) and two park impoundments (BMD Pond and Farm Pond) in October 2000, and documented 12 native fish species (Table 4-22; Mather et al. 2003). No fish were found in Farm Pond. An additional 8 fish species were documented in the park by biological inventories during the 1980s, and another species, chain pickerel, was anecdotally reported for a total of 21 park species (Cook 1986, Cronan et al. 1981). One park species, the redbelly dace, is designated SC and SGCN in NH; this species is impacted by introduced predator fish as well as habitat alterations that reduce summer base flow levels and riparian cover (NH FGD 2009, NH FGD 2015). Cook (1986) captured >50 individuals of this species in marshy overflow ponds near BMD Pond in 1985-6, as well as a few individuals in BMD Brook, but this species was not detected during the park fish inventory in 2000. Another species, brook trout, is also designated SGCN; this cold-water species is sensitive to habitat alteration (NH FGD 2015). As described in section 4.1.5 herein, McGarigal et al. (2017) have projected a

roughly 0.5 probability that brook trout will persist in BMU Brook until 2080 under a changing climate.

The most common fish species sampled by the park inventory in both streams was blacknose dace, followed by slimy sculpin and brook trout in BMU Brook, and by common shiner and white sucker in BMD Brook.

Table 4-22. Freshwater fish species documented in stream or pond habitats in Saint-Gaudens National Historic Site. The 1939 survey occurred on Blow-me-down Brook upstream of the park boundary, in Plainfield, NH. "x" indicates species was detected, and "†" indicates only a single individual recorded.

Common Name	Latin Name	Survey year			Habitat				Notes
		2000	1980s	1939	BMU Brook	BMD Brook	BMD Pond	Overflow Ponds	
Longnose sucker	*Catostomus catostomus*	–	x	–	–	–	x	–	–
White sucker	*Catostomus commersonii*	x	x	x	x†	x	x	–	–
Common shiner	*Luxilus cornutus*	x	x	–	–	x	x	–	–
Golden shiner	*Notemigonus crysoleucas*	x	x	–	–	x	–	x	–
Spottail shiner	*Notropis hudsonius*	x	–	–	x	x	–	–	–
Redbelly dace	*Phoxinus eos*	–	x	–	–	x	–	x	NH SC and SGCN
Bluntnose minnow	*Pimephales notatus*	–	x	–	–	x	–	–	–
Blacknose dace	*Rhinichthys atratulus*	x	x	x	x	x	–	–	–
Longnose dace	*Rhinichthys cataractae*	x	x	x	x†	x	–	–	–
Creek chub	*Semotilus atromaculatus*	x	x	x	–	x	x	x	–
Fallfish	*Semotilus corporalis*	x	x	x	x†	x	x	–	–
Chain pickerel	*Esox niger*	–	x	–	–	–	x	–	Anecdotal
Rock bass	*Ambloplites rupestris*	–	x	–	–	x	x	–	–
Redbreast sunfish	*Lepomis auritus*	–	x†	x	–	x	x	–	–
Pumpkinseed	*Lepomis gibbosus*	x	x	–	–	x	x	–	–
Bluegill	*Lepomis macrochirus*	–	x	–	–	–	x	–	–

Table 4-22 (continued). Freshwater fish species documented in stream or pond habitats in Saint-Gaudens National Historic Site. The 1939 survey occurred on Blow-me-down Brook upstream of the park boundary, in Plainfield, NH. "x" indicates species was detected, and "†" indicates only a single individual recorded.

Common Name	Latin Name	Survey year			Habitat				Notes
		2000	1980s	1939	BMU Brook	BMD Brook	BMD Pond	Overflow Ponds	
Tessellated darter	*Etheostoma olmstedi*	–	x	–	–	x	x	–	–
Yellow perch	*Perca flavescens*	–	x	–	–	x	–	–	–
Brook trout	*Salvelinus fontinalis*	x	x	x	x	x	–	–	NH SGCN
Slimy sculpin	*Cottus cognatus*	x	–	–	x	–	–	–	–
Brown bullhead	*Ameiurus nebulosus*	x	x	–	–	x	x	–	–

Assessment Points

The NH Department of Environmental Services (NH DES) has developed both cold-water and transitional-water fish assemblage Indexes of Biotic Integrity (IBI) for wadeable streams in the state (NH DES 2007, NH DES 2011). The cold-water IBI (CWIBI) is applicable to 1st to 4th order wadeable species-poor streams north of 43.75 degrees latitude or at higher elevation (up to 775 ft asl) below that latitude, draining 1-15 mi^2, such as BMU Brook. However, the occurrence of more than four fish species in BMU Brook, including the warm-water spottail shiner, suggests use of the transitional water (TWIBI) to assess that stream. The TWIBI uses 8 metrics to assess integrity (Table 4-23).

Table 4-23. The transitional water fish assemblage Index of Biotic Integrity for New Hampshire wadeable streams from NH Department of Environmental Services (2011) adapted to NPS condition ratings.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
% of brook trout & slimy sculpin	>20%	5-20%	<5%
% of creek chub, common shiner and fall fish	<=2%	2-20%	>20%
% of fluvial specialists excluding blacknose dace	>=60%	40-60%	<40%
Number of coldwater species	>=2	1	0
% of tolerant Species	<33%	33-50%	>=50%
% of benthic insectivores	>40%	20-40%	<20%
% of generalist feeders	<=10%	10-30%	>30%
Brook trout age class structure	YOY* and adults	YOY	No YOY

*YOY = young-of-year.

Condition and Trend

Current fish monitoring data are not available for assessing condition of SAGA fish communities.

Level of Confidence and Data Gaps

Fish communities at SAGA are a data gap. Park managers could consider surveying overflow pools in the BMD Pond wetland complex to determine if the SC/SGCN species redbelly dace still inhabits this area, as well as considering establishment of a monitoring program for brook trout in BMU Brook.

4.4.7. Birds

Description and Relevance

As a visible and charismatic faunal group that generate high public interest, birds were selected as a priority vital sign for monitoring in NETN parks (Mitchell et al. 2006). Forest breeding birds are useful indicators of habitat fragmentation and anthropogenic change (Robinson et al. 1995, Rosenberg et al. 1999). Many species of grassland breeding birds have experienced steep population declines in conjunction with loss of habitat in recent decades (Brennan and Kuvlesky 2005, Askins et al. 2007).

Data and Methods

NETN relies on volunteer monitors to conduct annual forest bird monitoring at SAGA (Faccio and Mitchell 2015). Monitoring has occurred at this park every year since 2007, with duplicate annual surveys occurring every year beginning in 2008. Volunteers record the species of each individual bird detected during 10-minute point counts at five forested point stations. Data from second surveys were included in the guild-based ecological integrity assessment presented here, but these data were excluded from summaries and trend analysis to facilitate comparison across years (Faccio and Mitchell 2015).

The park bird inventory surveyed eleven point count stations in forest, field and wetland habitats at SAGA three times annually during the breeding seasons in 2001 and 2002, in addition to targeted area searches for hawks and waterfowl (Faccio 2003). This inventory occurred prior to the acquisition of the BMDF property in 2010, so the habitats found on that property (including fields and floodplain forest) were not surveyed. The inventory detected 85 bird species, 62 of which were confirmed or suspected of breeding in the park. Annual forest bird monitoring at SAGA has detected an additional five bird species, while an additional three bird species (*Melospiza lincolnii* [Lincoln's sparrow], *Icterus spurius* [orchard oriole], *Vireo philadelphicus* [Philadelphia vireo]) have been noted at the park by observers submitting data to eBird since 2012 (Faccio and Mitchell 2015; S. Faccio, personal communication; eBird 2017). The current park bird list includes an additional 55 bird species for which presence is unconfirmed but suggested by a previous park inventory or other historical evidence (NPS 2017a).

No threatened or endangered bird species are present in the park. Eleven bird species detected during the park bird inventory or annual monitoring are considered priority conservation species, as shown in Table 4-24.

