National Park Service
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Natural Resource Stewardship and Science

Natural Resource Condition Assessment for Ninety Six National Historic Site

Natural Resource Report NPS/NISI/NRR—2012/523

ON THE COVER
Ninety Six NHS Reenactor Cannon Crew
Photograph by: NPS

Natural Resource Condition Assessment for Ninety Six National Historic Site

Natural Resource Report NPS/NISI/NRR—2012/523

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Prologue

Publisher's Note: This was one of several projects used to demonstrate a variety of study approaches and reporting products for a new series of natural resource condition assessments in national park units. Projects such as this one, undertaken during initial development phases for the new series, contributed to revised project standards and guidelines issued in 2009 and 2010 (applicable to projects started in 2009 or later years). Some or all of the work done for this project preceded those revisions. Consequently, aspects of this project's study approach and some report format and/or content details may not be consistent with the revised guidance, and may differ in comparison to what is found in more recently published reports from this series.

Abbreviations

ANC - Acid Neutralizing Capacity
ARD - National Park Service Air Resources Division
AVIP - Aviation Conservation Implementation Plan
BBS - Breeding Bird Survey
BCI - Bird Community Index
BOD - Biochemical Oxygen Demand
CASTNET - Clean Air Status and Trends Network
COOP - Cooperative Observer Program
COWP - Cowpens National Battlefield
CRMS - Center for Remote Sensing and Mapping Science (UGA Department of Geography)
CUPN - Cumberland/Piedmont Monitoring Network
DO - Dissolved Oxygen
EMF - Ecological Monitoring Framework
EPA - Environmental Protection Agency
FAA - Federal Aviation Administration
HUC - Hydrologic Unit Code
I&M - Inventory and Monitoring
KIMO - Kings Mountain National Military Park
MRLC - Multi-Resolution Land Characteristics Consortium
NAAQS - National Ambient Air Quality Standards
NB - National Battlefield
NCDENR - North Carolina Department of Environment and Natural Resources
NHS - National Historic Site
NISI - Ninety Six National Historic Site
NLCD - National Landcover Dataset
NMP - National Military Park
NPCA - National Parks Conservation Association
NPS - National Park Service
NRCA - Natural Resource Condition Assessment
NRCS - Natural Resource Conservation Service
NTU - Nephelometric Turbidity Unit
NWS - National Weather Service
PIF - Partners in Flight
POMS - Portable Ozone Monitoring Station
PPM - Parts per million
RAWS - Remote Automated Weather Station
SAO - Surface Airways Observation Network
SCDHEC - South Carolina Department of Health and Environmental Control
SCDNR - South Carolina Department of Natural Resources
SCEPPC - South Carolina Exotic Pest Plants Council
SSURGO - Soil Survey Geographic
UGA - University of Georgia
USGS - United States Geological Survey
VOC - Volatile Organic Compounds

Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p. xiii) for more information.

Executive Summary

This report provides a comprehensive assessment of the state of natural resources at Ninety Six National Historic Site (NISI). It also addresses sets of stressors that threaten these resources and the biological integrity of habitats in the park. Because of the relatively recent start of I&M data collections at NISI, this report can also play a role in directing future efforts for monitoring. This assessment focuses on vital signs outlined by the Cumberland/Piedmont Network, and on attributes for which recent I&M data collections have been conducted. Assessed attributes are roughly organized into broad groups of resources as follows: air, water, animal communities, plant communities, and landscape dynamics.

Data used in the assessment included I&M reports and bio-inventories, spatial information, park-commissioned reports, publicly-available data (EPA Storet, National Landcover Datasets), and personal communication with park unit staff and other subject matter experts. No new field data were collected for this report. When available, published criteria were used to derive a condition assessment based on available data, and when appropriate, we identified opportunities for improved data collection to allow for stronger assessment in the future.

Ninety Six National Historic Site commemorates the site of a Revolutionary War battle that began on May 21, 1781 and lasted until June 18, wherein Patriot soldiers fought against occupying British for control of the Star and Stockade Forts. Before the war, the settlement at Ninety Six served as an important colonial trading hub along the Cherokee Path. Visitation averages 50,000-60,000 visitors annually, and the park hosts regular educational events focused on interpretation and reenactment.

Ninety Six National Historic Site represents a small region of protected land amidst a larger complex of mostly rural agricultural area in the central region of the South Carolina Piedmont. Forested land comprises about 75% of the area in the park, and grassy areas and fields that highlight the battlefield sections comprise 15%. There are approximately six kilometers of streams flowing through the park, all of which begin outside its boundary, save a single tributary to Henley Creek that begins near the visitor's center. Palustrine forest borders the bottomland area around Henley Creek where it contains most of the park unit's 46 wetlands, which together comprise approximately six hectares. From recent surveys 364 plants have been documented at NISI, of which 70 were determined to be exotic. Eight sensitive focal plant species were identified, of which three were addressed in this report: Oglethorpe Oak, American columbo, and green-fringed orchid. Recent inventory efforts for vertebrate species have reported 22 fish, 123 birds, 24 mammals, and 31 species of reptiles and amphibians from the park. No state or federally listed threatened or endangered vertebrate species have been reported from the park, although several reported species were of conservation concern.

Several broad classes of potential threats and stressors to natural resources can be identified for NISI. They include:

- Decreased air quality – High ozone concentrations pose human health risks and can cause damage to sensitive vegetation.

- Decreased water quality – High levels of bacterial contaminants and changes in water chemistry can pose human health risks, harm sensitive aquatic species, and can leave waters vulnerable to the effects of atmospheric deposition.
- Exotic plant species – The presence and proliferation of exotic plants can cause loss of native plant diversity and can negatively alter habitat for animal communities.
- Exotic/range-expanding/parasitic animal species – The presence and proliferation of exotic animal species, species outside of their native range, and parasitic species can cause loss of native animal diversity.
- Insect pests – Insect pests can cause loss of native plant diversity and negatively impact animal habitat.
- Altered fire regimes – Loss of fire in an ecosystem can cause loss of plant and animal biodiversity.
- Landscape change – An expansive category including negative impacts from development, human population increases, agricultural land uses, and habitat alteration and fragmentation.

Fourteen ecological attributes were assessed for this report (Figure 1). Of these, five (35.7%) were ranked as good, four (28.6%) were ranked as fair, one (7.1%) was ranked as poor, and four (28.6%) were not assigned a rank due to lack of appropriate data or lack of appropriate ranking protocols. Assessment method and data quality were both highly variable among assessed attributes. Therefore condition rankings are not necessarily directly comparable. In addition, while some stressors such as ozone concentration are clearly quantifiable under a certain framework (e.g. EPA NAAQS), other relevant considerations, such as effects on plants, are not as well understood. Additional protocols are currently underway for vegetation and landscape monitoring, which will aid future condition assessment efforts within parks in the CUPN.

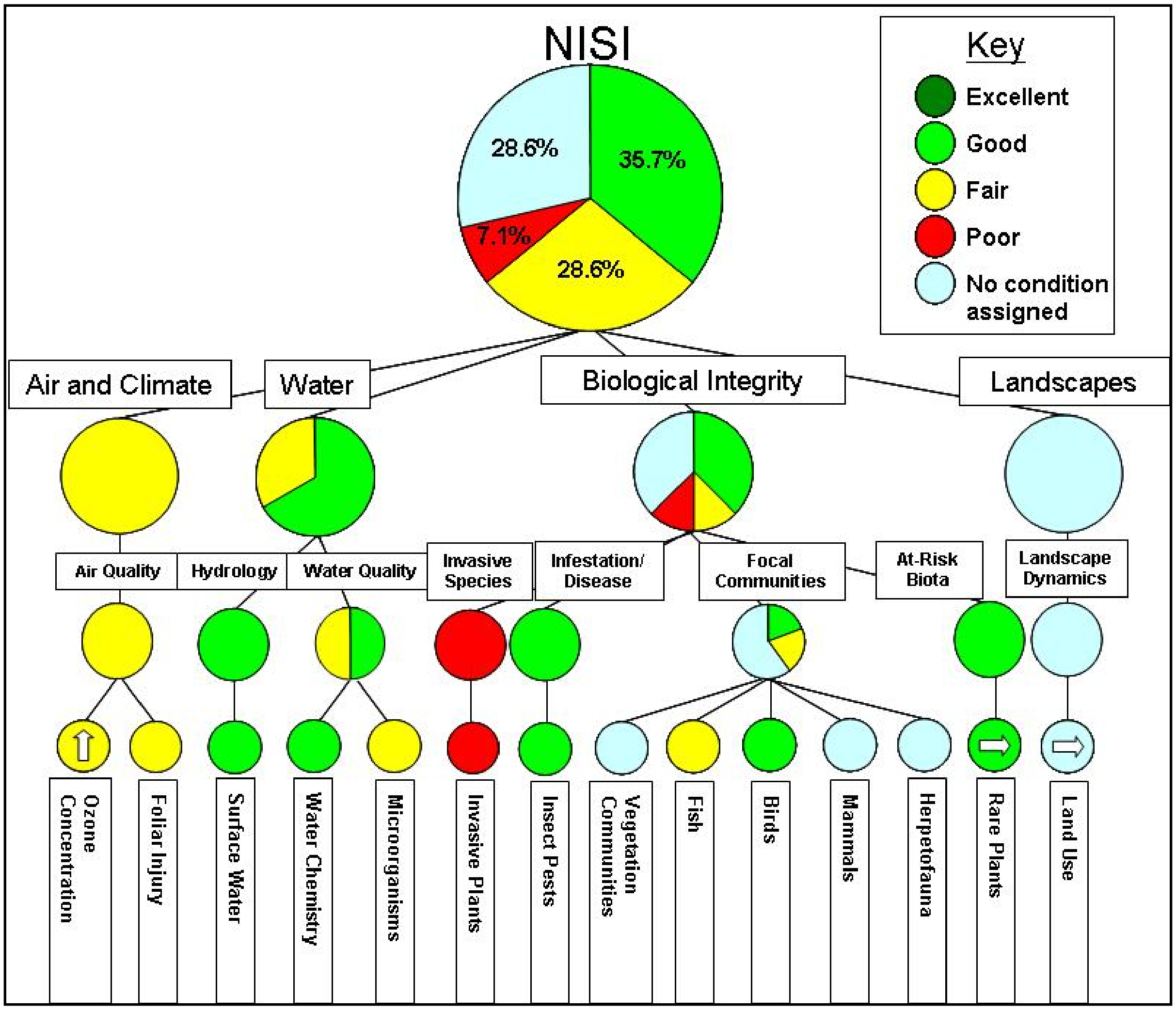


Figure 1. Summary of ecological condition status for Ninety Six National Historic Site. Fourteen attributes from four broad categories were assessed. Numbers within segments of the park-wide pie chart represent percentage of attributes (out of 14) ranked as that status.

Purpose

The objective of this Natural Resource Condition Assessment (NRCA) is to analyze existing data to provide an assessment of the current conditions of key ecological attributes at Ninety Six National Historic Site (NISI). The National Park Service has initiated an Inventory and Monitoring (I&M) Program to collect and analyze data on park natural resources (NPS 2010). Goals of this program include the collection of baseline inventory data on park resources, and the monitoring of key resource condition indicators (NPS 2010). Based on location and natural resource characteristics, the NPS assigned park units to one of 32 ecoregional networks. Each network chose a subset of "vital signs" to represent "physical, chemical, and biological elements and processes of park ecosystems that…represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values" (NPS 2010). Ninety Six National Historic Site is a member of the Cumberland/Piedmont Network (CUPN), and the vital signs chosen by this Network (see Appendix A) received much of the focus of our efforts. This report will assist in establishing baseline conditions, will aid park personnel in future management decisions, and will serve as a summary of key biotic and abiotic ecological attributes.

The primary audience for our report includes park-level superintendents and resource managers, with a secondary focus on regional managers and coordinators. This report will be useful for several decision and management functions including near-term strategic planning, resource and budget allocation, General Management Plan (GMP) and Resource Stewardship Strategy development, and Desired Condition management objectives. In addition, this report will be a valuable contribution for broader directives including assessment of the Department of Interior's "land health goals," or the "resource condition scorecard" created by the Federal Office of Management and Budget (OMB).

Ranking Methodology

We based our ranking framework upon the National Park Service Ecological Monitoring Framework (EMF; Fancy et al. 2009; Table 1). The NPS framework divides monitoring into six general categories: air and climate, geology and soils, water, biological integrity, human use, and landscape pattern and processes (Fancy et al. 2009). Each of these general categories, referred to as level-one, is further subdivided into level-two and level-three categories (Appendix A). Identified NPS vital signs and other attributes assessed in this report were level-three categories. For example, the level-one category biological integrity, is divided into four level-two categories: invasive species, infestations and disease, focal species or communities, and at-risk biota. Invasive species, in turn, includes two level-three categories: invasive/exotic plants and invasive/exotic animals. Using this framework assisted us in selecting a meaningful subset of ecological attributes from a comprehensive list. It provided an organized system to discuss attributes and present findings. And because it is hierarchical, results could be summarized at multiple levels.

To assess park natural resources we considered the current condition of resources, the trend of the current condition, and the quality of the data available for each resource. We developed a list of ecological attributes suitable for condition assessment using 1) level-three category attributes from the monitoring framework described above, 2) the inventory and monitoring goals for the Cumberland Piedmont Network (CUPN; Leibfried et al. 2005), and 3) input from NISI staff. Methods used to assess the condition of each attribute are described in the appropriate sections of this report. When appropriate, we performed statistical comparisons using $a = 0.05$. The condition of each attribute was graphically represented with a colored circle where the color indicated the condition on a four-tiered scoring system of excellent (dark green), good (light green), fair (yellow), or poor (red). For several attributes, a condition was not assigned because available data were insufficient or because we lacked a defensible ranking method. These attributes are indicated with a blue circle.

Table 1. Ecological monitoring framework of essential natural resource attributes that were assessed at Ninety Six National Historic Site for this report.

Ecological Monitoring Framework—NISI			
Level 1 Category	**Level 2 Category**	**Level 3 Category**	**Specific Resource / Area of Interest**
Air and Climate	Air Quality	Ozone	Ozone levels and impact on native plants
	Weather and Climate	Weather and Climate	Existing climate/weather information
Water	Hydrology	Surface water dynamics	Discharge
	Water Quality	Water Chemistry	Temp, pH, specific conductivity, DO, ANC
		Microorganisms	*E. Coli*, fecal, and total coliforms
Biological Integrity	Invasive Species	Invasive/Exotic Plants	Presence/absence, invasibility
	Infestations and Disease	Insect Pests	Gypsy moths, southern pine beetle, Ips beetle
	Focal Species and Communities	Vegetation Communities	Presence of globally-ranked or historically significant communities
		Fish Communities	Diversity
		Bird Communities	Diversity
		Mammal Communities	Diversity
		Herpetofaunal Communities	Diversity
	At-risk Biota	T&E Species and Communities	Oglethorpe Oak (locally listed)
Landscape	Landscape Dynamics	Land Cover and Land Use Change	Changes within/without NISI

When possible, we assigned a trend to the condition of each assessed attribute. We graphically presented condition trend using an arrow within the condition circle. Arrow orientation indicated improving condition (arrow points up), stable condition (arrow points right), or deteriorating condition (arrow points down). As with condition status, we did not assign a trend in cases where data were insufficient, or when we lacked a defensible method to determine a trend. In cases where no trend was assigned, the arrow-shaped trend graphic was omitted from the condition ranking.

For each assessed attribute, we also assessed the quality of the data used to determine the condition. This was done to provide context for the reliability of the rankings and to help identify areas where insufficient data exist. Specific data sources and characteristics are discussed within the narrative of each attribute section. Data quality was assessed using three pass-fail categories—thematic, spatial, and temporal—and was adopted from the data quality ranking utilized by Dorr et al. (2009). The "thematic" category refers to the relevance of the data used to make the assessment, such as whether the attribute of interest was measured directly or inferred from a secondary variable. The "spatial" requirement was met if the available data were spatially relevant for the assessment. The "temporal" requirement was met if the data were collected sufficiently recently to reflect the current condition at the time of publication. An overall data quality rank was assigned by summing the criteria that were met. Data quality was good (green bar) if all three criteria were met, fair (yellow bar) if two were met, or poor (red bar) if one was met. In rare cases where a good condition was assigned to an attribute for which data quality was poor, attention is drawn to the ranking with an asterisk. Data quality is graphically presented beside the condition and trend assessment of each attribute. Table 2 provides examples of the condition graphics used in this report.

We have provided a comprehensive assessment of park condition with the caveat that our analysis is limited by the type and quality of data available, and by the availability of evaluation methods and reference conditions. Although we attempted to assess conditions using relevant and defensible metrics for each attribute, it is important to note that condition rankings are relative for each condition, and identical rankings for different attributes may hold separate meanings and implications. When possible, we used published metrics and established reference thresholds to assign rankings. In cases where no published quantitative metric or standard was available, we used our own judgment, often basing our decision on similar metrics available in the literature.

Table 2. Example condition assessments. Attribute condition is indicated by the color of the circle. Dark green=excellent, light green=good, yellow=fair, red=poor, blue=no condition assigned. Condition trend is indicated by the arrow within the circle. Pointing up=improving condition, pointing right=stable condition, pointing down=declining/deteriorating condition, no arrow=no trend assigned. Checkmarks indicate whether data met the thematic, spatial, and temporal criteria for data quality, as described in the text. The colored bar under the check marks indicates the overall data quality score. Green (good) = 3 checks, yellow (fair) = 2 checks, red (poor) = 1 check. An asterisk (*) brings additional attention when an attribute was ranked as good with data meeting only one quality criterion.

		Data Quality			
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**	**Interpretation**
Example 1:		✓	✓	✓	Condition: Excellent Trend: Improving Data Quality: Good
			3 of 3: Good		
Example 2:	*			✓	Condition: Good Trend: Stable Data Quality: Poor
			1 of 3: Poor		
Example 3:		✓	✓		Condition: Fair Trend: Declining Data Quality: Fair
			2 of 3: Fair		
Example 4:				✓	Condition: Poor Trend: None assigned Data Quality: Poor
			1 of 3: Poor		
Example 5:		✓	✓	✓	Condition: None assigned Trend: None assigned Data Quality: Good
			3 of 3: Good		

Data Description

We used a variety of data sources in this report. Data collected pursuant of I&M program goals were our most important source of information about park resources. We also used other data provided by NPS staff at NISI (e.g. personal communication, unpublished reports, management plans), and relevant data available from non-NPS sources. In some cases, raw data were available in electronic spreadsheets or databases. In other cases, data were taken from written documents. Other data were available for download in electronic form from online databases. Table 3 summarizes the data and sources that were used in the following condition assessments.

Table 3. Data sources used to assess ecological condition of natural resources in Ninety Six National Historic Site.

Attribute	Assessment Measure	Data Sources	Data Description	Data Period
Ozone	4th highest maximum 8-hour average ozone concentration; 2nd highest 1-hr ozone concentration	Portable Ozone Monitoring System (POMS) in NISI	Hourly measurements of ozone concentration within NISI	Three week period June/July 2005
	National IDW 4th highest max 8-hr mean concentration	NPS Air Resources Division (ARD) in collaboration with the University of Denver	Model-interpolated ozone exposure maps using data from general region; 2008 APPR; 2005 – 2008 GPMP Reports	1995-1999 model, 1999-2003 model
	Foliar injury risk predictions (3-metric index)	NPS report for the Cumberland Piedmont Monitoring Network; Kohut (2007)	Kriged predictions extracted from US-wide ozone models; Foliar Injury Risk Assessments	1995-2003
Surface Water Dynamics	Flow (l/sec)	NPStoret data for NISI	Raw water quality monitoring data from quarterly sampling at four stations within NISI	2002-2007
Water Chemistry	Temperature (max, mean), pH (mean), Specific conductance (mean), DO (mean), ANC (mean)	NPStoret data for NISI; NPS Water Quality Monitoring Report for the CUPN (Meiman, 2007/2009)	Raw water quality monitoring data from quarterly sampling at four stations within NISI; Summarized water quality data for NISI	2002-2007
Microorganisms	*E. coli* (mean colonies/100mL); Fecal coliforms (mean colonies/100mL)	NPStoret data for NISI; NPS Water Quality Monitoring Report for the CUPN (Meiman, 2007/2009)	Raw water quality monitoring data from quarterly sampling at four stations within NISI; Summarized water quality data for NISI	2002-2007
Invasive/Exotic Plants	Presence, relative predominance, and invasibility of exotics	NatureServe vegetation assessment (White and Govus, 2003)	Survey and discussion of NISI vegetation	2003
		NPS vegetation collections	Survey of NISI vegetation	2003

Table 3. Data sources used to assess ecological condition of natural resources in Ninety Six National Historic Site (continued).

Attribute	Assessment Measure	Data Sources	Data Description	Data Period
Insect Pests	Presence or absence of gypsy moths	US Forest Service	Report on catches of gypsy moths on federal lands, including NISI lands.	2007-2008
	Risk of infection by southern pine beetle; Ips beetle	US Forest Service, Forest Health Technology Enterprise Team	Southern pine beetle hazard maps for South Carolina	2009
Vegetation Communities	Presence of G2/G3 ranked communities	NatureServe and Center for Remote Sensing and Mapping Science at UGA	Spatially explicit description of NISI vegetation communities	2002
	Wetlands	National Park Service, Tennessee Technological University (Roberts and Morgan, 2007)	Inventory and classification of wetlands for NISI	2003
Fish Communities	North Carolina fish IBI score	National Park Service, SCDNR survey (Scott 2006)	Final report and raw data from electroshock survey of three streams, a small pond, and Star Fort Lake	2005
Bird Communities	O'Connell Bird Community Index (BCI) score	National Park Service, bird survey (Seriff 2006)	Final report and raw data for point count and unconstrained surveys throughout the park	2004-2006
Mammal Communities	Percent of expected species reported	National Park Service, mammal survey (Pivorun 2009)	Progress report, draft final report, and raw data from non-volant mammal trapping and sightings	2006-2008
		National Park Service, bat survey (Loeb 2007)	Final report and raw data from mist netting and acoustic sampling	2005-2007
Herpetofaunal Communities	Percent of expected species reported	National Park Service, herp survey (Reed and Gibbons 2005)	Final report, museum specimen file, from unconstrained searches and coverboards	2003-2005
T&E Species & Communities	Presence of Oglethorpe Oak	National Park Service, NatureServe database	Species occurrence database for NISI	2004
		USDA, online database	Nationwide plant database	2009
Landcover and Use	Land use change	Multi-Resolution Land Characteristics Consortium	Retrofitted landcover change maps to compare 1992 to 2001 NLCD layers	1992-2001
		National Land Cover Dataset	Nationwide landcover datasets	1992-2001
		CRMS	Land cover dataset	2002-2003

Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p. xiii) for more information.

Park Resources and Introduction

Park Location and Significance

Ninety Six National Historic Site (NISI) was designated in 1973 and is located 100 kilometers (60 miles) west of Columbia, SC in Greenwood County, just above the Georgia border and Savannah River (Figure 2). The nearby town of Ninety Six is located two miles north of the park on Highway 248. The park comprises a total of 414 hectares (1,022 acres), and features an original earthen fortification—the 1781 Star Fort (Figure 3)—and is also the site of two significant Revolutionary War battles. The name Ninety Six refers to the distance of the Cherokee Path, a commercial trading route, from the historic town of Ninety Six to the Cherokee town of Keowee in the Blue Ridge foothills, near where Clemson, SC is today.

Park Objectives

Ninety Six National Historic Site was established by congress in 1976 to "preserve and commemorate…an area of unique historical significance associated with the settlement and development of the English Colonies in America and with the southern campaign of the American Revolutionary War…." (P.L. 94-393). Initial land acquisitions for the park were made solely to obtain and protect significant historic sites (Rehm 1988). Pursuant of the Centennial Initiative, a service-wide initiative for parks to set strategies for the future, NISI managers produced a Centennial Strategy (NPS 2007). Goals in NISI's Centennial Strategy included improvements to park buildings and educational facilities, extensive archeological surveys, and further restoration of the site towards the historical conditions existing in the late 18th century.

Climate, Geology, and Soils

NISI falls within the temperate region of South Carolina, and has an average annual temperature of 15.9 degrees Celsius (ºC), with mean annual maximum and minimum temperatures of 22.7 ºC and 9.2 ºC, respectively. The average annual precipitation is 116 cm (45.7 inches).

Ninety Six NHS is located in the Piedmont of South Carolina, in the Charlotte terrane geologic zone. The geology is characterized by high-grade felsic gneisses and amphibolites, with local regions of gabbro igneous rock. Soil series within the park include Chewacla, (fine-loamy, mixed, active, thermic, Fluvaquentic Dystrudepts), Coronaca (fine, kaolinitic, thermic, Rhodic Paleudalfs), and Mecklenburg (fine, mixed, active, thermic, Ultic Hapludalfs). Chewacla soils are typically located on alluvial land adjacent to streams and are poorly to moderately well-drained. Coronaca soils typically occur on two to ten percent slopes, are moderately to well-drained and represent weathered hornblende, gabbro, or diorite. Mecklenburg soils are deep, well-drained, and occur on gentle to steep slopes with red and brownish-yellow subsoils (NRCS 2006). Together these three series and their associations comprise 72% of the soils in the park.

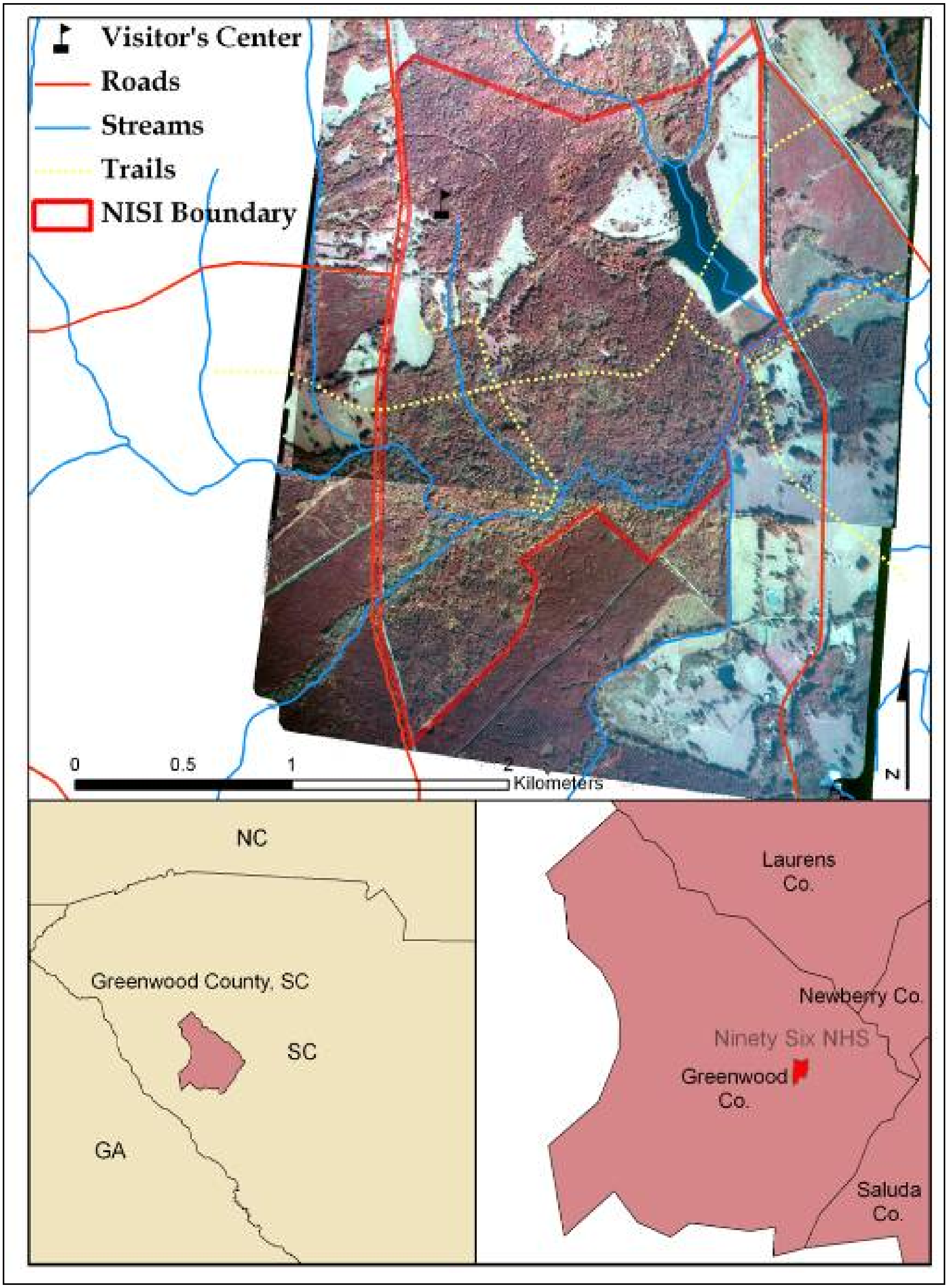


Figure 2. Ninety Six National Historic Site location within Greenwood County, SC.

Figure 3. The Star Fort [Source: NPS 2008a]

Hydrology

A variety of waterways are located within a few kilometers of the park including Lake Greenwood, the Savannah River, Cuffytown Creek, and Coronaca Creek. Henley Creek and Tolbert Branch both flow through the park unit and are fed by two unnamed tributaries, one of which is outflow from Star Fort Pond. In addition, two unnamed tributaries enter Star Fort Pond from slightly north of the park unit.

NISI falls within the Saluda hydrologic cataloging unit (HUC 03050109), which is part of the Santee hydrological accounting unit (HUC 030501; Figure 4). The water resources of NISI are classified as Category Three by the I&M monitoring plan, meaning that they lack a significant role in the aesthetic or establishment of the park, and contain no rare aquatic species. Quarterly water quality and monitoring data has been collected during even-numbered years since 2004 (Meiman 2009).

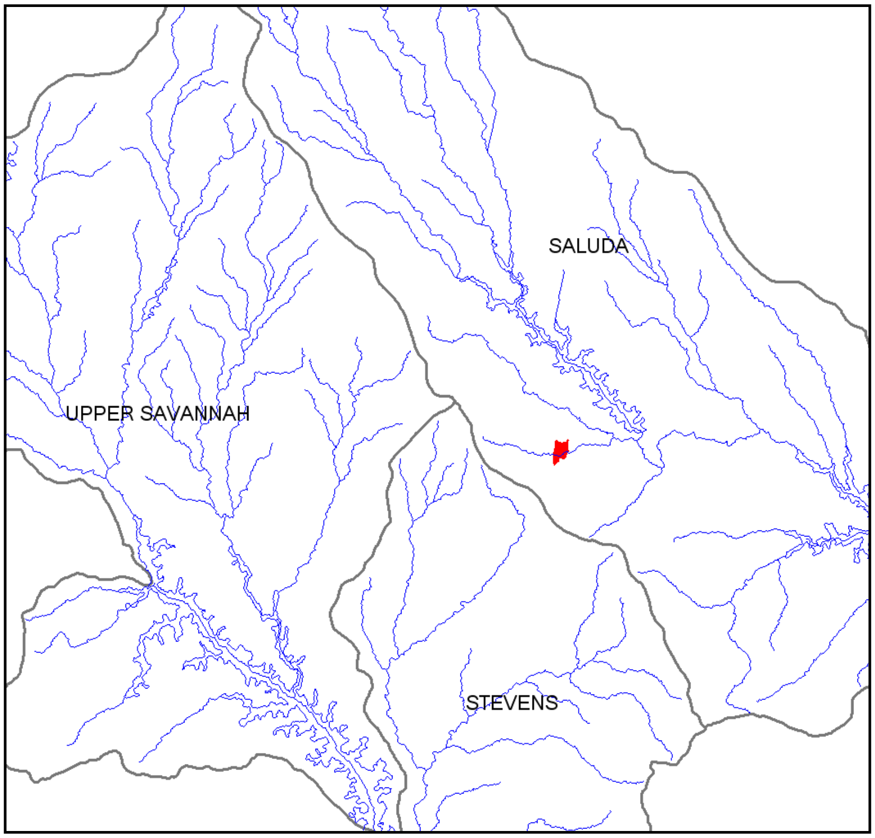


Figure 4. Location of NISI (in red) within the Saluda cataloging unit (HUC 03050109).

History and Park Significance

The original town of Ninety Six was settled by Robert Gouedy in 1751, and soon grew into an important trading depot along the Cherokee Trail. The settlement served as an important British post and also helped maintain a connection with Cherokee allies to the west. When British Loyalists confronted Patriots on the site of Ninety Six in November 1775, there were at least 100 villagers living in the surrounding area (NPS 2008A). In 1781, Nathanael Greene, a general in the Continental army, laid siege to the Loyalist-held Ninety Six site with an attempt to overrun the Star Fort. His attack was unsuccessful, and Greene left Ninety Six to the Loyalists after twenty-eight days of fighting making the siege of Ninety Six the longest siege of the American Revolution. The Loyalists were ordered to burn the town, leaving it in ruins. Later that decade, people began to resettle the area, which then was known as Cambridge, though this resettlement was short-lived and mostly abandoned by 1815.

Today, the site features many artifacts of historical significance such as the original Star Fort, constructed in 1781, as well as several reconstructed structures such as the Stockade Fort and siege trenches used by Greene and his men during their attack. Other historic roads and trading routes such as the Cherokee Trail and Charleston Road still exist, as do the original town sites of Ninety Six and Cambridge. The current town of Ninety Six is located just over a mile north of the park.

Natural Resources and NPS Vital Signs

Ninety Six NHS is a relatively small area of protected land (414 ha) maintained principally for its military historical significance during the past 250 years. Nevertheless, the original significance of this site as a trading depot along the Cherokee Trail owed much to its setting within the natural resource rich backcountry of SC. At the time of settlement, the region was located in a vast wilderness boasting extensive hardwood forests, multiple streams, and abundant wildlife. Presently, approximately three-quarters of the park, (78%), are forested, which includes 440 acres (45%) of planted pine. Most of the remainder is comprised of open area / field (18%) (MRLC 2009b).

Despite its primary significance as a historic park, NISI still has significant natural resources. As part of the I&M monitoring program, NatureServe established 15 sampling vegetation monitoring plots on a 0.52 km^2 grid, and these surveys confirm that there are many natural resources worthy of preservation within the park boundary (Leibfreid et al. 2005). In particular, Ninety Six NHS boasts a large area of wetland forest including examples of the globally imperiled floodplain canebrake community (NatureServe 2009). Floodplain canebrakes usually consist of thickets of river cane (*Arundinaria gigantea)* and are thought to be fire dependent. Without fire, canebrakes can become less vigorous and are eventually outcompeted by woody vegetation (Platt and Brantley 1997). They provide critical habitat and food for many species of birds such as the hooded warbler (*Wilsonia citrina*), bobwhite quail (*Colinus virginianus*), and wild turkey (*Meleagris gallopavo*) (Platt and Brantley 1997). Ninety Six NHS also contains a population of Oglethorpe oak (*Quercus oglethorpensis*)—a rare southeastern oak (G3).