Table 4-24. Bird species with conservation status documented in Saint-Gaudens National Historic Site. Special concern is assigned to species that could become threatened in the foreseeable future (NH Fish and Game Department 2009). Inventory refers to the park bird inventory (Faccio 2003) and monitoring refers to annual forest bird monitoring (Faccio and Mitchell 2015). SC = special concern, SGCN = species of greatest conservation need designated by the NH Fish and Game Department, RCC = birds of regional conservation concern.

Common Name	Scientific Name	Conservation Status	Detection	Comment
Osprey	*Pandion haliaetus*	NH SC	Inventory	Transient
Chimney swift	*Chaetura pelagica*	SGCN	Inventory	–
American woodcock	*Scolopax minor*	SGCN	Inventory	–
Belted kingfisher	*Megaceryle alcyon*	RCC	Inventory, Monitoring	–
Scarlet tanager	*Piranga olivacea*	RCC	Inventory, Monitoring	Park breeder
Purple finch	*Haemorhous purpureus*	SGCN	Inventory	Park breeder
Bobolink*	*Dolichonyx oryzivorus*	SGCN	Inventory	Grassland breeder
Canada warbler	*Cardellina canadensis*	SGCN	Inventory	–
Veery	*Catharus fuscescens*	SGCN, RCC	Inventory, Monitoring	Park breeder
Wood thrush	*Hylocichla mustelina*	SGCN, RCC	Inventory, Monitoring	Park breeder
Eastern wood pewee	*Contopus virens*	RCC	Inventory, Monitoring	Park breeder

*Seen in agricultural fields at BMDF in early May (K. Jones, personal communication).

In addition, trends in bird relative abundance and species richness were assessed across the eleven-year (2007-2017) NETN dataset using regression analysis.

Assessment Points

To assess and interpret condition of forest birds, NETN has developed an avian ecological integrity assessment consisting of 13 guilds in three ecological integrity categories: compositional, functional, and structural (Table 4-25; Faccio et al. 2011, Faccio and Mitchell 2015). Each guild is broadly categorized as “generalist” or “specialist” (i.e., comprised of species with a narrow range of habitat tolerances, or a low intrinsic rate of population growth). In general, the presence of specialist guilds is indicative of high ecological integrity, while generalist guilds indicate low ecological integrity. Bird species from five groups (perching birds or passerines, woodpeckers, cuckoos, swifts and hummingbirds, and doves) were assigned to one or more guilds based on their life history traits, and the proportional species richness of each guild was calculated by dividing the number of guild members detected by the total number of species detected (Faccio et al. 2011, Faccio and Mitchell 2015). Condition was determined using the assessment points shown in Table 4-24. Since some guild

members are likely missed during an annual survey, the condition assessment was based on the recent three-year dataset (2012-2014).

Table 4-25. Forest Avian Ecological Integrity thresholds for 13 response guilds (from Faccio and Mitchell 2015). Percentages are proportional species richness.

Biotic Integrity Element	Response Guild Metric	Ratings (% Species Richness)		
		Good Condition	***Moderate Concern***	***Significant Concern***
Compositional	Exotic Species	0%	0.5 -7%	> 7%
	Nest Predator/Brood	< 10%	10 - 15%	> 15%
	Resident	< 28%	28 - 41%	> 41%
	Single-Brooded	> 68%	50 - 68%	< 50%
Functional	Bark Prober	> 11%	4 - 11%	< 4%
	Ground Gleaner	> 9%	4 - 9%	< 4%
	High Canopy Forager	> 12%	7 - 12%	< 7%
	Low Canopy Forager	> 22%	14 - 22%	< 14%
	Omnivore	< 30%	30 - 50%	> 50%
Structural	Canopy Nester	> 35%	29 - 35%	< 29%
	Forest-ground Nester	> 18%	5 - 18%	< 5%
	Interior Forest Obligate	> 35%	10 - 35%	< 10%
	Shrub Nester	< 18%	18 - 24%	> 24%

Condition and Trend

At least 61 bird species have been detected at SAGA during forest bird monitoring since 2007. The most common birds sighted during forest bird monitoring included ovenbird (*Seiurus aurocapillus*), red-eyed vireo (*Vireo olivaceus*) and veery (a species of conservation interest).

Pooling forest bird monitoring data from 2011-2014, Faccio and Mitchell (2015) reported *good condition* for six of 13 guilds measuring forest avian ecological condition, while another six guilds warranted *moderate concern*, and the remaining guild (Shrub nester) warranted *significant concern* (Table 4-26). Looking at change between two time periods (2007-2010 and 2011-2014) at SAGA, Faccio and Mitchell (2015) reported an increase in condition for 1 of 13 guilds (Low canopy forager), while the large majority of guilds (11) showed no change and one guild (omnivore) showed declining condition (Table 4-26). Neither bird relative abundance nor species richness detected during NETN annual monitoring showed a significant inter-annual trend across the eleven-year (2007-2017) dataset.

Table 4-26. Condition and trends in park-wide Forest Avian Ecological Integrity Assessment for Saint-Gaudens National Historic Site (adapted from Faccio and Mitchell 2015). Change reports change in condition between two time periods (2007-2010 and 2011-2014).

Biotic Integrity Element	Response Guild Metric	2011-2014 Condition		Change
		Percentage	Rating	
Compositional	Exotic Species	0%	*Good condition*	No change
	Nest Predator/Brood Parasite	4%	*Good condition*	No change
	Resident	24%	*Good condition*	No change
	Single-Brooded	57%	*Moderate concern*	No change
Functional	Bark Prober	15%	*Good condition*	No change
	Ground Gleaner	9%	*Moderate concern*	No change
	High Canopy Forager	9%	*Moderate concern*	No change
	Low Canopy Forager	22%	*Good condition*	Improving condition
	Omnivore	33%	*Moderate concern*	Declining condition
Structural	Canopy Nester	30%	*Moderate concern*	No change
	Forest-ground Nester	13%	*Moderate concern*	No change
	Interior Forest Obligate	37%	*Good condition*	No change
	Shrub Nester	26%	*Significant concern*	No change

Level of Confidence and Data Gaps

Confidence in status assessment of Forest Avian Ecological Integrity from the four-year dataset is medium. Confidence in change between two time periods is medium, and confidence in eleven-year unchanging trend is high. The status and trend of bird species at the BMD Farm property is a data gap, which could be filled by a bird inventory and subsequent bird monitoring program in the fields and other habitats at BMD Farm.

4.4.8. Amphibians & Reptiles

Description

Amphibians and reptiles are valued park resources that may serve as useful bioindicators of environmental stress from changes in wetland extent and quality, atmospheric deposition, climatic change, habitat degradation and habitat loss. At SAGA, key habitats for amphibians include BMD Pond and its fringe wetlands, particularly temporary ponds located north of BMD Pond (Cook et al. 2008).

Data and Methods

Amphibians and reptiles are not currently monitored at SAGA. An inventory of amphibians and reptiles conducted at SAGA in 2001 documented 7 anuran species, 5 salamander species, 2 turtle species and 3 snake species (including two snake species recorded incidentally by park staff), for a total of 17 of the 19 herptile species known or likely to have historically occurred at SAGA (Table 4-27; Cook et al. 2008). The remaining two species reported to occur here, the Jefferson salamander and wood turtle, both designated species of special concern in the state, were observed in SAGA in

the 1980s (Cook 1986, Cook et al. 2008, NH FGD 2009). The former was also detected during park coverboard monitoring in 2011. The most common herptile species observed during the park inventory were spring peeper, red-spotted newt, spotted salamander, and northern green frog.

Table 4-27. Amphibian and reptile species observed at Saint-Gaudens National Historic Site, with conservation status and relevant AmphIBI components. Reptiles are not considered by the AmphIBI. See text for details.