Natural Resource Conditions

Air Quality

Ozone

Ozone is an atmospheric constituent produced from reactions involving nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. In humans, exposure to high levels of ozone can contribute to respiratory problems, inhibit lung capacity, and overall impair the immune system. High ozone levels are also harmful to plants, and can inhibit agricultural crops as well as natural communities (NPS 2008b). Ozone is one of the main air quality considerations in the CUPN, as well as one of the EPA's criteria pollutants, which it regulates using National Ambient Air Quality Standards (NAAQS). The EPA specifies two thresholds for primary and secondary pollutant limits. Primary limits are set with human health factors in mind, while secondary standards pertain to considerations of visibility, vegetation health, and building integrity. In the case of ozone, the NAAQS lowered primary and secondary standard concentrations starting May 27, 2008 from 0.080 ppm to 0.075 ppm for the specific metric used to measure ozone. This metric, defined as 3-year averages of the 4th highest daily maximum 8-hour average ozone concentration (4th Hi Max 8-hr), results in nonattainment of the NAAQS when it exceeds 0.075 ppm (NPS 2006a).

Monitoring
As part of the CUPN monitoring program, a Portable Ozone Monitoring System (POMS) was established at NISI, which collected hourly measurements of ozone concentrations at NISI for three weeks during June and July of 2005. These were the last ozone data collected inside the park, and after this monitoring season the POMS was rotated among other CUPN parks. Because ozone was only monitored for a 3-week period by the POMS at NISI, this station does not meet the EPA standard for regulatory monitoring of a 3-year average, though the results from this station are still useful for baseline comparison. Also located within 30 km of the park are four National Weather Service Cooperative Observer Program Stations (COOP) and one Surface Airways Observation (SAO) network monitor. Collectively, these stations record basic weather measurements such as temperature, precipitation, visibility, and pressure, though none of them record ozone concentrations (Davey et al. 2007).

During this 3-week monitoring period at NISI, the 4th Hi Max 8-hr ozone concentration was only 0.060 ppm, and none of the days exceeded the 0.075 ppm reference during an 8-hr average (Figure 5). The overall daily average was 0.015 ppm, which is quite low. Previously, the EPA also used to implement a maximum 1-hr standard of 0.120 ppm for ozone concentration—a standard which it revoked in 2005. For NISI, this standard is 0.068 ppm and suggests that the park unit demonstrates little risk of exceeding the EPA standards (NPS 2006).

Interpolated Estimates
Although actual ozone monitoring data is scarce at NISI, the NPS Air Resources Division (ARD) has also produced interpolated national exposure maps for various air quality related variables, including ozone. These interpolations are based on monitoring data collected from the EPA Clean Air Status and Trends Network (CASTNET). Continuous inverse distance-weighted models interpolated 0.085 ppm at NISI as the 4th Hi Max 8-hr metric for the period from 1995-

1999 (Figure 6), with an overall average predicted concentration of 0.033-0.036 ppm. A similar model for the period from 1999-2003 yielded a prediction of 0.084 ppm for the 4th Hi Max 8-hr concentration, with an average concentration of 0.031 ppm, and a final prediction estimated a concentration of 0.076 ppm for the period 2003-2007. These averages are noticeably higher than the daily average over the 3-week monitoring conducted in 2005, the first two of which would represent NAAQS violations if they were based on actual observations within the park. The final average would represent a NAAQS violation under the current threshold of 0.075 ppm, adopted in 2008.

Summary
Historical ozone monitoring is much more extensive at nearby Cowpens NB than at NISI, where concentrations have significantly decreased during the period 1998-2007. It is possible a similar trend is present at NISI, which would explain the lower maximum and average concentrations in 2005 compared to estimates for the previous 10 years, although data at NISI are insufficient to definitively conclude that there has been a significant decline. Considering the earlier ozone estimates, levels appear to be improving and falling below threshold levels. In addition, the earlier estimated concentrations for each 5-yr period are at levels elevated enough to cause concern. Consequently we assigned a "fair" ranking to the ozone condition status at NISI, with an improving trend to reflect the decreasing concentrations over each time period, both predicted and observed (Table 4). Continued data collection from the POMS on Bumble Bee Hill, even if only during the high-ozone summer months, would enhance the ability to detect future changes in this network vital sign. Currently, the POMS is scheduled to return to NISI for monitoring in 2013 as part of the CUPN monitoring program (T. Leibfreid, pers. comm.).

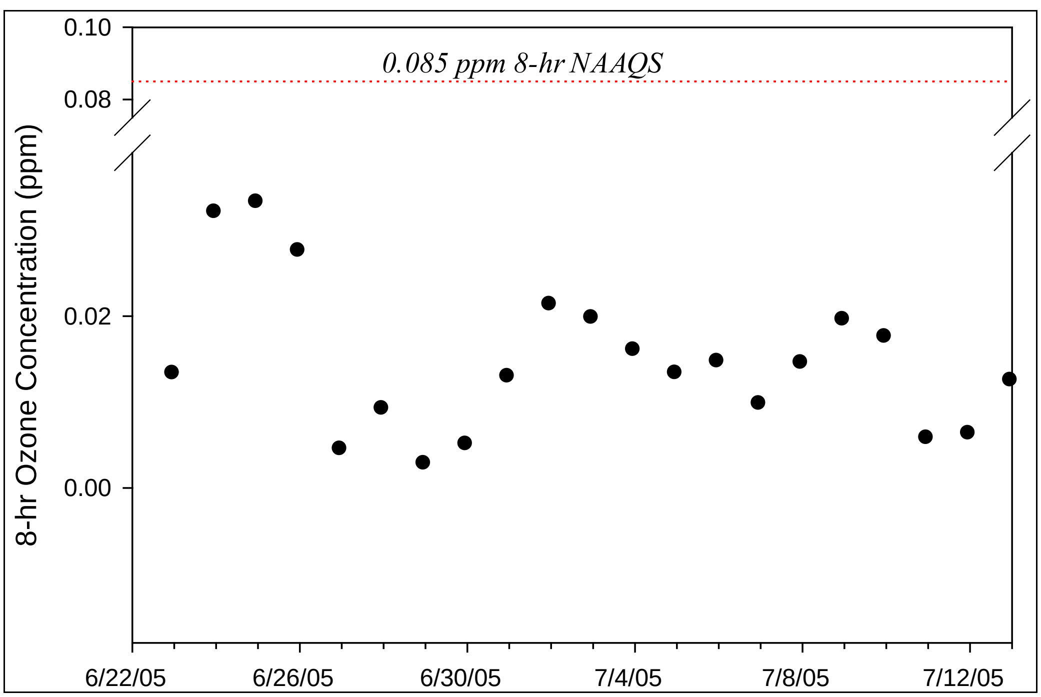


Figure 5. Ozone monitoring at the Bumble Bee Hill POMS in NISI shows low concentrations over its 3-week collection period. These levels were well below the EPA 4th highest max daily 8-hr mean concentration (red line) used as a reference.

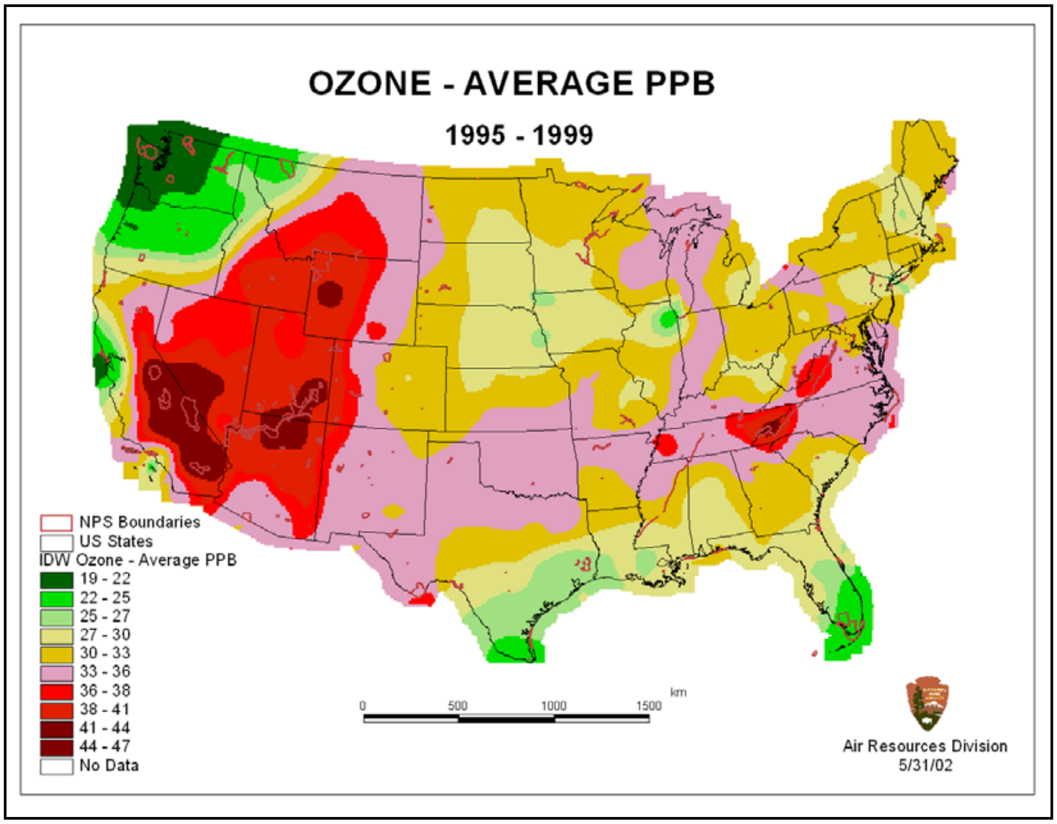


Figure 6. National average ozone predictions for 1995-1999 placed NISI within the range of 0.033 – 0.036 ppm.

Table 4. The condition status for ozone at NISI was good. The data quality used to assess this attribute was good. A trend of improving was assigned to the condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Ozone Concentration	⇧	✓	✓	✓
		3 of 3: Good		

Foliar Injury

Ozone concentrations are linked with deleterious growth or physiological effects in certain sensitive plant species (Ollinger et al. 1997; Lefohn and Runeckles 1987). The NPS ARD also developed foliar injury maps to predict potential harm to vegetation in each of the I&M parks. Out of all of the CUPN parks, NISI was the only park to receive a low risk rating from the ARD in a 2004 assessment of the overall foliar injury risk. Ozone foliar injury metrics for NISI are not measurements, but are kriged (spatially interpolated) predictions extracted from ozone models for the entire US. These metrics are available as yearly predictions from 1995-1999 as part of a 2004 foliar injury assessment report for the CUPN, while predictions are only available as an average over the periods 1999-2003 and 2003-2007 (Table 5). In a separate assessment, Kohut (2007) outlined foliar injury risks for 244 NPS units using exposure indices, plant species, and exposure environment (e.g. temperature and soil moisture), which resulted in an assignment of low risk for NISI.

Table 5. Set of foliar injury indices for NISI (NPS 2004).

NISI Ozone Foliar Injury Indices					
	Sum06	W126	N60	N80	N100
	--ppm-hr--		--hrs--		
1995	20	26	477	59	5
1996	19	24	424	40	2
1997	26	32	583	77	3
1998	38	51	917	195	24
1999	32	43	780	155	13
1995-1999 Mean	**27**	**35**	**636**	**105**	**9**
1999-2003 Mean	**27**	**38**	**--**	**--**	**7**
1995-2003 Mean	**27**	**37**	**--**	**--**	**8**
2003-2007 Mean	**21**	**29**	**--**	**--**	**3**

*Foliar injury indices are provided as a mean prediction from 1999-2003 based on NPS ARD interpolations.

Sum06 (ppm-hr): 8-10 (low), 10-15 (mid), 16+ (high)
W126 (ppm-hr): 5.9-23.7 (low), 23.8-66.5 (mid), 66.6+ (high)
N100 (hr): 6-50 (low), 51-134 (mid), 135+ (high)

Sum06 Metric

To assess the overall foliar injury risk, three indices based on ozone concentrations were developed for a representative group of ozone-susceptible plant species (NPS 2004). The first metric, Sum06, is an index representing the cumulative hourly sum of ozone concentrations ≥ 0.060 ppm between 8 AM and 8 PM over a moving 90-day period. This maximum usually occurs during the summer period. The NPS Air Resources Division classifies 8 cumulative ppm-hours as the threshold for foliar injury, with the potential for growth reduction starting at 10 cumulative ppm-hr (NPS 2004). At NISI, Sum06 prediction values averaged 27 cumulative hours > 0.060 ppm for both of the earlier prediction periods and 21 ppm-hrs for 2003-2007, each of which is well within the region for foliar injury, despite low concentrations of ozone compared to NAAQS (Table 5).

W126 Metric

The second index, W126, is a twofold description which includes the sum of hourly concentrations during the peak ozone season from April through October, and also considers the number of hours where the concentration was ≥ 0.010 ppm for the same period (LeFohn et al. 1997). For the hourly sum, this index weights the values using a sigmoidal function according to the equation

$$W_i = \frac{1}{1 + M * e^{-(A*C_i)}} \qquad \text{(Eq. 1)}$$

where W_i is the weighing factor for concentration C_i in ppm, and M and A are constants (M = 4403 ppm^{-1} and A = 126 ppm^{-1}). The constant A represents the ozone concentration of maximum weighting, and lends itself to the naming of the index. By using this index, higher ozone concentrations are weighted disproportionately greater since they present more of a threat for foliar injury (LeFohn & Runeckles 1987). For W126, highly-sensitive species are affected beginning at 5.9 cumulative ppm-hr, and moderately sensitive at 23.8 ppm-hr. Predictions at NISI for this metric averaged 35, 38, and 29 ppm-hr for respectively for the periods 1995-1999 1999-2003, and 2003-2007, all of which place the metric between the threshold affecting moderately and marginally sensitive species (Table 5).

N100 Metric

The final index is an N-value which corresponds to the number of hours that exceed 0.060, 0.080, and 0.100 ppm. Although these thresholds are relatively arbitrary, ozone concentrations above 0.080 and 0.100 ppm are typically associated with risk for foliar injury (NPS 2004). Like the W126 metric, this one is also separated into three categories for N100 based on plant sensitivity: highly sensitive plants are those affected by ozone levels exceeding 6 cumulative ppm-hr, moderately sensitive plants are affected at levels > 51 ppm-hr, and marginally sensitive plants are affected at levels > 135 ppm-hr. Average predicted indices were 9, 7, and 3 hrs for each monitoring period, respectively. These first two periods fall into the region affecting only highly sensitive species, while the latest prediction falls even below that threshold (Table 5).

Sensitive Species

It is also possible to predict the severity of foliar injury risk in the park unit based on the species composition in the park. To that end, the NPS and the US Fish and Wildlife Service developed a list of ozone sensitive plant species, defined as species that “exhibit foliar injury at or near ambient ozone concentrations in fumigation chambers and/or are species for which ozone foliar symptoms…have been documented” (Porter 2003). Table 6 lists species identified as sensitive to ozone, cross-referenced with NPSpecies to include only species identified at NISI.

Table 6. Nineteen species at NISI were identified as sensitive to ozone based on crosswalking the master NPS list of ozone sensitive species (Porter 2003) with the NPSpecies list for NISI.

Species		Family
Ailanthus altissima	Tree-of-heaven	Simaroubaceae
Apios americana	Groundnut	Fabaceae
Apocynum cannabinum	Dogbane	Apocynaceae
Cercis canadensis	Eastern redbud	Fabaceae
Clematis virginiana	Virgin’s bower	Ranunculaceae
Fraxinus pennsylvanica	Green ash	Oleaceae
Gaylussacia baccata	Black huckleberry	Rosaceae
Liquidambar styraciflua	Sweetgum	Hamamelidaceae
Liriodendron tulipifera	Tulippoplar	Magnolidaceae
Parthenocissus quinquefolia	Virginia creeper	Vitaceae
Pinus taeda	Loblolly pine	Pinaceae
Platanus occidentalis	Sycamore	Platanaceae
Prunus serotina	Black cherry	Rosaceae
Rhus copallina	Winged sumac	Anacardiaceae
Rudbeckia lacianata	Cutleaf coneflower	Asteraceae
Sambucus canadensis	American elderberry	Adoxaceae
Sassafras albidum	Sassafras	Lauraceae
Solidago altissima	Canada goldenrod	Asteraceae
Verbesina occidentalis	Yellow crownbeard	Asteraceae

Soil Moisture

In addition to these exposure indices, soil moisture conditions play a large role in mitigating or exacerbating the potential for foliar injury. During periods of higher soil moisture, injury risk is typically reduced as leaf stomates close, thus reducing ozone uptake (Kohut 2007). Often, the danger of ozone to plants is less than what may be apparent from ozone conditions alone, as environmental conditions that facilitate the production of ozone such as a clear sky, high temperatures, and high UV levels also tend to reduce atmospheric gas exchange in plants. The Palmer Z index (Palmer 1965) attempts to describe soil moisture and its departure from long-term averages for a given month and location by assigning a number in the range ±4.0 based on temperature, precipitation, and available soil water content, with ±0.9 representing the typical range for soil moisture (NPS ARD 2004; Wager 2003).

This method was used to calculate drought indices for the same 3-month and 7-month time periods used to calculate both the Sum06 and W126 metrics (Table 7 and Table 8) from 1995-1999. As the 2004 foliar injury report for the CUPN points out, there is little association between foliar injury metrics and levels of soil moisture at NISI over this five-year period. The only year without drought conditions during the Sum06 assessment period—1995—demonstrated the second lowest Sum06 metric, while the years with the highest metrics—1998 and 1999—showed primarily drought months which likely reduced the risk of ozone exposure. The W126 metric was also minimally variable and showed no clear association with soil moisture.

Table 7. Palmer Z indices for Sum06 at NISI (NPS ARD 2004).