Common Name	Scientific Name	Comments
American toad	*Anaxyrus americanus*	Tolerant
Gray treefrog	*Hyla versicolor*	–
Spring peeper	*Pseudacris crucifer*	Tolerant
American bullfrog	*Lithobates catesbeiana*	Tolerant
Northern green frog	*Lithobates clamitans melanota*	Tolerant
Pickerel frog	*Lithobates palustris*	Sensitive
Wood frog	*Lithobates sylvatica*	Sensitive, Target species
Jefferson salamander[1]	*Ambystoma jeffersonianum*	NH SC and SGCN
Spotted salamander	*Ambystoma maculatum*	Sensitive, Pond-breeding salamander, Target sp.
Northern dusky salamander	*Desmognathus fuscus*	–
Northern two-lined salamander	*Eurycea bislineata*	–
Eastern red-backed salamander	*Plethodon cinereus*	Tolerant
Red-spotted newt	*Notophthalmus viridescens viridescens*	Sensitive, Pond-breeding salamander
Common garter snake	*Thamnophis sirtalis sirtalis*	–
Northern ringneck snake[2]	*Diadophis punctatus edwardsii*	–
Eastern milksnake[3]	*Lampropeltis t. triangulum*	–
Common snapping turtle	*Chelydra serpentina serpentine*	–
Eastern Painted turtle	*Chrysemys picta*	–
Wood turtle[4]	*Glyptemys insculpta*	NH SC and SGCN , Historic observation

[1]Egg masses of this species observed in park by Cook (1986) and an individual observed in 2011 (S. Walasewicz, unpublished data).

[2]Neonates observed incidentally by park staff inside park buildings during the 2000s (Cook et al. 2008).

[3]Observed by Cronan et al. (1981) and an incidental observation by park staff in 2007 (Cook et al. 2008).

[4]Historical observation; two adult males observed in Blow-Me-Down brook by Cook (1986) but no recent observations.

Coverboard arrays were monitored by students and interns for amphibian abundance at two park sites from 2010-2015. All six species of amphibians known to inhabit the park were detected, including a single observation of a Jefferson salamander in 2011 at the Ravine Trail site (S. Walasewicz, unpublished data). The most frequently detected species was the red-backed salamander, which accounted for >90% of observations and was the only species detected every year. Regression analysis was used to determine trend in autumn counts of red-backed salamanders from 2010-2015.

Assessment Points

The Ohio Environmental Protection Agency has developed an Amphibian Index of Biotic Integrity (AmphIBI) to assess the quality of forested and shrub wetlands, based on characteristics of the amphibian community (Micacchion 2004). This index provides a tool to assess amphibian community condition. AmphIBI assesses condition based on five metrics of amphibian community composition: three metrics assess the relative abundance of sensitive and tolerant amphibian species, one metric assesses the number of pond-breeding salamanders, and one metric assesses the presence or absence of spotted salamanders or wood frogs (vernal pool breeding species correlated with the availability of forested cover). Species sensitivity to disturbance is estimated using a coefficient of conservatism (C of C) ranging from 1 to 10, with higher numbers assigned to sensitive species. A maximum of 10 points is awarded for each metric, which are summed to yield a maximum total index score of 50 points. Micacchion (2011) identified index scores >= 30 as superior wetland habitat, while scores below 20 are considered restorable wetland habitat (10-19) or limited wetland habitat (<10). Accordingly, we suggest assessment points for amphibian community condition as shown in Table 4-28, suggesting *significant concern* below 20, since this is designated by Micacchion as restorable which indicates management is warranted.

Table 4-28. Suggested assessment points for rating amphibian community condition (adapted from Micacchion 2011).

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
AmphIBI score	30 – 50	20 - 29	< 20

Condition and Trend

Current monitoring data were not available to assess condition and trend of amphibians and reptiles at SAGA. Looking at a 2001 dataset from the park Amphibian and Reptile Inventory (Cook et al. 2008), SAGA achieved an overall AmphIBI score of 23, showing *moderate concern*, with two of five AmphIBI metrics receiving high scores (>=7 out of 10). Amphibian species sensitive to disturbance (wood frog, spotted salamander, red-spotted newt) and pond-breeding salamanders are represented in the amphibian community, and vernal-pool breeding species associated with forest cover are present. Abundant individuals of stress-tolerant species (spring peepers, northern green frogs and eastern red-backed salamanders) are also present. Numbers of red-backed salamanders observed beneath coverboard arrays showed an unchanging trend from 2010 to 2015.

Level of Confidence and Data Gaps

Current status was not assessed. Confidence in six-year unchanging trend is low. A monitoring program based on anuran calling surveys, stream salamander surveys, salamander egg mass surveys, and periodic trapping of aquatic turtles would generate useful monitoring data for trend analysis (Cook et al. 2008).

4.4.9. Mammals

Description

National park units provide important habitat for native mammal species, which in turn play important roles in park ecosystems as consumers of park vegetation and as predators. Data describing the status and trends in key mammal populations provides valuable information to park managers.

Data and Methods

Park resource staff monitor wildlife using automatic cameras; however that data was not available for this assessment. A mammal inventory conducted at the park in 2004 surveyed the mammal community at 21 sampling points (10 traps and 11 indirect measure sites such as camera or trackplate) within six community types (riparian, wetland, field, conifer forest, mixed forest and deciduous forest; Gilbert et al. 2008). They detected 22 native mammal species (Table 4-29), in addition to the domestic dog; while the park bat inventory documented six bat species (Gates and Johnson 2012). In addition, park monitoring has detected bobcat, gray fox and opossum, while park observers have reported sightings of striped skunk, beaver, and woodchuck as well as river otter slide marks (K. Jones, personal communication, iNaturalist 2018). Additional species detected by previous surveys (masked shrew, star-nosed mole, hairy-tailed mole, and gray squirrel) are likely to still exist in the park, while the current status of muskrat is less certain (Cook 1986, Cronan et al. 1981, Gilbert et al. 2008). Fisher was the mammal most commonly detected during the inventory, and is widespread throughout the park, while white-footed mouse was the most commonly captured mammal (Gilbert et al. 2008). The moose has been designated a species of greatest conservation need in NH; this species is affected by brainworm and by winter tick loads (NH FGD 2015).

Table 4-29. Native mammal species other than bats documented within Saint-Gaudens National Historic Site. Park monitoring observations were caught on automatic cameras (K. Jones, personal communication).

Common Name	Latin Name	Source
Moose	*Alces alces*	Gilbert et al. 2008
White-tailed deer	*Odocoileus virginianus*	Gilbert et al. 2008
Coyote	*Canis latrans*	Gilbert et al. 2008
Gray fox	*Urocyon cinereoargenteus*	Park monitoring
Red fox	*Vulpes vulpes*	Gilbert et al. 2008
Bobcat	*Lynx rufus*	Park monitoring
Striped skunk	*Mephitis mephitis*	Cook 1986
River otter	*Lontra canadensis*	Park Cook 1986

Table 4-29 (continued). Native mammal species other than bats documented within Saint-Gaudens National Historic Site. Park monitoring observations were caught on automatic cameras (K. Jones, personal communication).

Common Name	Latin Name	Source
Fisher	*Martes pennanti*	Gilbert et al. 2008
Ermine	*Mustela erminea*	Gilbert et al. 2008
Long-tailed weasel	*Mustela frenata*	Gilbert et al. 2008
Mink	*Mustela vison*	Gilbert et al. 2008
Raccoon	*Procyon lotor*	Gilbert et al. 2008
Black bear	*Ursus americanus*	Gilbert et al. 2008
Viriginia oppossum	*Didelphis virginiana*	Park monitoring
Beaver	*Castor canadensis*	Cook 1986, Cronan et al. 1981
Meadow vole	*Microtus pennsylvanicus*	Gilbert et al. 2008
Red-backed vole	*Myodes gapperi*	Gilbert et al. 2008
Muskrat	*Ondatra zibethicus*	Cook 1986, Cronan et al. 1981
White-footed mouse	*Peromyscus leucopus*	Gilbert et al. 2008
Deer mouse	*Peromyscus maniculatus*	Gilbert et al. 2008
Woodland jumping mouse	*Napaeozapus insignis*	Gilbert et al. 2008
Meadow jumping mouse	*Zapus hudsonius*	Gilbert et al. 2008
Porcupine	*Erethizon dorsatum*	Gilbert et al. 2008
Southern flying squirrel	*Glaucomys volans*	Gilbert et al. 2008
Woodchuck	*Marmota monax*	Cronan et al. 1981
Gray Squirrel	*Sciurus carolinensis*	Cronan et al. 1981
Eastern Chipmunk	*Tamias striatus*	Gilbert et al. 2008
Red squirrel	*Tamiasciurus hudsonicus*	Gilbert et al. 2008
Northern short-tailed shrew	*Blarina brevicauda*	Gilbert et al. 2008
Masked shrew	*Sorex cinereus*	Cook 1986
Smoky shrew	*Sorex fumeus*	Gilbert et al. 2008
Star-nosed mole	*Condylura cristata*	Cook 1986
Hairy-tailed mole	*Parascalops breweri*	Cook 1986

Assessment Points

Assessment points for mammal species other than bat species and white-tailed deer have not been defined. Suggested assessment points for mammal condition could be set based on population monitoring of key species.