Sum06	Month 1	Month 2	Month 3
1995	2.82	-0.74	4.32
1996	-0.79	-1.08	-1.27
1997	1.59	-1.81	1.46
1998	-0.05	-1.76	-1.77
1999	-0.41	-2.25	0.14

Palmer Z drought index: -1.00 to -1.99 (mild), -2.00 to -2.99 (moderate), -3.00 and below (severe)
1.00 to 1.99 (low wetness), 2.00 to 2.99 (mid wetness), 3.00 and above (high wetness)

Table 8. Palmer Z indices for W126 at NISI (NPS ARD 2004).

W126	A	M	J	J	A	S	O
1995	-2.53	-1.27	2.82	-0.74	4.32	1.83	2.06
1996	0.66	-0.79	-1.08	-1.27	1.31	0.81	1.45
1997	0.73	-0.37	1.58	1.59	-1.81	1.46	1.93
1998	2.78	1.03	-0.05	-1.76	-1.77	1.57	-1.09
1999	-1.10	-0.96	2.67	-0.41	-2.25	0.14	-0.16

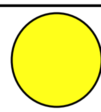
Palmer Z drought index: -1.00 to -1.99 (mild), -2.00 to -2.99 (moderate), -3.00 and below (severe)
1.00 to 1.99 (low wetness), 2.00 to 2.99 (mid wetness), 3.00 and above (high wetness)

Summary

Each of the three foliar injury prediction metrics (Sum06, W126, N100) showed an elevated risk over the separate interpolation time periods. All metrics for Sum06 and W126 fell into the middle and high risk injury classes, respectively, for each time period where data was available. The N100 metric demonstrated only a low risk for two of the individual years, 1998 and 1999, while it did not pose any concern for the remainder of the time periods. As a result, we assigned a "fair" condition ranking for foliar injury at NISI (Table 9).

The foliar injury metric is closely correlated to the 4th highest 8-hr ozone concentration metric used for air quality assessment, so it is expected that foliar injury risk will improve with decreasing ozone concentrations. Because the brief monitoring period at NISI showed low ozone concentrations in 2005 compared to previous estimates, it seems likely that future monitoring with the POMS would confirm lower ozone concentrations, which in turn would translate into lower foliar injury metrics. Foliar injury assessments are scheduled to begin at NISI in 2013 as part of the CUPN monitoring program (T. Leibfreid pers. comm.). However, at the time of this report, there is insufficient information to assign a trend. (Table 9).

Table 9. The condition status for foliar injury at NISI was fair. The data quality used to make this assessment was good. No trend was assigned to the condition.

Attribute	Condition & Trend	Data Quality: Thematic	Data Quality: Spatial	Data Quality: Temporal
Foliar Injury		✓	✓	✓
		3 of 3: Good		

Hydrology

Water Chemistry

Starting in 2004, quarterly water quality monitoring in NISI began at four sites: Tolbert Branch, the east and west boundaries of Henley Creek, and at Star Fort Lake (Figure 7). Samples collected every other year are accompanied each subsequent year by a comprehensive water quality report. To date, there have been three years of water quality data collected at NISI. Sampling in April 2004 stretched through January of the following year, while sampling in 2006 and 2008 included sampling from October the year prior through July. With the exception of the station in Star Fort Lake, all sampling locations are located at the park boundaries in order to represent water quality just prior to leaving the park unit (Star Fort Lake is a single site within the park). Water quality sampling locations are placed as close to the park boundary as possible in order to capture water quality characteristics from as much of the interior of the park as possible. The sites at West Boundary Tolbert Branch and Henley Creek represent streams that flow into the park. Overall, there are approximately 6 km of streams in NISI, and all sources of flow except one originate outside the park, including the two 1st order streams that serve as input to Star Fort Lake. A single tributary to Henley Creek originates inside the park, and is represented by sampling at the east Henley Creek station.

Monitoring and Use Classification

As part of the CUPN Water Quality Monitoring Plan, the NPS Water Resources Division requires monitoring of water temperature, pH, specific conductance, and DO, referred to as the core parameters, in addition to any other parameters deemed necessary by the vital signs process

(Leibfreid et al. 2005). Select parks in CUPN, like NISI, also collect field measurements of Acid Neutralizing Capacity (ANC) and *Escherichia coli* concentrations.

The South Carolina Department of Health and Environmental Control (SCDHEC) classifies streams throughout the state according to their use, and by definition, streams or waterbodies not included in the state-level classification are categorized based on the class of stream to which they are tributary (SCDHEC 2008a). In NISI, all of the streams are classified either directly or indirectly by these state standards as freshwater use (Meiman 2005). This means that the water associated with the designation are suitable for primary and secondary contact recreation as well as for "fishing and the survival and propagation of a balanced and indigenous aquatic community of flora and fauna." The SCDHEC also defines baselines for parameters within a freshwater classification, which includes all of the measures listed above, with the exception of specific conductance and ANC (SCDHEC 2008b). Although sampling intensities and methods performed at NISI sometimes do not meet the sampling requirements for SCDHEC standards, they are still useful as a comparison.

Temperature

Temperatures, according to the SCDHEC Water Classification Standards for free-flowing freshwater, are not to increase 2.8º C above natural conditions and never exceed 32.2º C. Natural conditions are described as "water quality conditions which are unaffected by anthropogenic sources of pollution" (SCDHEC 2008b). These rules are mainly intended to prevent discharge of heated liquids by industries. Meiman (2009b) reported normal average temperatures of ~5-30º C at all of the sampling stations within NISI. NPStoret data from 2002-2007 reflected the same range of temperatures, while the highest observations at Star Fort Lake were well below the maximum threshold of 32.2º C. Only on a single occasion was the sampled temperature 30.1º C. Confidence intervals ($\alpha = 0.05$) showed no significant differences between the sites averaged across seasonal fluctuations (Figure 8).

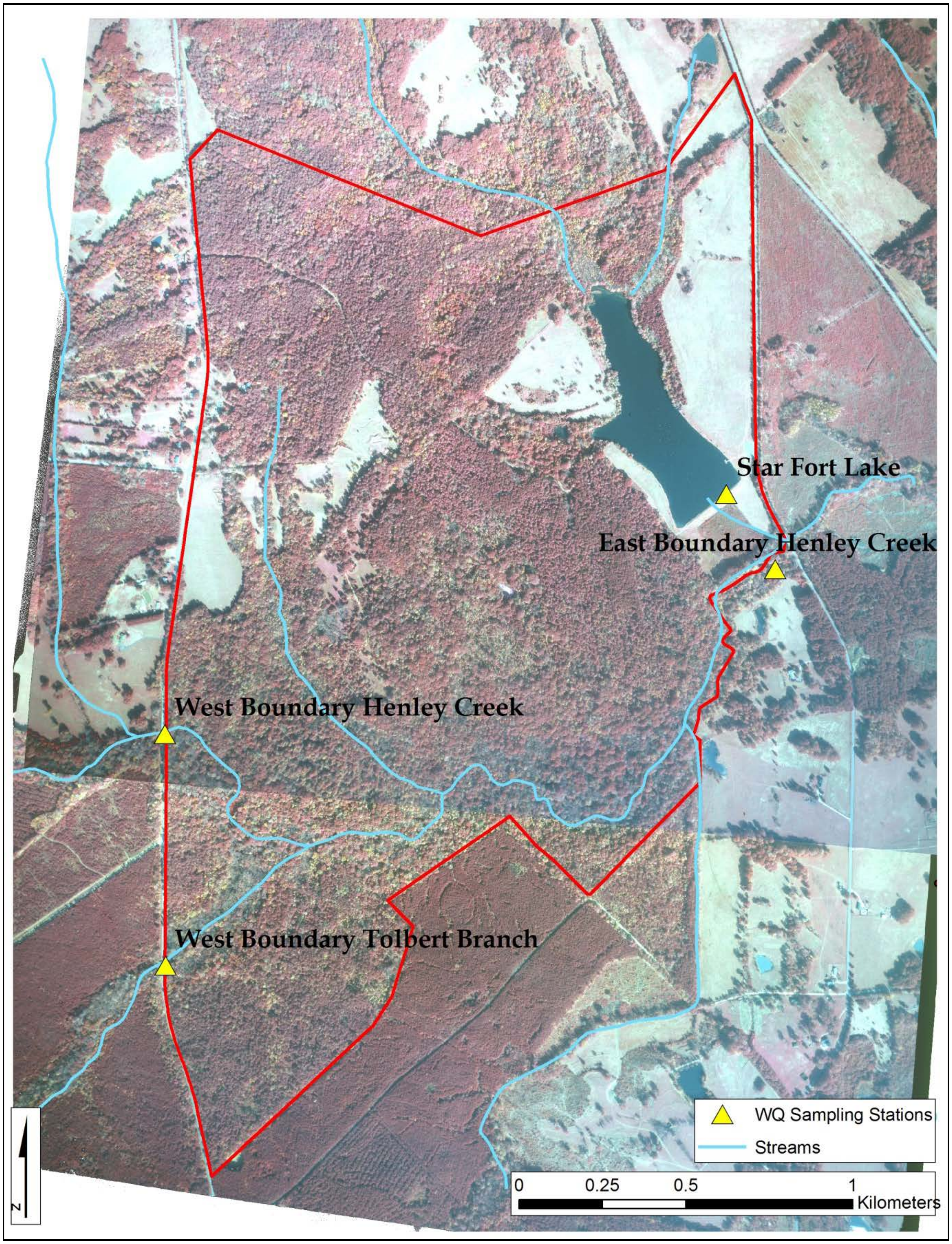
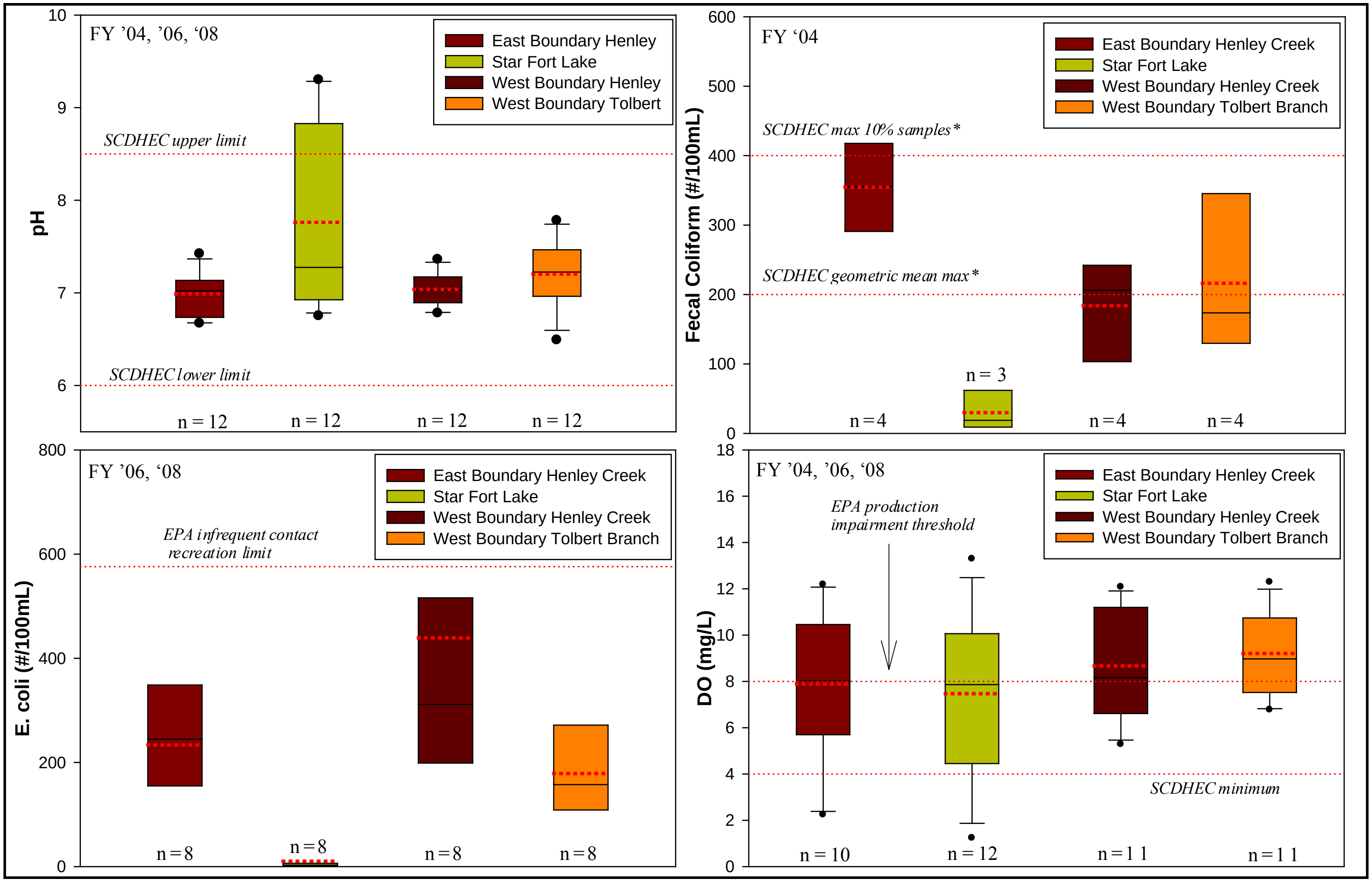
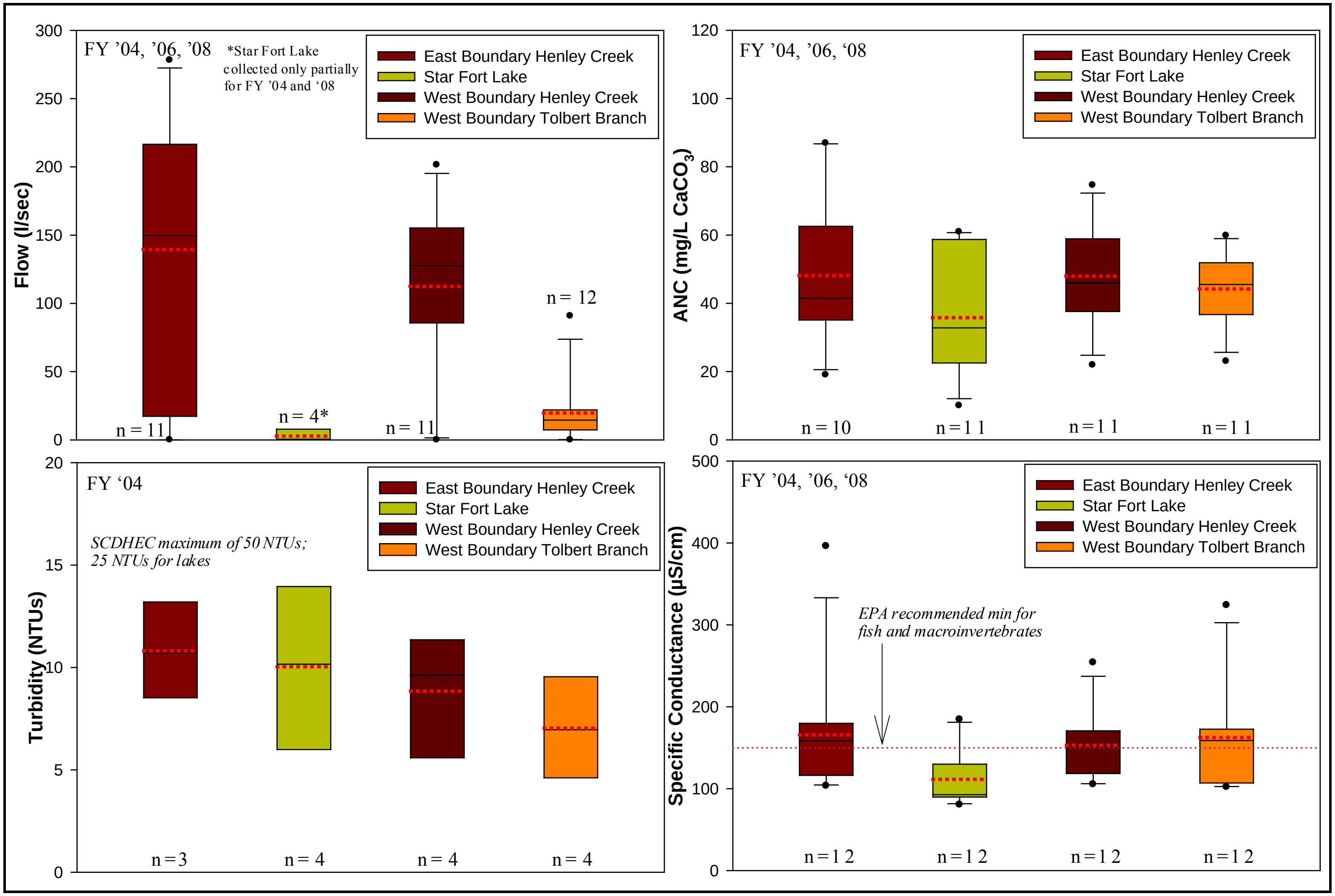


Figure 7. There are 4 water quality monitoring stations at NISI, including one at Star Fort Lake. Samples are collected quarterly during even years.



*Samples collected for fecal coliform do not meet state protocols, and therefore state standards are provided for reference only.**

Figure 8. Box and whisker plots for 4 monitoring locations (biennually 2004-2008) at NISI depict the four core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli* and ANC as stipulated by CUPN. Flow is used as a reference for loading amounts and relative contents of measurements. Turbidity measurements are determined on an individual park basis, and are not required at NISI, but are also provided to show relative watershed effects. Where available, South Carolina Department of Health and Environmental Control (SCDHEC) standards are given.



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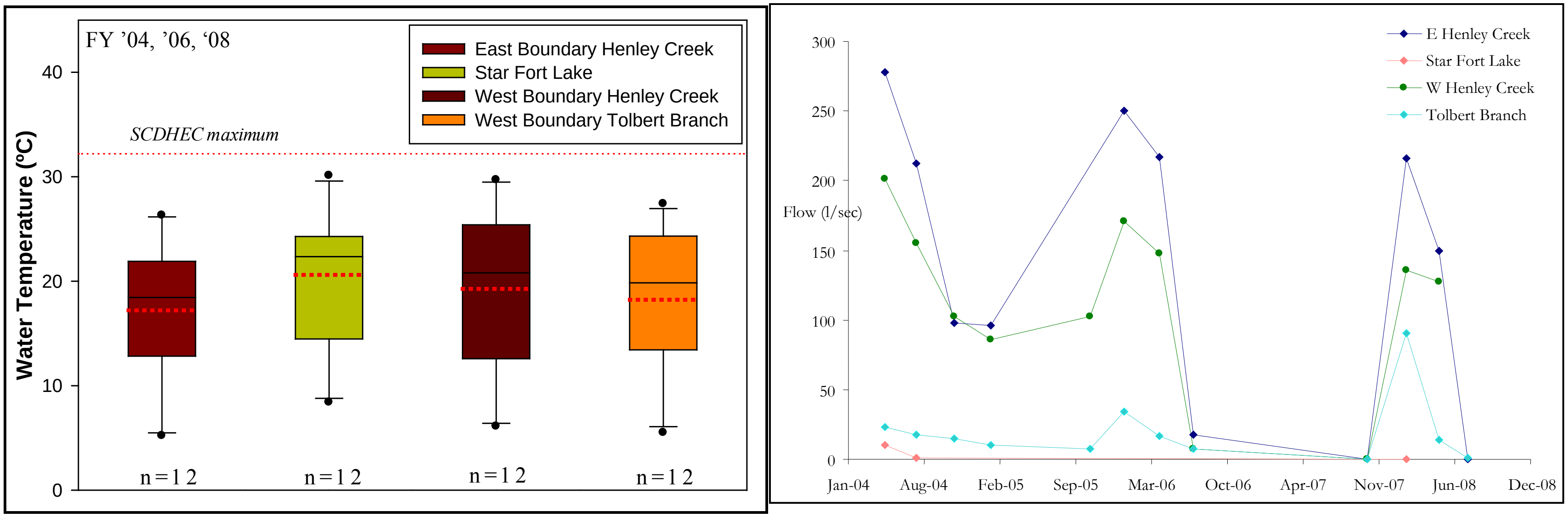

Figure 8. Box and whisker plots for 4 monitoring locations at NISI depict the four core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli* and ANC as stipulated by CUPN. Flow is used as a reference for loading amounts and relative contents of measurements. Turbidity measurements are determined on an individual park basis, and are not required at NISI, but are also provided to show relative watershed effects. Where available, South Carolina Department of Health and Environmental Control (SCDHEC) standards are given (continued).

Specific conductance

Specific conductance was collected at each of the stations using a dip-cell electrode sensor, which gives an estimate of the amount of dissolved inorganic solids that conduct electricity (EPA 1997). Higher amounts of solids increase the conductance levels, which are measured as the reciprocal of electrical resistance and expressed in $\mu S\ cm^{-1}$. Generally, specific conductance measures are closely related to the parent material associated with the stream. Although no state standard exists for this parameter, the EPA (1997) sampling methods manual identifies an ideal range of 150 to 500 µS/cm for "inland fresh waters…supporting good mixed fisheries," and furthermore indicates that "conductivity out of this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates." Overall, values at NISI ranged roughly from 80-400 µS/cm, with the highest values at E. Henley Creek, though the values were comparable with each other overall. Only Star Fort Lake averaged specific conductance levels below the EPA recommended minimum. Confidence intervals ($\alpha = 0.05$) showed no differences between the four sites. According to Meiman (2009b), higher specific conductance measurements observed during the last round of sampling are most likely the result of a drought period, which may have increased relative dissolved concentrations (Figure 8). There is no SCDHEC standard for this parameter.

pH

Measurements of pH are important to water quality because it affects multiple biological processes within aquatic systems. Low levels of pH can potentially increase the mobility of toxic elements, and in turn, their uptake by aquatic plants and animals (EPA 1997). Values for pH at NISI were extremely consistent and relatively invariable across sites, with an overall average of 7.2. SCDHEC stipulates an acceptable pH range from 6.0-8.5 for freshwater, and as Meiman (2009b) points out, summer samples from Star Fort Lake reflect alkalinity levels which exceed the state limit. Meiman attributes this to algae utilization of dissolved carbonates after depleting CO_2, which in turn results in an increase in concentration of OH^- hydroxyl ions. These algal concentrations may be affected by runoff from surrounding areas that contain high levels of nitrogen and phosphorus, especially if fertilizers applied to nearby areas flow into the lake. Agricultural fields surrounding the northern area of the park may be a source of these nutrients. Meiman (2009), however, attributes the high pH levels in the lake to natural conditions. Confidence intervals ($\alpha = 0.05$) show a difference between the highest (Star Fort Lake) and lowest (E. Henley Creek) pH means, but not between or among the intermediate sites (Figure 8).

Dissolved Oxygen

Dissolved oxygen (DO) is the final of the 4 core water quality parameters monitored at NISI, and is measured *in situ* using a sensor that adjusts for temperature, and which is calibrated for atmospheric pressure at each site. The significance of this observation derives from its sensitivity to natural or anthropogenic alterations to the stream, as sensitive aquatic plants are one of the main sources of oxygen, along with aeration and mixing of atmospheric O_2. Concentrations of DO are also important to the survival of essentially all aquatic species (Palmer et al. 1997). Several sources of runoff such as agriculture, urban areas, septic fields, or wastewater discharge can result in high biochemical oxygen demand (BOD) from microorganisms that break down their constituents, which can in turn deplete oxygen available to aquatic species (EPA 1997). SCDHEC stipulates daily DO averages of at least 5.0 mg/l with absolute minimums of 4.0 mg L^-

[1]. The EPA also creates national standards for DO in invertebrate habitat, stipulating levels of at least 8 mg L^{-1} for no production impairment (EPA 1986).

Although data collected for NISI do not show daily means, the overall mean over the 6-yr monitoring period is above 8 mg L^{-1} for 2 of the 4 sites (West Henley Creek and Tolbert Branch), where none of the individual measurements fell below the 4.0 mg L^{-1} threshold (Figure 8). Confidence intervals ($\alpha = 0.05$) show no differences in mean DO concentrations among sites over the full monitoring period. E. Henley Creek and Star Fort Lake had the lowest average DO concentrations, and some of the individual measurements fell below the 4.0 mg L^{-1} threshold. Meiman (2009b) explains, however, that these measurements were affected by the sampling site at Star Fort Lake and represent natural conditions. At Henley Creek, flow had stopped during sampling, resulting in measurements from stagnant pools. This suggests that locations overall do not exhibit chronic problems with low DO concentrations. However, it is possible that even a few days with low DO could cause widespread mortality and deleterious effects in water resources. With the current frequency of sampling, these events could remain undetected.

Acid-Neutralizing Capacity
Acid-neutralizing capacity (ANC) values are collected to assess the relative ability of water to buffer acidic loading that may result from precipitation or other inputs. Higher values of ANC, or alkalinity, are influenced by concentrations of carbonates, bicarbonates, phosphates, and hydroxides. Although the SCDHEC sets no standards for ANC, the EPA Goldbook (1986) recommends values greater than 20 mg L^{-1} for aquatic life. At NISI, overall ANC levels were affected by the drought in 2008, which resulted in higher levels of dissolved bicarbonates. Averages of ANC levels over the 6-yr monitoring period showed no significant differences between sites, and only two observations at E. Henley Creek and Star Fort Lake fell below the 20 mg/L threshold (Figure 8). The overall average of 44.0 mg L^{-1} $CaCO_3$ suggests that bicarbonate levels are sufficient to buffer acid loading and provide for aquatic life at NISI, and Meiman (2009) suggests discontinuing this metric for future sampling.

Summary
Overall, there is no evidence of chronic or substandard water quality conditions at NISI. As a result, the status for water quality at NISI receives a condition ranking of “good.” There is no apparent trend in the available data, although three years of monitoring data are insufficient to recognize long-term patterns (Table 10).

Microorganisms

In addition to the core parameters, measurements of *E. coli* and total coliform bacteria were included in the CUPN monitoring plan, and the SCDHEC has outlined limits for fecal coliform in its freshwater classification standards. Total coliform bacteria are a group of bacteria that live in the intestines of warm and cold-blooded organisms, and are typically assessed as indicators of health risks presented by associated viruses and pathogens, though the coliform themselves do not necessarily present a health risk. Fecal coliform are a subset of total coliform bacteria that exist only in warm-blooded organisms and would be most likely to enter the waters of NISI via wildlife feces (Figure 9). SCDHEC places a limit on fecal coliform of 200 colonies per 100 mL, based on any 5 consecutive samples during a 30-day period, and a limit of 400 colonies per 100mL on 10% of all samples during any 30-day period. At NISI, fecal coliform samples were collected during FY'04, while only *E. coli* was collected for FY'06 and FY'08. Although sampling for fecal coliform did not follow the protocol outlined by the SCDHEC during its single year of observation, samples at all locations except E. Henley Creek averaged concentrations less than 200 colonies per 100mL, while a single observation at E. Henley Creek exceeded the 400 colonies per 100mL absolute limit.

E. coli, is one of the most commonly monitored types of bacteria in the fecal coliform group (USEPA 1997). While there is no state standard for this measure, the EPA recommends an *E. coli* single-sample limit of 576 colonies per 100mL for infrequent recreational contact (EPA 1986). During subsequent rounds of sampling, *E. coli* concentrations were extremely variable, but surprisingly, W. Henley Creek showed the highest average of the 2 sampling periods, mainly due to a single observation of 580 colonies per 100mL. Meiman (2009b) suggests this high value is due to wildlife attraction to streams during the drought, though there is no apparent pattern of increase between the two sampling periods.

Summary
It was difficult to place an overall condition rating on this monitoring attribute since fecal coliform was monitored during FY '04. All sites averaged <400 fecal coliform colonies per 100 mL in FY'04, and subsequent *E. coli* observations were, for the most part, at even lower concentrations and well below the EPA recommendation. However, because so few samples had been collected, the two collective exceedances of fecal coliform and *E. coli* thresholds present significant concern about contamination in the park unit, and this issue should therefore continue to be closely monitored. For now, we assigned a cautious condition rating of "fair" to the status of microorganisms at NISI, while insufficient monitoring data exists to qualify this attribute with a trend (Table 10).

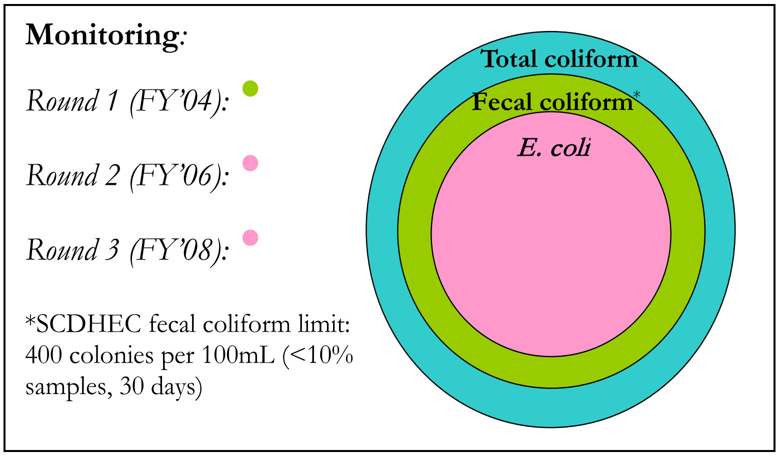

Figure 9. Venn diagram depicting relationship between coliform bacteria groups, and matching colors depicting sampling schedule for each fiscal year. Bacteria monitoring at NISI changed from fecal coliform to *E. coli* during the last two fiscal years.

Hydrology

Surface Water Dynamics
Flow is also monitored at each of the sampling stations to scale the flux of other parameter concentrations. Highly variable flows such as those that result from impoundments or large areas of impervious surface may adversely affect water quality and in turn alter aquatic biodiversity (Bunn and Arthington 2002). At NISI, sampling stations are located on small streams, with the exception of Star Fort Lake.

Regional drought during 2007 and 2008 greatly depressed flow values. Confidence intervals showed higher average flows (l sec^{-1}) at E. and W. Henley Creek, which averaged 126 l sec^{-1}, than at Star Fort Lake and Tolbert Branch, which averaged 11 l sec^{-1}, with an overall decrease reflecting the drought (Figure 8). Because rainfall events and natural cycles are the greatest source of flow variability at NISI, the condition status for flow receives a ranking of "good" (Table 10).

Table 10. The condition statuses for surface water, water chemistry, and microorganisms were respectively good, good, and fair at NISI. The data quality of each of these three assessments was good. No trend was assigned to any of these assessments.

Attribute	Condition & Trend	Data Quality: Thematic	Data Quality: Spatial	Data Quality: Temporal
Surface Water	Good (green)	✓	✓	✓
		3 of 3: Good		
Water Chemistry	Good (green)	✓	✓	✓
		3 of 3: Good		
Micro-organisms	Fair (yellow)	✓	✓	✓
		3 of 3: Good		

Invasive Species

NatureServe (White and Govus 2003) conducted the most recent comprehensive vegetation surveys at NISI, resulting in 364 species counted for the park from all inventories included in NPSpecies. In 2001-2002, NatureServe established ten 50 x 20 m permanent monitoring plots on a roughly 520 m grid, with an additional five plots in specific locations of unique vegetation types. According to White and Govus (2003), average species richness among plots was 47.7 (α), with an overall diversity of 254 (γ), which gives a β-heterogeneity value of 5.3. The plots themselves covered only 8 of the 18 identified community types, with an average sampling rate of 1.9 plots per each of the 9 community types.

White and Govus (2003) documented a total of 70 non-native species over the course of the two NatureServe vegetation assessment surveys at NISI, which also includes collections by Runyan and Osborne (2003). Although current numbers may be even higher, this proportion represents 19% of the 365 plant species documented in the park; statewide non-native plant diversity is 15% (NatureServe 2009). According to the 2008 South Carolina Exotic Pest Plant Council (SCEPPC) invasive species list, sixteen of the documented exotic plants at NISI are considered noxious or highly invasive (Table 11). These species include Japanese honeysuckle (*Lonicera japonica*), wisteria (*Wisteria* spp.), Elaeagnus (*Elaeagnus* spp.), and Japanese stiltgrass (*Microstegium vimineum*), each of which are also present at Kings Mountain NMP and Cowpens NB. However, a few of the invasives are unique to NISI including Taiwanese photinia (*Photinia serratifolia*), and oriental false hawksbeard (*Youngia japonica*). White and Govus (2003) suggest that most of these non-natives are the result of escaped plantings and seed mixes.

Morse et al. (2004) developed a methodology to quantify the threat posed by exotics to native species and ecosystems, called the I-rank. The overall I-rank consists of 20 questions which together cover four main subranks: ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty. We recalculated the I-ranks for each species, excluding consideration of current distribution and abundance, because that metric is relevant to the rangewide status, and we desired a park unit-level status. These rankings are shown in Table 11 and are expressed on a scale of zero to three, with three representing the greatest threat to park resources. Using this system, Japanese honeysuckle and silverberry (*Elaeagnus umbellata*) received the highest cumulative I-rank levels, though 11 species resulted in the medium rank. NatureServe (2009) reports honeysuckle as particularly difficult to eradicate once established, and recommends foliar herbicide after the first frost to minimize potential effects on native and non-target species. Silverberry is more easily treated; NatureServe (2009) recommends a cut-stump method in combination with glyphosate herbicide.

Table 11. List of 16 invasive species present at NISI listed by the SCEPPC (2008) as a significant (†) or severe threat (*) to ecological health. I-Rank is measurement of severity of invasibility adapted from Morse et al. (2004).

Species		I-Rank
*Lonicera japonica**	Japanese honeysuckle	2.33
*Elaeagnus umbellata**	Silverberry	2.17
Lespedeza cuneata†	Chinese lespedeza	2.00
*Microstegium vimineum**	Japanese stiltgrass	2.00
*Sorghum halepense**	Johnsongrass	1.83
*Pueraria montana**	Kudzu	1.83
*Phyllostachys aurea**	Golden bamboo	1.67
*Albizia julibrissin**	Mimosa	1.67
Cirsium vulgare†	Bull thistle	1.50
*Melia azedarach**	Chinaberry	1.50
*Wisteria sinensis**	Chinese wisteria	1.50
*Elaeagnus pungens**	Thorny olive	1.50
*Wisteria floribunda**	Japanese wisteria	1.33
Daucus carota†	Queen Anne's Lace	0.33
*Paspalum notatum**	Bahia grass	0.00
Paspalum dilatatum†	Dallis grass	Not Ranked
Poncirus trifoliata†	Trifoliate orange	Not Ranked

I-Rank is calculated as an average of ecological impact, trend in distribution and abundance, and general management difficulty, each of which is assigned a value of 1 to 3 (Morse et al., 2004). Each category is assigned a number based on its categorical rating and averaged to give the overall I-Rank: low (0.00-1.00), medium (1.01-2.00), or high (2.01-3.00). Ranks do not reflect overall abundance within the park unit.