Condition and Trend

Mammal condition and trends at SAGA were not determined due to lack of monitoring data.

Level of Confidence and Data Gaps
Mammal condition and trends are data gaps at SAGA.

4.4.10. *Bats*

Description
Bats provide valuable ecosystem services, including insect consumption and pollination. In the northeastern U.S., several bat species have been seriously impacted by white-nose syndrome (WNS), one of the worst wildlife health crises in recent history. Since 2006, WNS has spread across the eastern U.S. and Canada causing major mortality in populations of several species (Ingersoll et al. 2013); the disease was first detected in NH in 2009 (NH FGD 2015). Populations of some affected species (including little brown myotis and tri-colored bat) may be stabilizing at lower levels (Langwig et al. 2012). Bat fatalities at wind energy facilities are also cause for concern (Hayes 2013, Smallwood 2013).

Data and Methods
Data from a draft park bat suvey by Yates et al. (In press) was not available for inclusion in this assessment. A park bat inventory conducted in summer 2010 captured 7 individuals of three species during four nights of mist-netting at three park sites. Additionally, the inventory acoustically detected three additional species, for a total of six species detected in the park (Table 4-30). The most common bat species in the park in 2010 was the big brown bat, and this species has been observed inside the Beaman Barn at BMD Farm (Gates and Johnson 2012).

Table 4-30. Conservation status and detection of bat species in Saint-Gaudens National Historic Site. Detection status was reported by Gates and Johnson (2012) and by Bat Conservation and Management (2002).

Common Name	Scientific Name	Conservation Status	Detection during 2010 Inventory	Detection during 2002 Survey
Little brown myotis*	*Myotis lucifugus*	NH SGCN	Acoustic	Capture
Northern long-eared myotis*	*Myotis septentrionalis*	US and NH Threatened	Acoustic	Capture
Big brown bat*	*Eptesicus fuscus*	NH SGCN	Capture, Acoustic	Capture
Eastern red bat	*Lasiurus borealis*	NH SC and SGCN	Capture	Not detected
Hoary bat	*Lasiurus cinereus*	NH SC and SGCN	Capture	Not detected
Tri-colored bat*	*Perimyotis subflavus*	NH SC	Acoustic	Not detected

* designates species are affected by white-nose syndrome

A state-wide bat survey included two nights of mist-netting and acoustic data capture at SAGA in summer 2002, prior to the discover of WNS in the region (Bat Conservation and Management 2002). They captured 41 individual bats of at least 3 species at SAGA (Table 4-30), and the acoustic data has not been analyzed (S. Walasewicz, personal communication). The most common bat species in the park in 2002 was the little brown bat. Also, the state Fish and Game Department (NH FGD)

monitors winter bat populations in known hibernacula in the state, providing state-level bat population data.

Assessment Points

Monitoring data is not currently available to assess bat condition for SAGA. If bat monitoring is undertaken, the assessment points shown in Table 4-31 could be used to interpret bat condition from acoustic monitoring data, using recorded calls per hour as an index of bat activity compared to baseline data.

Table 4-31. Proposed assessment points for bat condition.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Bat activity	>= 80% of baseline	50% to 80% of baseline	< 50% of baseline

Condition and Trend

Capture rates of northern myotis and little brown myotis declined between the time of the 2002 survey and the 2010 park inventory. State-wide, winter counts of little brown myotis, northern long-eared myotis and tri-colored bat in hibernacula declined 99% from 2009 to 2011 (NH FGD 2015). In a regional study compiling data from Vermont to Virginia, populations of big brown bat showed declines of 40% since the onset of WNS (Turner et al. 2011).

Level of Confidence and Data Gaps

Bat condition at SAGA is a priority data gap, given the conservation status of bat species occurring here. If additional inventory and monitoring of bats occurs, sampling during spring and fall migration, in addition to the summer breeding season, would target potential rare and endangered species and common species not documented in the 2010 inventory (Gates and Johnson 2012). NPS has developed preliminary guidance for acoustic bat monitoring in parks, covering deployment of detectors, processing of call files, and data management (NPS 2016). The North American Bat Monitoring Program (NABat) also provides standardized methods for monitoring of bat populations using counts and acoustic analysis, and for analysis of resulting datasets (Loeb et al. 2015).

Any efforts to exclude bats from the Beaman Barn should be mitigated by establishing bat houses nearby as alternative roosts. Retention of snags, particularly those with exfoliating bark, and live trees with exfoliating bark (e.g., shagbark hickory), would also improve potential roosting habitat for several bat species (Gates and Johnson 2012).

4.4.11. Terrestrial Invertebrates

Description and Relevance

Invertebrates can be useful indicators of biological condition due to their diversity, abundance, and sensitivity to environmental change. A variety of terrestrial invertebrate taxa may serve as useful indicators of the ground layer (including ants, millipedes, snails, ground beetles, harvestmen and gnaphosid spiders), or the foliage layer (including ants, chrysomelid leaf beetles, theridiid spiders and arctiid moths) while isopods may be useful soil indicator species (Gerlach et al. 2013).

Butterflies are charismatic invertebrates which attract volunteer observers, and bees are critical pollinators which are sensitive to environmental contamination (Porrini et al. 2003, Rabea et al. 2010).

Data and Methods

Data were not available to assess terrestrial invertebrates at SAGA.

Assessment Points

Assessment points have not been defined.

Condition and Trend

Condition and trends cannot be assessed at this time.

Level of Confidence and Data Gaps

This data gap could be filled if funding permits. A protocol for monitoring bee populations was developed for use at National Wildlife Refuges and other locations (Droege et al. 2016).

4.5. Landscapes

Two indicators were included to assess condition and trend for Landscapes:

- Landcover/Connectivity
- Landuse

4.5.1. Landcover/Connectivity

Description and Relevance

Habitat fragmentation is a key threat to biodiversity. In general, large forest patches disproportionately support larger populations of fauna and more native, specialist, and forest interior species (Harris 1984, Forman 1995). The impacts of fragmentation have been especially well documented upon avian communities, and population declines of a variety of forest interior avian species are linked to habitat fragmentation (Austen et al. 2001, Boulinier et al. 2001). National historic parks and sites are particularly vulnerable to impacts from fragmentation due to their relatively small size and layout, typically determined by the location of historical features; both of these factors can increase vulnerability to fragmentation beyond park borders. These parks may also be more vulnerable to fragmentation due to their mandate to preserve and interpret historical features, which may include fragmented landscapes.

Data and Methods

Data to interpret the condition of landcover came from several sources. Wang and Nugranad-Marzilli (2009) used Landsat remote sensing data with ground-truthing to assess landcover change within a 5-km (3.1-mile) buffer surrounding the park from 1978 to 2002. Within this buffer, they found a small decline (11%, equivalent to 902 ha) in total forest area and a larger decline (62%, equivalent to 163 ha) in wetland area, with increases in areas of open water (108%, equivalent to 230 ha), herbaceous vegetation (56%, equivalent to 642 ha) and urban land (96%, equivalent to 147 ha).

Miller et al. (2011) assessed forest patch size at SAGA in 2010 using recent, leaf-on 1:6,000 scale orthophotography (Figure 4-24). This analysis will be repeated periodically to update status and determine trends. The NPScape program provides data for assessing status and trends in landscape dynamics within national parks (NPS 2017b). Using the 2011 National Land Cover Database (NLCD), forest density (p) was estimated using an automated moving window analysis within seven categories: intact ($p = 1.0$), interior ($0.9 \leq p < 1.0$), dominant ($0.6 \leq p < 0.9$), transitional ($0.4 \leq p < 0.6$), patchy ($0.1 \leq p < 0.4$), rare ($0.0 \leq p < 0.1$) and none ($p = 0.0$; Figure 4-25; Riitters 2011).