Susceptible Vegetation Types

Collectively, the majority of vegetation types in the park (54%) are what White and Govus (2003) refer to as human-modified communities, meaning they are especially vulnerable to invasion by exotic plant species (Figure 10). White and Govus mention that bamboo (*Phyllostachis* spp.) was planted next to an old homesite in the northern section of the park and continues to pose a threat of invasion to the surrounding Water Oak – Willow Oak and Loblolly Pine/Sweetgum successional communities, the former of which is known to contain several populations of the G3-listed Oglethorpe Oak (*Quercus oglethorpensis*). The Loblolly Pine/Sweetgum successional forest, on the other hand, is not of high conservation value. These successional forests harbor more invasive exotic species, perhaps because of their high level of human disturbance. This disturbance leads to conditions conducive to invasion and establishment of new species (White and Govus 2003). This is the most abundant forest type, comprising 135 ha, or roughly 35% of the park.

Other forest types that are particularly susceptible to invasive plant species include the Successional Sweetgum forest (28 ha), Successional Black Walnut forest (2 ha), Successional Tuliptree-Hardwood forest (1 ha), Blackberry – Greenbrier Successional Shrubland Thicket (1 ha), and Southern Cattail Marsh (<1 ha) (White and Govus 2003), which overall comprise 22% of the park. Another ~1 ha throughout the park is dominated by a combination of invasive golden bamboo, wisteria, and other species. Lastly, 57 hectares are classified as cultivated meadow, which may include any variety of mown grasses and forbs. This vegetation type includes a 20 ha field in the northeast part of the park maintained for hay. These cultivated areas are important to the historical interpretation of the park, and include significant cultural areas highlighted by the park unit, including trails, earthworks, and the Star Fort. Despite their cultural value, cultivated meadows are potential sources of aggressively invasive plant species such as Japanese honeysuckle, the control of which is important to protecting other adjacent vulnerable communities.

Summary

White and Govus (2003) recommend invasive exotic control as the top management priority in NISI, particularly in the G3-ranked Southern Piedmont Oak Bottomland Forest and areas where floodplain canebrake communities are likely to occur. They also recommend that exotic removal be accompanied by reseeding of native species to ensure that invasives do not recolonize. They report that Chinese privet, bamboo, and other woody invasives are the most important species on which to focus control efforts because of their ability to outcompete other plants. Overall, NISI is assigned a "poor" condition ranking for the status of invasive species (Table 12). In summary, the reasons for this ranking include the predominance of exotic-invaded communities, the vulnerability of natural communities like the Water Oak – Willow Oak forest, the large list of exotics considered to be a significant or severe threat to ecological health, and the high proportion of exotics in the park. There is no information available on a trend for this vital sign, so no trend was assigned.

Because the inventory on which this assessment is based is greater than five years old, the data quality ranking does not receive a check for temporal quality in Table 12. A new "Early Detection Protocol" is being developed by the CUPN for invasive plants, however, which was in part informed by vegetation monitoring conducted at NISI in 2011. This assessment revealed that many of the same problems with exotics exist nearly a decade after the survey by White and Govus (2003), including widespread infestation by Japanese honeysuckle and privet. Japanese stiltgrass has also spread throughout the floodplain regions of the park (S. McAninch, pers. comm.).

Additional analyses on this recent monitoring will likely reveal priorities for exotics management. In the meantime, specific areas mentioned by White and Govus (2003) could be assessed for more immediate treatment. These include the golden bamboo colony that continues to spread yearly from the old homesite, individual mimosa and chinaberry trees which often occur in open areas and along forest edges, and patches of Johnsongrass, a rhizomatically-spreading plant that is easily identifiable and often occurs in open areas. Other species such as Japanese stiltgrass, *Ligustrum* spp., and *Elaeagnus* spp. also represent high-priority targets for treatment, though these species may be more widespread in forested areas making effective treatment more difficult.

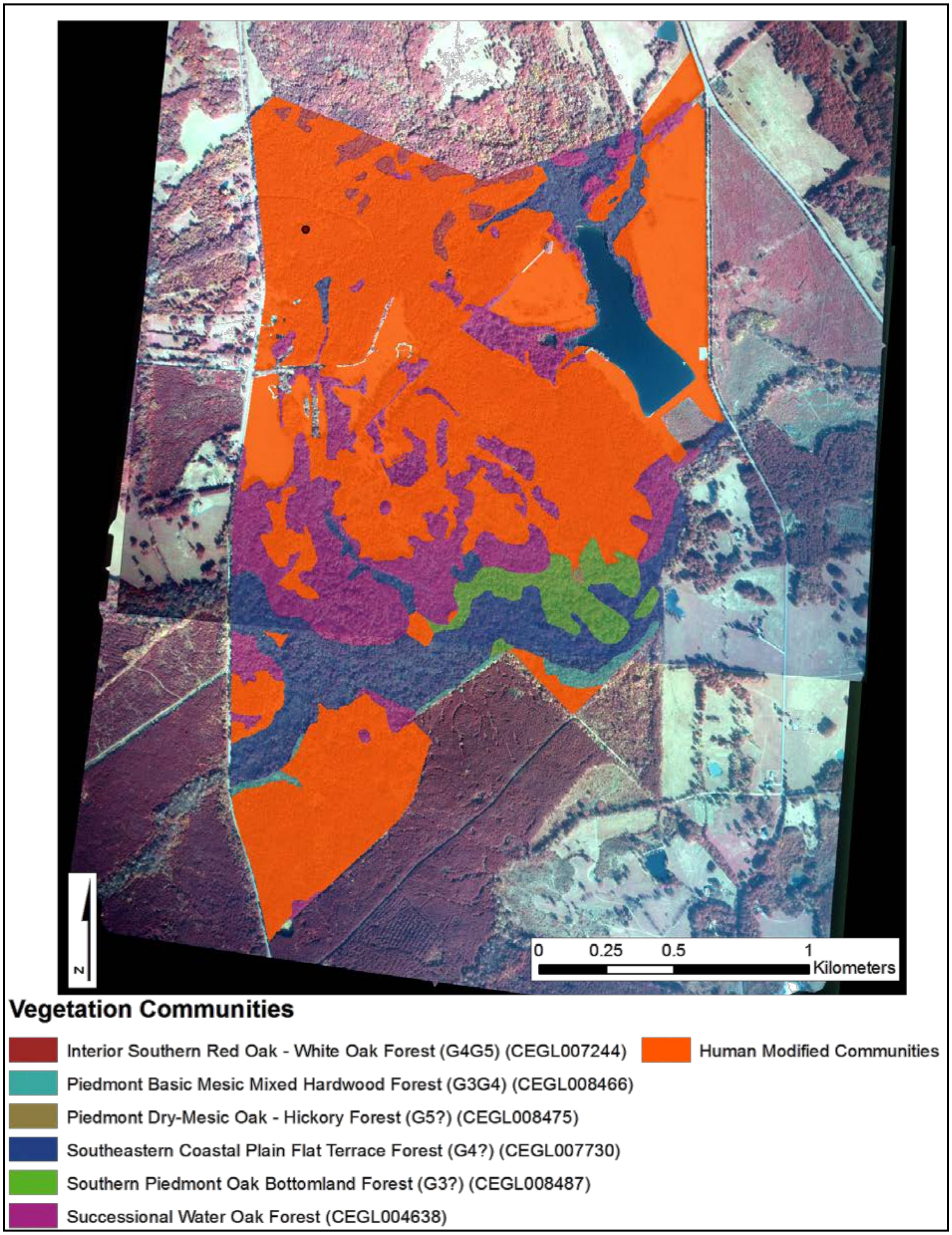

Figure 10. Human-modified communities comprise 54% of the park and are considered only semi-natural or exotic species dominated (White and Govus 2003).

Table 12. The condition status for invasive plants at NISI is poor. The data quality of this assessment is fair. No trend was assigned for this condition.

		Data Quality		
Attribute	Condition & Trend	Thematic	Spatial	Temporal
Invasive Plants	●	✓	✓	
		2 of 3: Fair		

Infestations and Disease

Southern Pine Beetle

Because such a large portion of NISI is forested, this park unit is susceptible to infestation by forest pests. One of the main forest insect pests in the southeast is the native southern pine beetle (*Dendroctonus frontalis*), which causes tree mortality at a higher rate than any other forest pest in the southeast. Typical pine beetle stand infestations last from 3-4 years (Fettig et al. 2007). To assess the risk of infestation in this region, the Forest Health Technology Enterprise Team of the US Forest Service constructed a southern pine beetle 30-m resolution vulnerability map for the entire southeastern region using 8 separate models in 15 different ecoregions. Each model adopted a set of parameters to assess infestation risk in that region, resulting in a southern pine beetle infestation risk map at 30-m resolution. The parameters of the ecoregional model that included NISI were slope, southern pine basal area, aspect, and soil clay content. Figure 11, adapted from that model, shows overall risk within NISI between minimal and low, with highest risk regions concentrated in forested regions in the northwest and southwest parts of the park, in addition to the forest adjacent to Star Fort Lake (Ellenwood & Krist 2007; Krist 2009).

The areas showing the highest risk for southern pine beetle infestation correspond most closely with the Loblolly/Sweetgum Successional community type, which is the largest single community type present at NISI and by itself represents an overall infestation risk between low and moderate (Figure 11). In addition, the Loblolly/Sweetgum Successional community was the only vegetation type containing a permanent sampling plot for which White and Govus (2003) noted pine beetle damage. Southern pine beetle outbreaks have been linked in part to areas experiencing altered fire regimes, modified species composition, and nonnative introduction (Strom et al. 2002; Fettig et al. 2007). It is especially important to monitor these high-risk areas of the Loblolly/Sweetgum stands for stressors such as these that could lead to infestation.

Ips Beetle

A secondary pest relevant to the park is the Ips beetle (*Ips avulsus*) – a beetle that, along with the Southern pine beetle, is responsible for the majority of pine mortality in the southern region. This species of Ips beetle is known to attack loblolly, shortleaf, and Virginia pine, all of which occur at NISI. However, the Ips beetle is only known to infest weakened and unhealthy trees that may result from an extreme disturbance such as fire, storms, drought, or cutting (Connor and Wilkinson 1983; Christiansen et al. 1987).

Gypsy Moth

Finally, another forest insect pest in the southeastern US is the European gypsy moth (*Lymantria dispar*), which were introduced from Europe to the east coast of the US in the late 19^{th} century, and have subsequently been shown to have a negative effect on tree health from infestation and defoliation (Schultz and Baldwin 1982; Elkinton and Liebhold 1990).

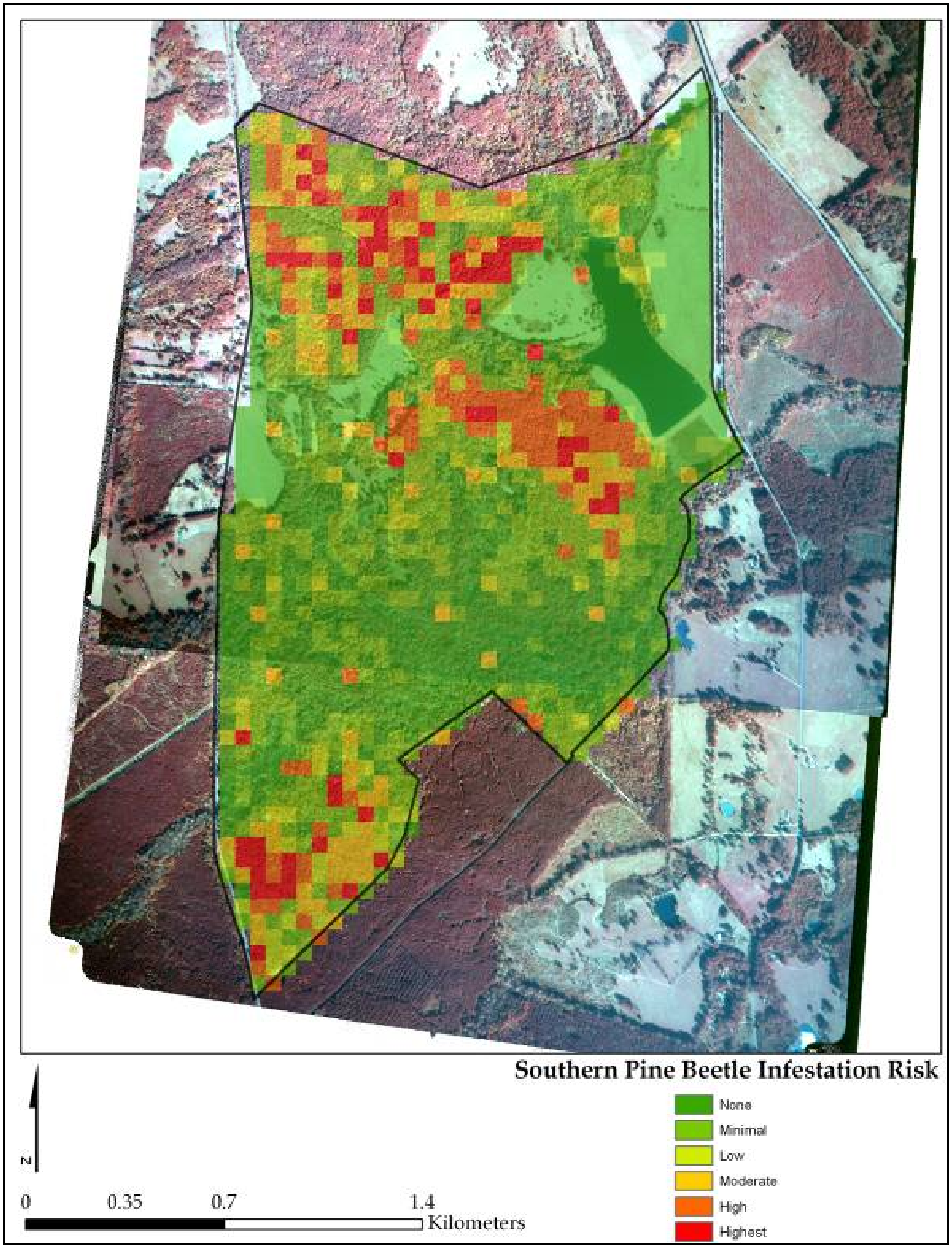

Figure 11. Overall risk of southern pine beetle infestation at NISI. The highest risk modeled at NISI coincides with the Loblolly/Sweetgum Successional community (Krist 2009).

The Forest Health and Monitoring division of the US Forest Service has annual reports for gypsy moth traps for 2007 and 2008, during which 2 traps were placed in NISI, though neither of these traps captured any moths. Although there are several gypsy moth traps monitored throughout South Carolina, in fact, none of them have captured any moths for the duration of the reports since 2002, which would suggest they currently do not pose a threat to NISI and the surrounding region (Puckett 2002-2008).

Overall, insect pests appear to present a minimal risk to the stands at NISI. Gypsy moth traps have shown no presence of this pest in or near NISI. Although much of the park unit is forested, the southern pine beetle risk map shows an overall low to moderate risk at NISI, despite patches of high susceptibility in areas with loblolly pine. The unpredictable nature of pine beetle outbreaks, however, makes it difficult to anticipate where an infestation will occur. For these reasons, the status of insect pests at NISI receives a condition ranking of "good," with insufficient information to assign a trend (Table 13).

Table 13. The condition status for insect pests at NISI is good. The data quality used in this assessment is good. No trend was assigned for this condition.

Attribute	Condition & Trend	Data Quality: Thematic	Data Quality: Spatial	Data Quality: Temporal
Insect Pests	●	✓	✓	✓
		3 of 3: Good		

Forest Communities

Classification

NatureServe in Durham, NC collaborated with the Center for Remote Sensing and Mapping Science (CRMS) at the University of Georgia to classify and map vegetation communities present at NISI, in accordance with the national standards outlined by the US National Vegetation Classification (Grossman et al. 1998, Anderson et al. 1998). Aerial color infrared photos were collected during leaf-on of fall 2002 by US Forest Service Air Photographics. These images were orthorectified and interpreted using software and manual analysis to assign vegetation types to specific signatures. In addition, repeated ground-truthing of vegetation was used to agree on and modify the vegetation classifications. Overall, there were 18 community types outlined at NISI out of 240 distinct vegetation polygons mapped by CRMS, which includes 7 natural vegetation types and 11 successional or exotic-dominated communities (Figure 12) (White and Govus 2003).

Approximately three-quarters of the park unit (760 acres) is forested. Most of the remainder is comprised of open area / field (18%) (MRLC 2009b). There are six successional vegetation types, which collectively comprise 570 acres, the majority of which is the successional Loblolly – Sweetgum Forest (CEGL008462). This vegetation type is the most predominant community in the park, and also represents the area most vulnerable to an infestation by southern pine beetle (see *Forest Pests*).

Accuracy Assessment

In 2005, NatureServe performed an accuracy assessment of the vegetation map created by the CRMS (Lyons and O'Donoghue 2007). Researchers produced a confusion matrix based on 137 randomly stratified points used for ground-truthing. Ground-truthing locations were stratified based on the relative proportion of each vegetation type. Mapped vegetation types were considered correct if the primary, secondary, or tertiary vegetation types assigned by CRMS matched what researchers observed on the ground. Results of this method showed correct mapping of 101 ground-truthing points, or 74%. When restricted to only the primary vegetation, 90 points (66%) were accurate. The results showed that the Interior Southern Red Oak – White Oak Forest (CEGL007244) and the Water Oak Forest (CEGL004638) were commonly confused, as were the Successional Sweetgum Forest (CEGL007216) and the Southeastern Coastal Plain Flat Terrace Forest (CEGL007730). Lumping each of these pairs together, they advised, would increase the overall map accuracy to 80%.