Another source of landscape level data comes from the NALCC's *Connect the Connecticut* project (http://connecttheconnecticut.org/). They sought to identify both aquatic and terrestrial core and buffer habitat areas in the Connecticut River watershed to guide conservation efforts. Core habitats represent the highest priority areas for conservation of ecosystems and species, while buffer areas are those identified as having strong influence on the ecological integrity of nearby core areas. SAGA fell within a high quality buffer for the Connecticut River aquatic core habitat, as well as a second tier terrestrial core area with supporting landscape (McGarigal et al. 2017). [10]

[10] See https://nalcc.databasin.org/datasets/c80764173c644bd594056e341c90ac70 and https://nalcc.databasin.org/datasets/923b6870cced4168862ce8ce927169f9

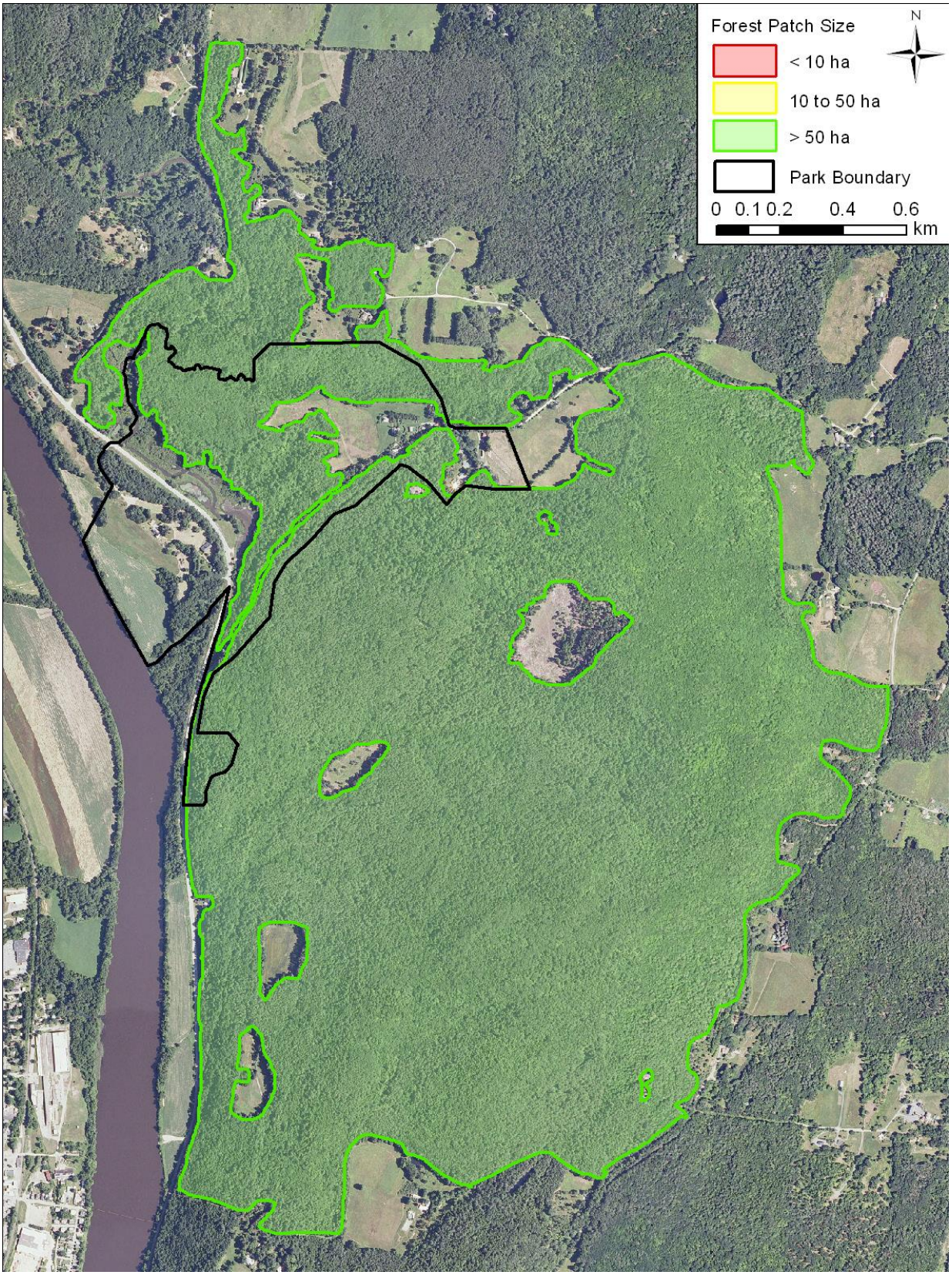

Figure 4-24. Forest patch size delineated at Saint-Gaudens NHS (excerpted from Miller et al. 2011).

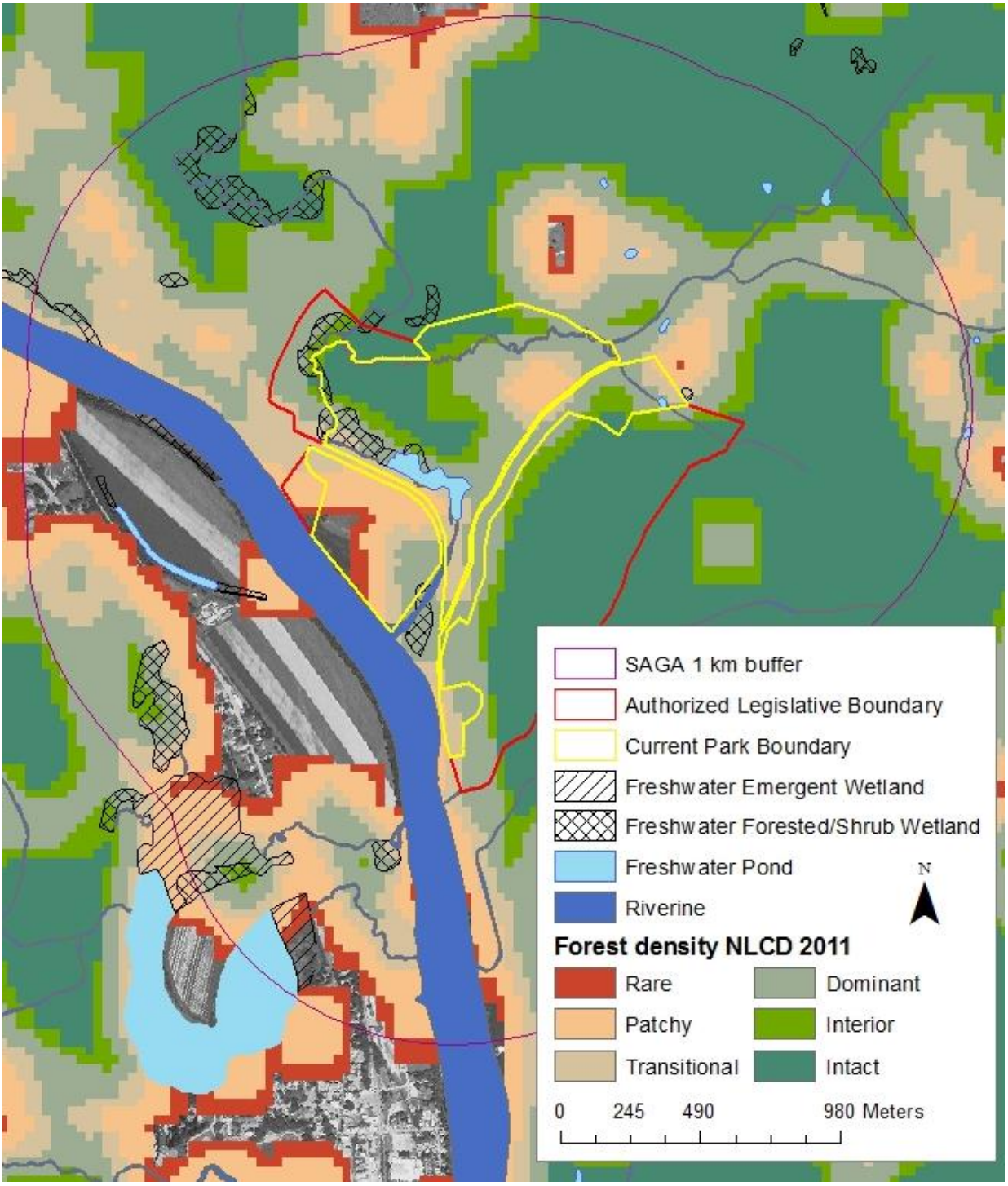

Figure 4-25. Forest density at Saint-Gaudens National Historic Site.

Assessment Points

Miller et al. (2011) assessed ecological integrity of forest patch size based on the needs of invertebrates, small mammals and bird species dependent upon intact forest habitat (Kennedy et al. 2003). SAGA is too small to support large mammal populations, so the needs of large mammals were

not factored into the assessment points for this metric. Assessment points based on forest density classes are suggested as shown in Table 4-32.

Table 4-32. Assessment points for forest patch size and forest density.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Forest patch size	> 50 ha	10-50 ha	< 10 ha
Forest density	Forested area is predominantly interior or intact class	Forested area is predominantly dominant class	Forested area is predominantly transitional or less dense class

Condition and Trend

Miller et al. (2011) delineated SAGA and the surrounding land into two large forest patches separated by Saint Gaudens Road and perforated by lawn and fields (Figure 4-24). All of the park's forested area fell within these relatively large (>50 ha) but perforated patches, which shows *good condition*. Interpretation of forest density from NLCD 2011 imagery shows SAGA forest to be a mix of intact, interior, dominant, and transitional forest classes, warranting *moderate concern* (Table 4-33; NPS 2017b). Trends were not assessed.

Table 4-33. Interpretation of forest density at Saint-Gaudens National Historic Site from National Land Cover Database 2011.

Forest Density	Intact	Interior	Dominant	Transitional
% SAGA Forest	29%	17%	42%	12%

Level of Confidence and Data Gaps

Assessment of condition from two data sources with established assessment points is medium. Trends were not assessed.

4.5.2. Landuse

Description and Relevance

Land conversion to anthropogenic uses eliminates and fragments wildlife habitat and increases sources of local pollution and pathways for invasive exotic species. Land conversion to impervious surfaces increases runoff and reduces water quality and watershed buffering. Small parks are particularly vulnerable to land conversion that occurs outside park borders, particularly conversion occurring upstream of park wetlands and water courses.

Data and Methods

Data to assess land use at SAGA came from several sources. Wang and Nugranad-Marzilli (2009) assessed landcover change within a 5-km (3.1-mile) buffer surrounding SAGA from over the 25-year period from 1978 to 2002. Within this buffer, they found an increase (147 ha or 96%) in urban land during this time period. However, this increase may in part be an artifact created by the increase in resolution and spectral bands of later Landsat sensors.

Miller et al. (2011) assessed the percentage of anthropogenic versus natural land use within a 100-m radius circle surrounding each forest plot (Figure 4-26). Using the 2011 NLCD, NPScape provided data describing coverage by impervious surfaces (Figure 4-27; NPS 2017b).

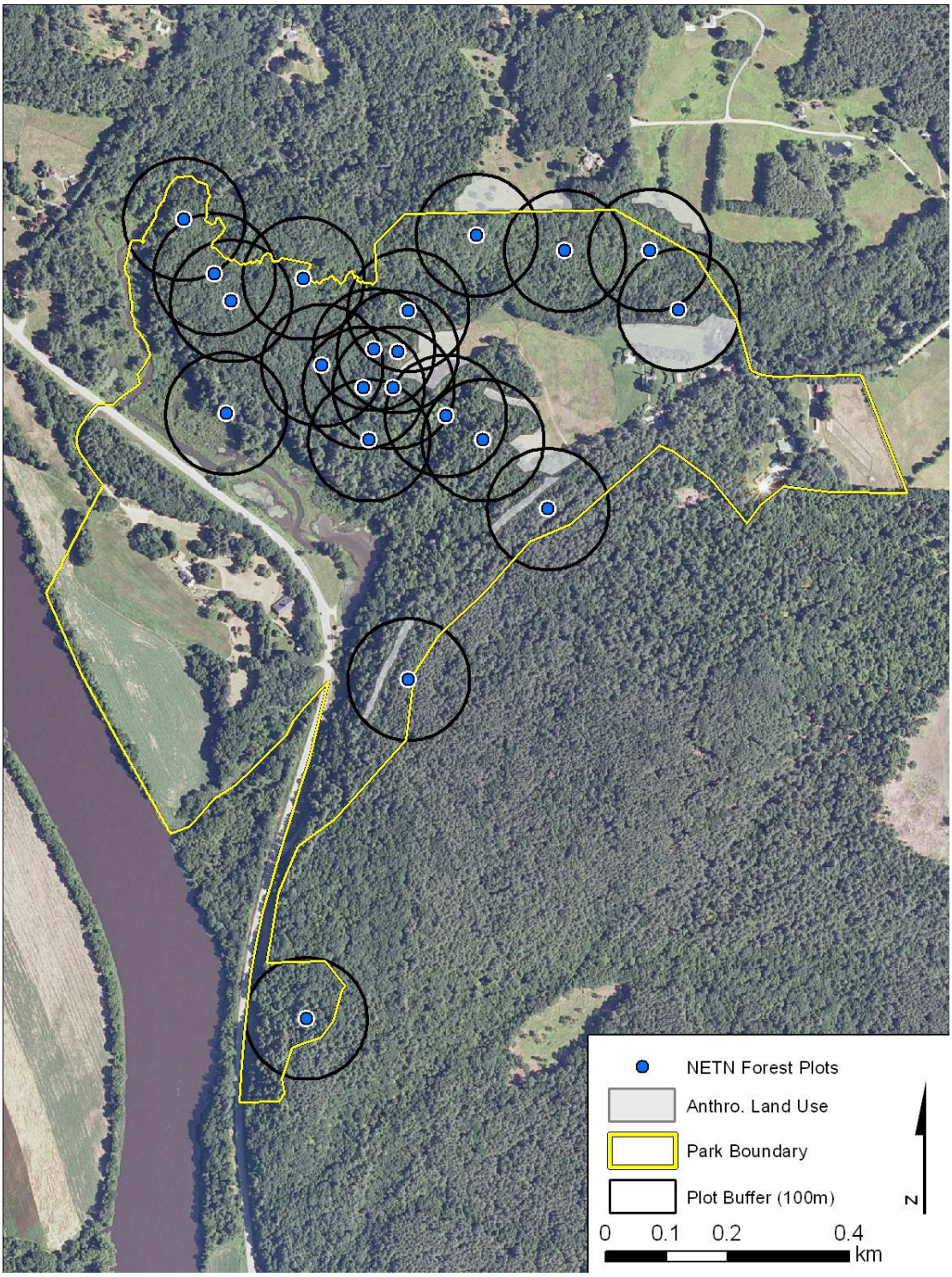

Figure 4-26. Anthropogenic land use surrounding forest plots at Saint-Gaudens National Historic Site (excerpted from Miller et al. 2011).