Significant Communities

Floodplain Canebrake
Despite the large numbers of human-modified areas, there are several vegetation types in the park unit that are especially valuable to the park due to their natural condition or rarity. One of the most significant natural communities relevant to NISI is the Floodplain Canebrake (CEGL003836) vegetation type, ranked as a G2? community by NatureServe (2009). It is significant because it is a historically abundant community that is now fairly rare on a broad scale. The Floodplain Canebrake is associated with the Southeastern Coastal Plain Flat Terrace Forest (CEGL007730), and is dominated by river cane (*Arundinaria gigantea*)—an ecologically significant species. Although the Floodplain Canebrake community is not present as the dominant vegetation type of any portion of NISI, it does occur as a secondary vegetation type in a single small patch (~1 acre) of Southeastern Coastal Plain Flat Terrace Forest in the southwestern portion of the park unit (Figure 12 and Figure 13). More importantly, this community type was more abundant throughout the southeast during the time of settlement, with much of its subsequent decline due to fire suppression and a reduction in grazing (White and Govus, 2003; Platt and Brantley, 1997). The canebrake refers to the thickets of river cane that often allow the establishment of few or no other species in the understory. In his *History of the Upper Country of South Carolina*, John Logan describes in the region "vast brakes of cane…often stretching in unbroken lines of evergreen for hundreds of miles…," and in regions with "the highest degree of [soil] fertility" reaching heights of up to 20 or 30 ft (Logan 1859). Historically, canebrake communities also contained variable overstory cover from woodland and forest, though this type of association is even rarer in occurrence. Logan also reports that "on certain rich soils…cane was frequently found…growing luxuriantly on the tops of the highest hills." At NISI, small areas of canebrake still occur along Ninety Six Creek, though White and Govus (2003) point out that these areas are typically along forest canopy openings.

Southern Interior Oak Bottomland Forest
Another significant community described by White and Govus (2003) at NISI is the G3-ranked Southern Interior Oak Bottomland Forest (CEGL008487). This community type comprises about 13 ha along the outer portion of the Ninety Six Creek floodplain, and is one of the few remaining natural associations within the park unit (Figure 13). This community contains a relatively high canopy tree diversity which includes long-lived overstory species such as cherrybark oak (*Quercus pagoda*), swamp chestnut oak (*Quercus michauxii*), and green ash (*Fraxinus pennsylvanica*), as well as a diverse shrublayer including American hazelnut (*Corylus americana*), spicebush (*Lindera benzoin*), and possumhaw (*Ilex decidua*). Oglethorpe Oak is

also present in the understory of this community. The herbaceous layer is noted for a number of showy plants including Atamasco lilies (*Zephyranthes atamasca*). White and Govus (2003) note this community type as a whole is particularly vulnerable to invasion by Chinese privet, which they identify as the single greatest threat to the ecological integrity of the park, and probably one of the most worthy management priorities.

Undisturbed Communities

Besides rare communities, several vegetation types are notable for their relatively undisturbed quality, and for this reason are perhaps prime candidates for protective management. One such vegetation type is the Piedmont Basic Mesic Mixed Hardwood Forest (CEGL008466) (G3/G4), which occurs only on about 9 acres of north-facing slopes along Ninety Six Creek, with a diverse herb layer containing species such as Bosc's panicgrass (*Dichanthelium boscii*), American columbo (*Frasera caroliniensis*), and little brown jug (*Hexastylis arifolia*). White and Govus (2003) indicate that invasive species do not currently pose much of a threat to this community type (Figure 13). A similar but more common natural community is the Piedmont Dry-Mesic Oak-Hickory Forest (CEGL008475), which also occurs mainly on north-facing slopes. Although this community is widespread throughout the southeast, it only occupies ~1 acre within NISI, and represents mainly second growth.

Interior Southern Red Oak – White Oak Forest

Another common natural community type is the Interior Southern Red Oak – White Oak Forest (CEGL007244), which comprises 14 acres in NISI (Figure 13). This type mainly contains oaks and hickories, with few shrub and herb layer species. At NISI, White and Govus (2003) note this community is particularly old (>50 years) and occurs mainly in the northern section of the park unit.

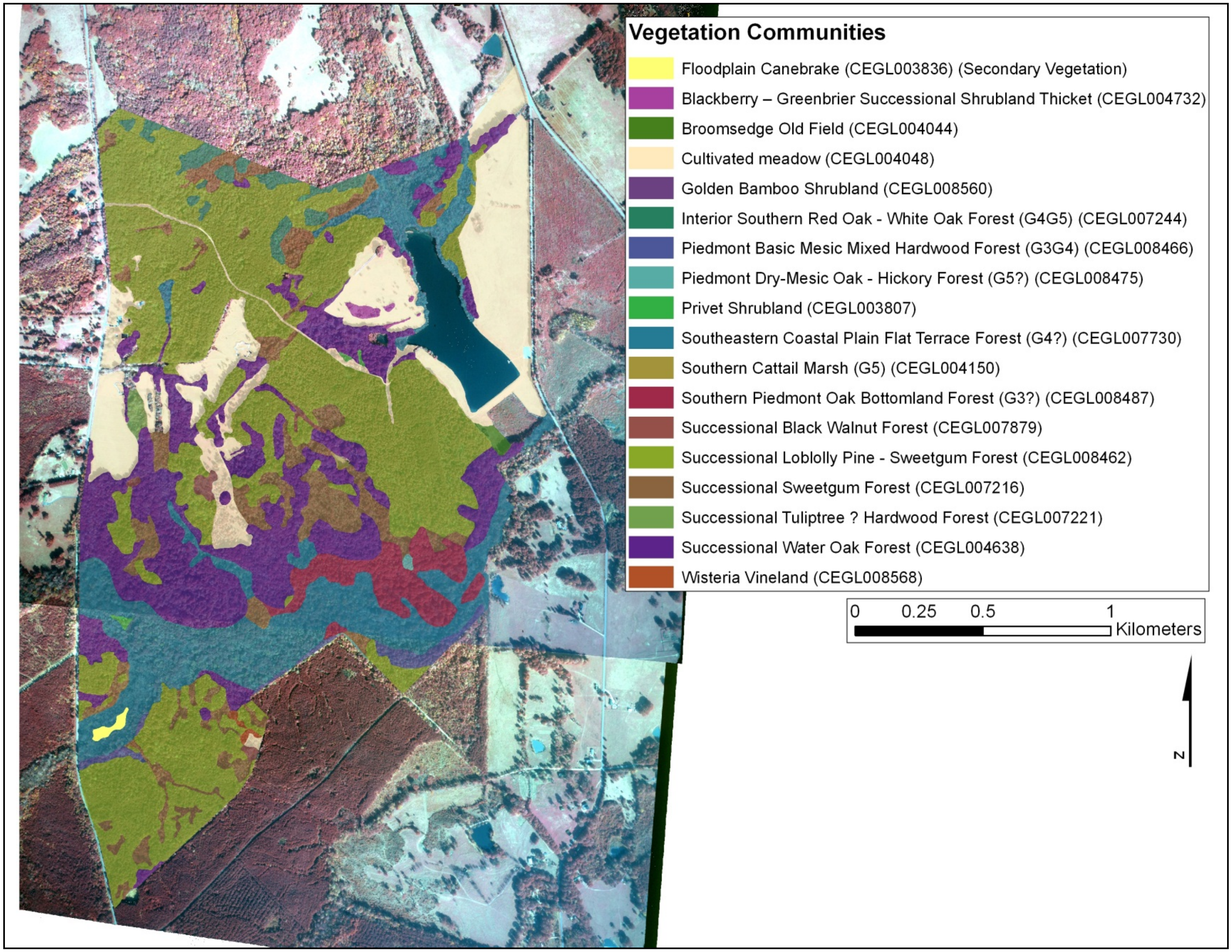

Figure 12. White and Govus (2003) identified 18 distinct vegetation communities at NISI, which were delineated by the CRMS (2005). There are 15 NatureServe plots located within NISI on a 0.52 m^2 grid.

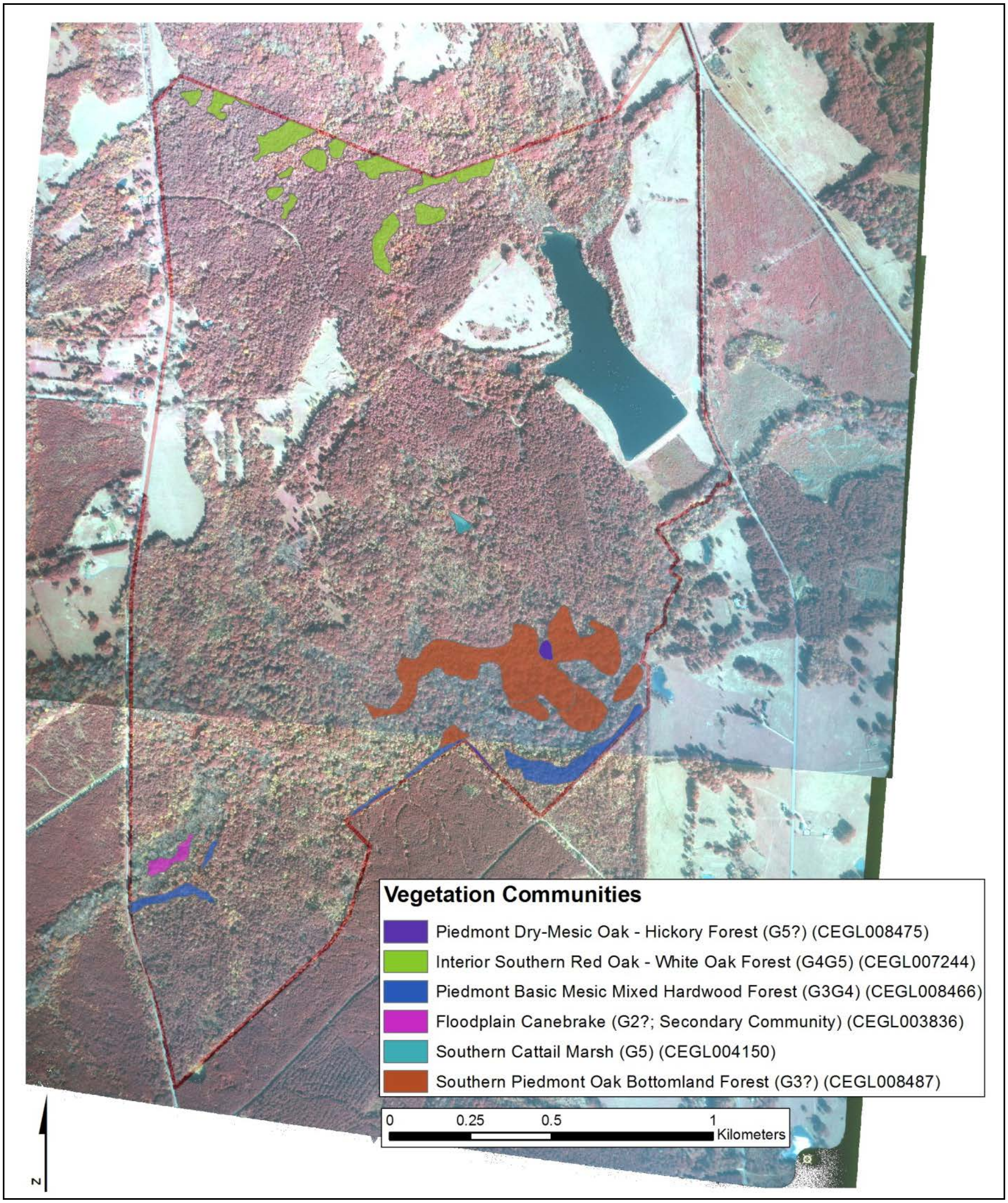

Figure 13. Significant vegetation communities identified at NISI.

Southern Cattail Marsh

The last significant community identified by White and Govus (2003) as a “semi-natural” community is the Southern Cattail Marsh (CEGL004150), which mainly consists of cattails (*Typha latifolia*) along with other common wetland species like sedges (*Carex* spp.) and bulrushes (*Schoenoplectus* spp.). They note that although the wetland area is the result of human modification, the community is still significant due to the amount of amphibian habitat it provides. This community type comprises ~1 acre at NISI (Figure 13).

Wetland Communities

Ninety Six NHS is also significant because of the large amount of wetland area present within the park. These areas contain a unique vegetative composition, and in turn provide habitat for a distinctive set of animal species. Roberts and Morgan (2007) identified 46 wetland areas covering 14.7 acres and averaging 0.3 acres apiece (Figure 14), even though National Wetlands Inventory (NWI) classification from 1989 only placed 6 wetlands within the boundary, which Roberts and Morgan attribute to their possible short hydroperiod or small size.

In 1998, the NPS issued a directive proclaiming a goal of “no net loss of wetlands,” as well as the adoption of the wetlands classification system described by Cowardin et al. (1979) as the standard for NPS wetlands inventories (Mainella 2002). Using this system, wetlands are classified into 1 of 5 general systems, as well as various descriptive subsystems that depend on hydrologic regime, water chemistry, or the plant community (Roberts and Morgan 2007). A shorthand notation corresponds with each combination of descriptors. Based on the Cowardin et al. (1979) system, Roberts and Morgan (2007) classified 32 of the wetlands within NISI as palustrine, forested, deciduous (PF01) with 14 seasonally flooded (PF01C) 11 temporarily flooded (PF01A), 6 semi-permanently (PF10E), and one semi-permanently flooded (PF01F). Non-forested wetlands included 2 that were classified as seasonally flooded scrub-shrub cover (PSS1C; flooded >2 weeks/year), 2 palustrine emergent wetlands (non-woody vegetation) with temporary flooding (PEM1A; flooded <2 weeks/year) and seasonally flooded (PEM1C). The other 10 wetlands were classified as palustrine open-water wetlands (POW). Wetland presence was systematically determined in part by surface water presence, vegetation type, and specific indicator species such as boxelder (*Acer negundo*), panic grass (*Dicanthelium clandestinum*), giant cane (*Arundinaria gigantea*), and alder (*Alnus serrulata*) (Roberts and Morgan 2006).

Because the Cowardin wetland description does not incorporate the source of hydrology for each wetland, their landscape position, or hydrodynamics, Roberts and Morgan (2007) further provided a hydrogeomorphic class for each wetland based on Brinson (1993).

Figure 14. Roberts and Morgan (2007) identified 46 wetland locations at NISI, mostly around Henley Creek in the Southern Piedmont Oak Bottomland Forest.

Hydrogeomorphologically, 29 of the wetlands were riverine, 12 were depressional, 4 were slope, and one was a lacustrine fringe wetland. Non-depressional wetlands such as riverine wetlands usually cover a greater area than depressional wetlands, and are dictated by the regional water table, while depressional wetlands are usually relatively small, and result from the terrestrialization of previous water bodies that become filled with organic matter. Riverine wetlands, specifically, are associated with streams, and usually occur next to larger streams with minimal slope, and are often recharged by overbank flow during flood periods in addition to groundwater. Depressional wetlands, on the other hand, are usually controlled by an independent water table, meaning that they are charged mostly from precipitation and runoff (Kolka and Thompson 2006).

Wetland Valuation

The majority of riverine wetlands were associated with the Tolbert Branch in the southern portion of the park, which Roberts and Morgan (2007) suggest might be actually former parts of the stream channel that shifted over time, leaving periodically inundated remnants. Wetlands were also classified based on the presence of invasives, amount of carbon export, flood attenuation level based on hydrogeomorphological setting, groundwater discharge, surface water storage, and research potential. Research potential was largely dictated by whether the wetland was large (>0.20 acres) and supported plant species of high interest.

Carbon export is highest for wetland areas adjacent to a stream or river due to long periods of contact between litter and surface water (Mulholland and Kuenzler 1979), and vegetative cover also plays a large role in the amount of organic carbon loading (Mattson et al. 2008). At a watershed scale, carbon export reflects net primary productivity (NPP), and changes in production at this level may reflect other variations within the watershed such as hydrologic regime or even climate change. As Roberts and Morgan (2007) point out, different forms of carbon also play an important role in the food web of detrital microorganisms and invertebrate shredders. At NISI, 20 of the slope wetlands received a high rating for carbon export potential, with another 6 classified as medium and 9 as low. For surface water storage, 36 of the wetlands received a high rating based on hydrogeomorphological rating, while 4 were low. A related value, groundwater discharge, was high for 3 wetlands, medium for 2, and low for 10, and relates to maintaining flow levels during periods of low rainfall, which in turn affects habitat structure and biodiversity in adjacent rivers or streams (Roberts and Morgan 2007).

Wetlands were also classified on the basis of other criteria such as cultural value, which included consideration for uniqueness, size, historical use, and accessibility. A sizeable wetland, for example, that is located on an old homesite and is easily reached from a nearby road would qualify as culturally significant, and using this criteria, only 8 wetlands in NISI were recognized for their cultural value. Another quality ranking—economic value—was based on a combination of flood attenuation ability and significance of potential visitor attraction, which was not further specified (Roberts and Morgan 2007). Twenty-seven of the wetlands were identified as having significant economic value. Wetlands were also classified as low, medium, or high based on the uniqueness of their plant community, with higher consideration for wetlands with obligate (estimated >99% occurrence in wetlands) and facultative-wetland species (estimated 67%-99% occurrence in wetlands; Table 14), as opposed to facultative species (estimated 34%-66% occurrence in wetlands) and exotics (Reed 1988). Ten of the wetlands received a high rating for this class, 16 as medium, while the remaining 20 were low. In addition, 30 wetlands were noted as being invaded by exotics.

Lastly, each wetland was assigned a rating based on its ability to provide amphibian habitat based on the length of hydroperiod, using a two-week cutoff as a short-term ponding period. Amphibians in particular are sensitive to the length of the hydroperiod, because they require saturated soils or standing water to lay eggs and complete their lifecycle (Paton & Crouch 2002). Typically, wetlands with larger vernal pools belong to the depressional hydrogeomorphological class, and of the 46 wetlands, 29 were classified as high value, 10 as medium, and the remainder as low. This wetland function is of particular importance in light of intensifying amphibian decline over the past 25 years, for which some of the main causes include habitat loss or alteration, species invasion, road density, and pesticide and fertilizer use (Beebee and Griffiths 2004; Blaustein et al. 1994); all of which may be applicable to wetlands within NISI. Vitt et al. (1990), among others, proposed amphibians as a potential bioindicator due to their high position on the food chain and complex life history. With all of these considerations in mind, it is important that NISI continues to manage for the protection of existing wetland areas.