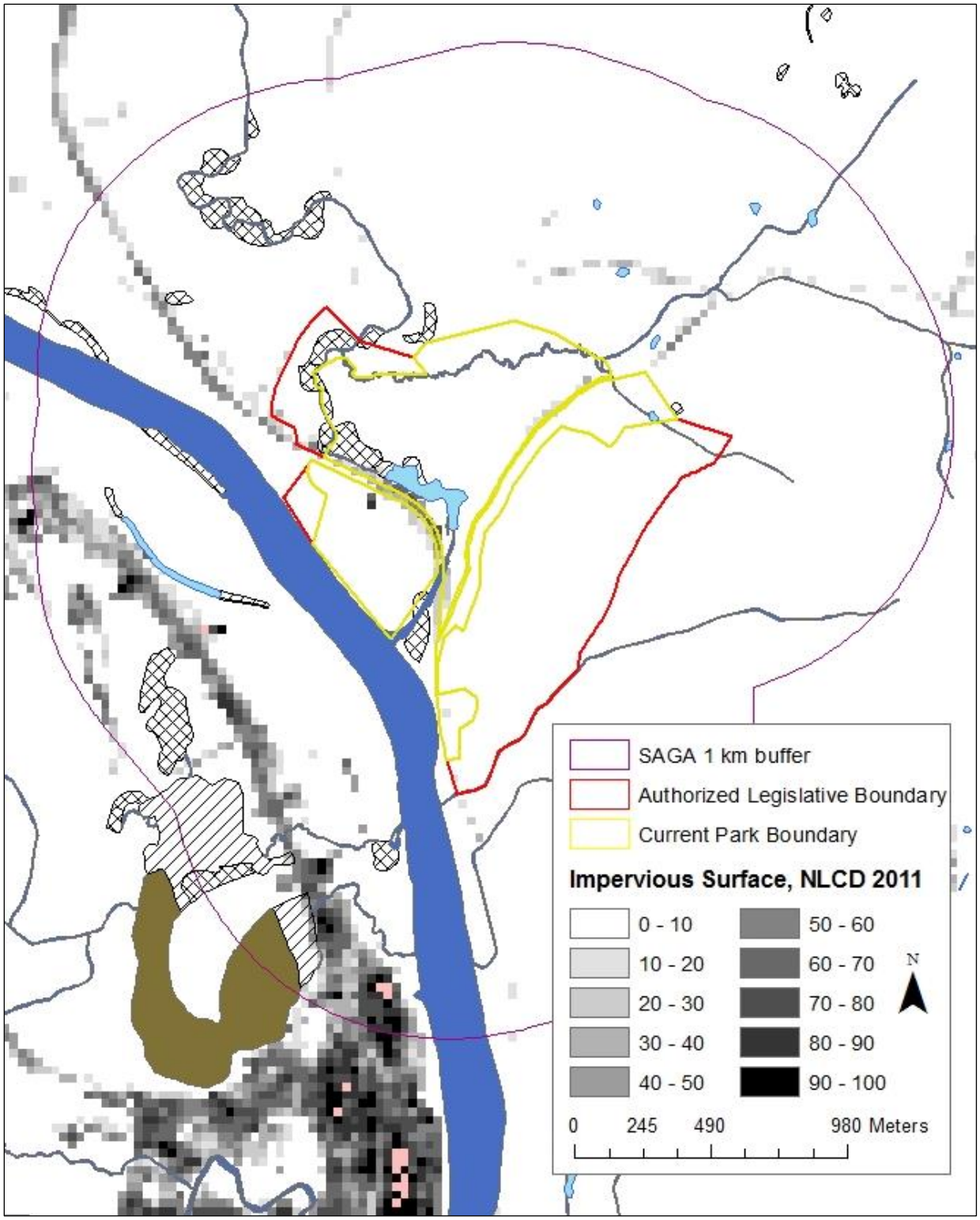

Figure 4-27. Impervious surfaces at Saint-Gaudens National Historic Site.

Assessment Points

Miller et al. (2011) assessed anthropogenic land use (ALU) using the assessment points shown in Table 4-34, based on theoretical models that examined the combined impacts of habitat loss and fragmentation (McIntyre and Hobbs 1999, O'Neill et al. 1997). Wagner et al. (2014) suggested the *good condition* assessment point for impervious cover (IC) used here, based on impacts to water quality and habitat (Goetz et al. 2003, Schiff and Benoit 2007), as well as a second assessment point for *significant concern*.

Table 4-34. Assessment points for land use condition based on anthropogenic land use and impervious cover.

Metric	*Good Condition*	*Moderate Concern*	*Significant Concern*
Anthropogenic land use	< 10%	10 – 40%	> 40%
Impervious cover	< 10%	11 – 25%	> 25%

Condition and Trend

Anthropogenic land use within a 100 m radius surrounding NETN forest plots at SAGA averaged 9.3%, just within the 10% assessment point representing *good condition*. The most common anthropogenic land uses were open lawn and fields maintained either as part of the park's historic core or by neighbors along the park's northeast border. Coverage by impervious surfaces within the SAGA boundary was minimal, falling below the 10% assessment point to warrant *good condition*. Within a 1-km (0.6-mile) boundary surrounding SAGA, land surfaces largely contain <10% impervious cover with the exception of road corridors, particularly the U.S. Route 5 corridor in VT, which lies outside the SAGA watershed, and NH Route 12A, which partially drains into SAGA wetlands.

Level of Confidence and Data Gaps

Assessment of park land use condition based two metrics with established assessment points is medium. Trends were not assessed.

5. Discussion

Assessment of natural resource condition at SAGA reflects condition supportive of a wide variety of native flora and fauna within the park forests, wetlands, water courses and BMD Pond. Due to the park's relatively small size, the condition of natural resources is particularly affected by stressors originating outside of park boundaries, including climate change, air pollution, road impacts, invasive species and regional wildlife trends. Status and trends in park natural resource condition are summarized in Appendix A.

5.1. Data Gaps

This assessment revealed several data gaps which could be filled by additional park monitoring if funding permits. These gaps and potential additional monitoring activities are summarized in Table 5-1. The recently acquired BMD Farm property is a notable data gap, and inventory and monitoring activities should be expanded to include locations at this property.

Table 5-1. Data gaps and potential monitoring activities at Saint-Gaudens National Historic Site.

Data Gap	Potential Monitoring Activities
Blow-me-down Farm	The BMD Farm property is a data gap which could be filled by efforts to map ecological communities, inventory species, and expand monitoring efforts to include this property.
Climate change	Expand efforts to identify and monitor status and trend of key indicators of climate change, and to identify and monitor valued park resources at high risk to climate change impacts.
Visibility and viewshed	Inventory important views from key observation points within the park. Monitor key landscape scenes and viewsheds using time-lapse photography.
Soundscape	Monitor with automated recorders.
Lightscape	Monitor with automated photography using available methods or with simple star counts using citizen scientists.
Stream macroinvertebrates	Monitor using available methods.
Invasive exotic animals	A simple, rapid, annual monitoring program could enable early detection of high priority pests such as HWA and EAB in the park.
Wetland vegetation	Monitor key sites using available methods.
Fish	Consider surveys in overflow pools in the Blow-me-down Pond wetland complex to determine if redbelly dace still inhabits this area. Establish a monitoring program for key species such as brook trout.
Birds	Inventory and monitor bird species at BMD Farm including field habitats.
Amphibians and reptiles	Cook et al. (2008) suggested a monitoring program based on coverboards, anuran calling surveys, stream salamander surveys, salamander egg mass surveys, and periodic trapping of aquatic turtles.
Bats	Monitor bat community with annual, automated acoustic monitoring. Follow up with mist-netting at key sites to confirm status of species of conservation concern.

Table 5-1 (continued). Data gaps and potential monitoring activities at Saint-Gaudens National Historic Site.

Data Gap	Potential Monitoring Activities
Mammals	Monitor using game camera networks for medium or larger mammals, and live-trapping grids for small mammals.
Terrestrial invertebrates	Consider monitoring pollinators, butterflies and moths, isopods, ants, chrysomelid leaf beetles or theridiid spiders.

5.2. Management Recommendations

Early detection of key forest pests and rapid response must continue to be a high priority for the park, and continued diligence in detecting and eradicating exotic pests is critical. Given the importance of eastern hemlock as a foundation species critical for both terrestrial and aquatic park ecosystems, the spread of HWA is a priority threat at SAGA. In addition to an annual monitoring program, the development of a Forest Pest Action Plan for high priority pests in advance of detection would help ensure readiness for rapid response. Such a plan would include some combination of: cultivation of resistant trees; treatment; and post-mortality management of dead trees. Both chemical and biological methods for suppressing HWA are currently being used in other national parks, such as Great Smoky Mountains NP and Delaware Water Gap NRA.

Invasive earthworms cause dramatic changes in forest ecosystems and are very difficult to eradicate. Land managers can focus on limiting the spread of invasive earthworms by restricting the use of bait worms and using best practices for composting and horticulture (Ceballos 2017).

To protect park wetlands, brooks and BMD Pond from chloride, the park could incorporate and publicize best practices for de-icing roads and parking lots, and for water softening. Any new transportation projects within the park watershed should receive careful attention by park staff for impacts to park wetlands, brooks and BMD Pond.

Continuing the use of careful mowing practices in the park will protect wildlife including grassland birds. Mowing should occur as infrequently as possible and should occur at times when turtles and snakes are less active, such as cold times of year (i.e., late fall). If necessary to mow during the warm season, mowing should occur during times of drought and high heat intensity, such as in August, when turtles avoid open areas and bird nesting has finished (Cook et al. 2008). Type of mower, and height, speed, and pattern of mowing can all affect small animal mortality and should be carefully considered (MA NHESP 2009).

Low levels of standing dead trees (snags) and coarse woody debris (CWD) limit the availability of valuable habitats in the park. Park managers may allow these structural features to continue to accumulate by leaving snags and CWD in place whenever possible. Retention of snags, particularly those with exfoliating bark, and live trees with exfoliating bark (e.g., shagbark hickory), would also improve potential roosting habitat for several bat species (Gates and Johnson 2012). In addition, efforts to exclude bats from the Beaman Barn should be mitigated by establishing bat houses nearby as alternative roosts (Gates and Johnson 2012).

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Appendix A: Vital Sign Report for Saint-Gaudens National Historic Site

Table A-1. Conditions and trends of vital signs at Saint-Gaudens National Historic Site.

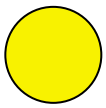
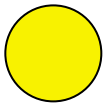
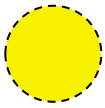
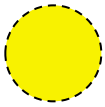
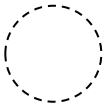
Category	Vital Sign	Condition & Trend	Findings
Air and Climate	Ozone		Estimated ozone pollution (2011-2015) warranted *moderate concern* for human health, and showed *good condition* for park vegetation. Data was not sufficient to assess trend. Ozone pollution reflects regional trends resulting from activities occurring outside NPS boundaries.
	Acidic deposition & stress		Estimated wet deposition of nitrogen (2011-2105) warranted *moderate concern* for acidic deposition, while estimated wet deposition of sulfur warranted *significant concern* to sensitive park ecosystems. Regional trends are improving. Acidic deposition reflects regional trends resulting from activities occurring outside NPS boundaries.
	Visibility & particulate matter		Estimated impairment of park views due to anthropogenic haze (2011-2015) warranted *moderate concern* for visibility and particulate matter. Regional trends are improving. Visibility is impaired by pollution from activities primarily occurring outside NPS boundaries.
	Mercury contamination		Estimated mercury wet deposition (2013-2015) and predicted MeHg concentration in park surface waters warranted *moderate concern* for mercury contamination. Data was not sufficient to assess trend. Mercury deposition reflects regional trends resulting from activities occurring outside NPS boundaries.
	Climate & Phenology		Changes in temperature and precipitation over the historical record warrant *significant concern*. Climate change reflects global and regional trends resulting from activities occurring outside NPS boundaries.
	Soundscape		Modeled data suggest anthropogenic sound may reduce park listening area 30 - 50%. Soundscape is affected activities originating from both within and outside NPS boundaries.
	Lightscape		Modeled data suggest anthropogenic light sources visibly impact park views of the night sky. Lightscape is affected by sources originating from both within and outside NPS boundaries.
	Viewshed		Viewshed is a data gap. Consider identifying key park views to monitor using time-lapse photography.

Table A-1 (continued). Conditions and trends of vital signs at Saint-Gaudens National Historic Site.

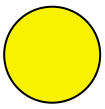
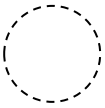
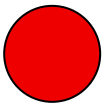
Category	Vital Sign	Condition & Trend	Findings
Geology and Soils	Forest soil condition		Analysis of forest soils (2010-2012) indicated soils were well buffered, but warranted *significant concern* for nitrogen saturation and *moderate concern* for aluminum toxicity. Data was not sufficient to assess trends. Forest soil condition is affected by activities occurring both within and outside NPS boundaries.
Water	Water quantity		Assessment points for water quantity are not defined. Ten-year (2007-2016) trends in stream discharge for Blow-me-up and Blow-me-down Brooks were unchanging. Water quantity is affected by factors originating from both within and outside NPS boundaries.
	Water quality		Water quality in Blow-me-down Pond and two streams showed *good condition* for many metrics, but warranted *moderate concern* for high phosphorus levels, mercury and aluminum contamination, and for deteriorating trends in chloride and total phosphorus. Water chemistry is affected by activities originating from both within and outside NPS boundaries.
	Stream macroinvertebrates		Stream macroinvertebrates are a data gap. Consider monitoring using available protocols.
Biological Integrity	Invasive exotic plants		Invasion of Blow-me-down Pond and park forests by exotic plants warranted *moderate concern*, and showed a deteriorating eight-year trend in forest habitats. The spread of invasive exotic plants is affected by activities occurring both within and outside NPS boundaries.
	Invasive exotic animals		Hemlock wooly adelgid has been detected in Sullivan County, both the emerald ash borer and winter moth have been detected in neighboring counties, and crazy snake worm (*Amynthas agrestis*) has been detected in the park. These invasive exotic pests are a *significant concern* to park ecosystems. The spread of invasive exotic animals reflects regional trends resulting from activities occurring outside NPS boundaries.
	Wetland vegetation		Wetland vegetation is a data gap. Preliminary assessment of wetland buffers indicated *moderate concern* for buffer width.

Table A-1 (continued). Conditions and trends of vital signs at Saint-Gaudens National Historic Site.

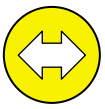
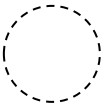
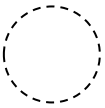
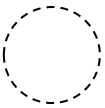
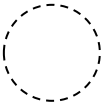
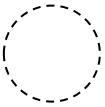
Category	Vital Sign	Condition & Trend	Findings
Biological Integrity (cont.)	Forest vegetation		Forest vegetation fell short of desired late-successional forest structure, warranting *moderate concern*. Low levels of standing dead trees (snags) and coarse woody debris warranted *moderate concern,* and no significant trend was detected. Tree regeneration and tree mortality showed *good condition*, while tree foliage damage warranted *moderate concern*. Forest condition is affected by activities occurring both within and outside NPS boundaries.
	White-tailed deer		Mean regional deer density estimates (2013-2015) indicated good condition with an unchanging eleven-year trend (2005-2015). Assessment of deer-browse indicator species in forest plots also indicated *good condition*. White-tailed deer herbivory reflects regional trends resulting from activities occurring both within and outside NPS boundaries.
	Fish		Fish communities are a data gap. Consider monitoring to determine status and trends of key species or guilds.
	Birds		For 2011-2014, six of thirteen forest bird condition guilds showed *good condition* for ecological integrity, while another six guilds warranted *moderate concern*, and one guild warranted *significant concern*. The majority of guilds showed no change between two time periods (2007-2010 and 2011-2014).
	Amphibians and reptiles		Current condition of amphibian and reptile communities is a data gap. Sensitive species, pond-breeding salamanders and vernal pool-breeding amphibians were represented in the amphibian community during the park inventory in 2001. Numbers of red-backed salamanders observed beneath coverboard arrays from 2010 to 2015 showed an unchanging trend.
	Mammals		Population trends for mammal species are a data gap. Consider monitoring to determine status and trends of key species or guilds.
	Bats		Population trends for bat species are a data gap. Consider monitoring to determine status and trends of key species or guilds.
	Terrestrial Invertebrates		Population trends for terrestrial invertebrate species are a data gap. Consider monitoring to determine status and trends of key species or guilds.

Table A-1 (continued). Conditions and trends of vital signs at Saint-Gaudens National Historic Site.

Category	Vital Sign	Condition & Trend	Findings
Landscapes	Landcover /connectivity		Forest patch size was sufficient to support invertebrates, small mammals and many bird species, but patch configuration and perforation has reduced the amount of interior or intact forest habitat, warranting *moderate concern*.
	Land use		Low levels of anthropogenic land use surrounding forest plots and minimal coverage by impervious surfaces both showed *good condition*.

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