Summary

There is currently no recommended protocol or ranking system in place for vegetation communities, and as a result, we did not assign a ranking to this vital sign as it pertains to forest and wetland areas at NISI (Table 15). However, data collected by NatureServe and vegetation classifications performed by the CRMS provide a thorough baseline knowledge of vegetation resources at NISI. As of this writing, the CUPN continues to work with NatureServe to develop a vegetation monitoring protocol for the network. This protocol will likely provide methods to evaluate condition objectives for vegetation communities within the park unit (T. Leibfreid, pers. comm.).

Table 14. Twenty plants at NISI are either facultative wetland (FACW; wetland occurrence 67%-99%) or obligate wetland (OBL; wetland occurrence >99%) species.

Species		Indicator Status
Acer negundo	Ash-leaved maple	FACW
Alnus serrulata	Hazel alder	FACW
Arundinaria gigantea	River cane	FACW
Carex crinita	Fringed sedge	FACW
Carex joorii	Cypress swamp sedge	OBL
Celtis laevigata	Sugarberry	FACW
Cephalanthus occidentalis	Buttonbush	OBL
Dicanthelium clandestinum	Panic grass	FACW
Fraxinus pennsylvanica	Green Ash	FACW
Ilex decidua	Possumhaw	FACW
Ilex verticillata	Winterberry	FACW
Juncus coriaceus	Leathery Rush	FACW
Lemna persullina	Duckweed	OBL
Potamogeton diversifolius	Pondweed	OBL
Quercus lyrata	Overcup oak	OBL
Quercus phellos	Willow oak	FACW
Sagittaria sp.	Arrowhead	OBL
Salix nigra	Black willow	OBL
Typha latifolia	Cattail	OBL
Ulmus americana	American elm	FACW

Table 15. The condition status for vegetation communities at NISI was not ranked. The data quality for this attribute was good. No trend was assigned for this condition.

Attribute	Condition & Trend	Data Quality: Thematic	Data Quality: Spatial	Data Quality: Temporal
Vegetation Communities	◯	✓	✓	✓
		3 of 3: Good		

Fish Communities

The southeastern United States supports the richest fish diversity in North America, north of Mexico, and native fishes are of great conservation concern in the region (Warren et al. 2000). NISI contains several small streams, ranging in size from 1st to 4th order, draining watersheds to the west of the park. These streams drain into Henley Creek within the park. Henley Creek flows into Ninety Six Creek which in turn empties into the Saluda River approximately one km downstream from Lake Greenwood, and 9.2 km from the NISI boundary (Figure 15). The watershed is contained in the Santee-Cooper drainage basin. Ninety Six also contains Start Fort Lake, a 27-acre impoundment, and a small, unnamed, shallow, heavily vegetated pond. Star Fort Lake was impounded in the early 1950s and has been managed by the state of South Carolina since the early 1990s as a recreational fishery (SCWMRD 1991). The lake was drained in 1984 and restocked with bluegills (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), and largemouth bass (*Micropterus salmoides*; SCWMRD 1991). A similar drawdown and restocking was performed in 1991-92 (SCWMRD 1991). At the time of this report, management of Star Fort Lake included seasonal closings, limited fishing days, size and bag limits, and restrictions on the use of live bait minnows (SCDNR 2010).

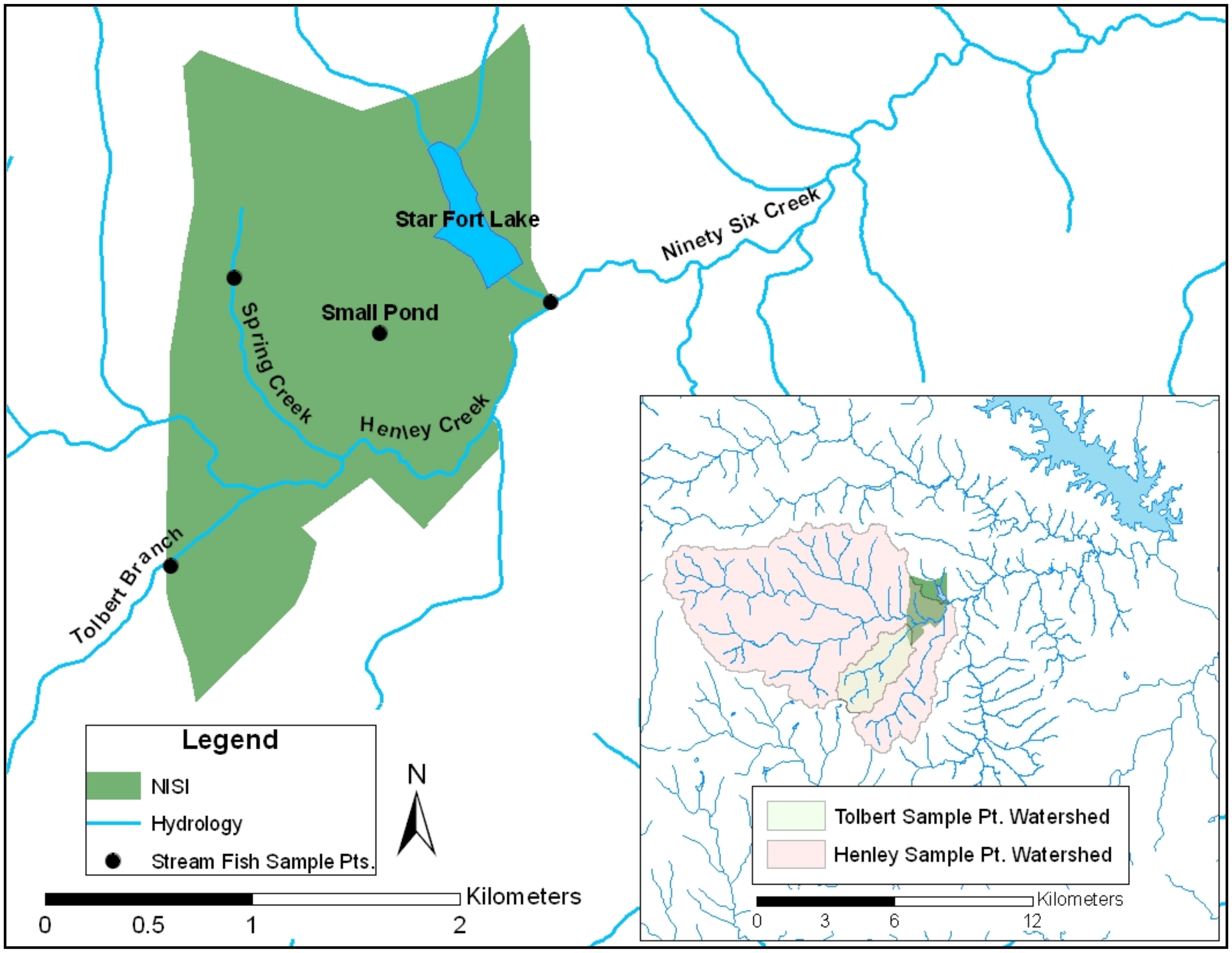

Figure 15. Flows and impoundments in NISI showing stream fish sampling locations from the 2005 survey. Inset shows broader area, including the catchment areas upstream of the Tolbert Branch (6.9 km^2) and Henley Creek (76.9 km^2) sampling locations (Scott 2006).

Upon taking over management of Star Fort Lake, the SCDNR (then S.C. Wildlife and Marine Resources Department) conducted electrofishing and fish trapping efforts in 1990 (SCWMRD 1991). These efforts yielded the three stocked species as well as black crappie (*Pomoxis nigromaculatus*), pumpkinseeds (*Lepomis gibbosus*), warmouth (*Lepomis gulosus*), and golden shiners (*Notomigonus crysoleucas*; SCWMRD 1991). From analysis of these samples, fisheries managers concluded that densities of sunfish were relatively low, but individual sunfish were in good condition relative to state averages (SCWMRD 1991). They further suggested that the pond was "crowded" with bass, as evidenced by a population heavily skewed towards juvenile fish and the relatively poor condition of individual fish (SCWMRD 1991).

A new baseline survey of NISI fishes was conducted in the summer of 2005 (Scott 2006). This effort sampled three park streams, Star Fort Pond, and the small pond, reporting 22 species from

5 families (Scott 2006; Figure 15; Table 16). Streams and the small pond were sampled using a single pass with a backpack electrofishing unit (Scott 2006). Star Fort Lake was sampled using a boat electrofishing unit (Scott 2006). The combined stream sample included 19 species from 5 families and the combined pond sample included 9 species from 4 families. The most abundant family reported from streams was Cyprinidae, and the most common cyprinid was the yellowfin shiner (*Notropis lutipinnis*; Scott 2006). The most abundant family reported from Star Fort Lake was Centrarchidae, and the most common centrarchid was the bluegill (Scott 2006). The small pond contained a dense population of a single species, the eastern mosquitofish (*Gambusia holbrooki*; Scott 2006).

No federal or state listed fish species are known to occur at NISI. Three of the species reported from the 2005 survey were identified in the South Carolina Comprehensive Wildlife Conservation Strategy (CWCS) as species of priority conservation concern (SCDNR 2005; Scott 2006). These species were the rosyface chub (*Hybopsis rubrifrons*), the flat bullhead (*Ameiurus platycephalus*), and the Carolina darter (*Etheostoma collis*). Three species reported in the survey were non-native to the Saluda drainage: the redear sunfish, the green sunfish (*Lepomis cyanellus*), and the channel catfish (*Ictalurus punctatus*; Warren et al. 2000; Scott 2006). Of these, the channel catfish occurred only in Star Fort Lake where it had been stocked to support a recreational fishery. The redear sunfish was reported from both Tolbert Branch and Star Fort Lake and had been stocked in Star Fort Lake to support a recreational fishery. The green sunfish was reported only from Tolbert Branch and Henley Creek. The three CWCS conservation priority species comprised about 11% of the total park baseline fish sample, and approximately 16% and 19% of the Tolbert Branch and Henley Creek samples, respectively (Scott 2006). Scott (2006) stated that the relatively high proportion of these species in the sample was an indicator of good quality for NISI fish assemblages. The Carolina darter, reported from Tolbert Branch, and the flat bullhead, reported from both Tolbert Branch and Henley Creek, were listed as "vulnerable" species by Warren et al. (2000) in an assessment of southeastern U.S. fish.

To further assess the condition of the stream fish communities and of fish habitat at NISI, we evaluated the baseline samples from Tolbert Branch and Henley Creek using an index of biotic integrity (IBI) developed for North Carolina (Karr 1982; NCDNR 2005). Fishes are good indicators of freshwater habitat quality. They are nearly ubiquitous in freshwater streams, occur in diverse communities including multiple trophic levels, are relatively easy to sample and identify, and are widely studied (Karr 1981). The IBI approach to evaluating aquatic resources assesses fish communities based upon relative density and diversity of sampled populations, as well as the life history attributes and the ecological roles of community species. Generally, good conditions are indicated by assemblages containing a wide diversity of trophic specialists, and with relatively high proportions of specialists and sensitive species. The North Carolina IBI (NCIBI) was developed, tested, and widely used as an assessment tool across the mountain and piedmont ecoregions of North Carolina (NCDENR 2006). Because the index was developed for applicability across a broad region, and because all fish species reported at NISI were included in the NCIBI species list, we believe it to be reasonably robust for use in NISI which is slightly outside its originally intended range. The NCBI is recommended for use with electrofishing samples taken over a 600-foot reach (NCDENR 2006). The Tolbert sample was taken over a 390-foot reach and the Henley sample was taken over a 443-foot reach (Scott 2006). Because the baseline park sample did not include data about fish condition or size, two metrics could not be calculated and raw scores were adjusted with a multiplier, as suggested by the NCDENR Standard Operating Procedure manual for a 10-metric index (NCDENR 2006). Due to these variations from ideal sampling protocols, some caution is warranted when interpreting this index for NISI habitats.

Table 16. Twenty-two species of fishes from five families were reported from three streams and two ponds at NISI during the 2005 fish survey.

Scientific Name	Common Name	Stream total	Pond total
Centrarchidae			
Lepomis auritus	redbreast sunfish	35	0
Lepomis cyanellus	green sunfish	5	0
Lepomis gulosus	warmouth	4	1
Lepomis macrochirus	bluegill	13	74
Lepomis microlophus	redear sunfish	5	7
Micropterus salmoides	largemouth bass	2	67
Pomoxis nigromaculatus	black crappie	0	6
Cyprinidae			
Hybopsis rubrifrons	rosyface chub	24	0
Nocomis leptocephalus	bluehead chub	19	0
Notemigonus crysoleucas	golden shiner	0	1
Notropis hudsonius	spottail shiner	12	0
Notropis lutipinnis	yellowfin shiner	45	0
Notropis scepticus	sandbar shiner	13	0
Semotilus atromaculatus	creek chub	14	0
Ictaluridae			
Ameiurus natalis	yellow bullhead	2	0
Ameiurus platycephalus	flat bullhead	8	0
Ictalurus punctatus	channel catfish	0	12
Noturus insignis	margined madtom	1	0
Percidae			
Etheostoma collis	Carolina darter (Saluda form)	14	0
Etheostoma olmstedi	tessellated darter	11	0
Percina nigrofasciata	blackbanded darter	12	0
Poeciliidae			
Gambusia holbrooki	eastern mosquitofish	26	*

* Estimated density 75 individuals/m^2

The NCIBI score for Tolbert Branch indicated "excellent" condition, and the score for Henley Creek indicated "poor" condition (Table 17). The marked difference between the fish assemblages at these sites was unexpected. Although Henley Creek is larger and was sampled over a longer reach, fewer numbers and species of fishes were found (Table 17). The low IBI score for Henley Creek might result from reduced water quality caused by point source inputs in the upper watershed. Water quality monitoring data for NISI did not show strongly significant differences between Tolbert and Henley for most categories, although coliform counts were greater in Henley near the fish sampling site (Figure 8), suggesting that its watershed is more highly urbanized and receives a higher level of agricultural runoff. The outflow from Star Fort

Lake empties into Henley Creek at the downstream terminus of the fish sample site. It is possible that this outflow has some highly localized impact on the fish in that sample site, although this is conjecture. We did not assess the fish community of Star Fort Lake. The impoundment demonstrably provides suitable habitat for several common fish species and is managed as a recreational fishery.

We ranked the overall quality of NISI fish community as fair (Table 18). Factors contributing to the apparently lower quality of Henley Creek fish communities are unknown, but may occur in the watershed of this flow outside park jurisdiction. Because only one recent fish survey was available, we did not assign a trend to this attribute. The quality of available data was good.

A single baseline survey of the fishes of Ninety Six National Historic Site has been conducted. The quality of that survey was good and it provided appropriate inventory data. We recommend that if further monitoring efforts are conducted, they conform closely to the sample design used by Scott (2006). If managers desire to use the NCIBI for future assessment at NISI, then sampling reaches of 600 feet should be considered. However, if longer reaches are sampled, a sub-sample from reaches equal to those used by Scott (2006) should be identified to provide the most accurate comparison with the baseline inventory. If time and funding are sufficient in future monitoring efforts, collection of fish length, weight, and data on obvious deformities could provide insight on individual fish condition. The apparent difference in quality of the fish communities and fish habitat between Henley Creek and Tolbert Branch may be worth exploring with additional water quality sampling in the Henley drainage, and with further monitoring of fish communities.

Table 17. Metrics and scores from applying the North Carolina fish IBI to fish community samples from the two largest streams sampled at NISI during the 2005 fish survey. X=Log10*watershed area in miles^2.

Metric	**Scoring Criteria**			**Tolbert Branch**		**Henley Creek**	
	1	3	5	Value	Rank	Value	Rank
1: # species	<4.8*X+0.08	≥4.8*X+0.08	≥9.5*X+1.6	17	5	10	3
2: # of fish	<100	100-149	≥150	161	5	103	3
3: # darter spp.	<0.8*X	≥0.8*X	≥1.6*X	2	5	2	3
4: # sunfish/bass spp.	0 or 1	2	≥ 3	6	5	3	5
5: # sucker spp.	0	1	≥ 2	0	1	0	1
6: # intolerant spp	0		≥ 1	2	5	2	5
7: % tolerant	>35%	26-35%	≤25%	17.4	5	59.2	1
8: % omnivores	<10%, >50%	36-50%	10-35%	19.9	5	1.0	1
9: % insectivores	<45%, >90%	45-59%	60-90%	78.9	5	99.0	1
10: % piscivores	<0.24%	0.25-1.0%	≥1.0	1.2	5	0	1
				Total score	46		24
				Adjusted NCIBI	**56**		**28**

Table 18. The condition of fish communities at NISI was ranked as fair. The quality of data used to make this assessment was good. No trend was assigned to NISI fish community quality.

		Data Quality		
Attribute	Condition & Trend	Thematic	Spatial	Temporal
Fish Community		✓	✓	✓
		3 of 3: Good		

Bird Communities

Because birds are sensitive to environmental changes and are relatively easy to monitor, they are valuable indicators of terrestrial ecosystem quality and function (Maurer 1993). From August, 2003 to February 2006, 123 species of birds were reported from NISI (Seriff 2006; R. Carter, unpublished data; Appendix C). Seriff (2006) conducted sampling from 2004-2005. Breeding season data were collected using point counts at 15 pre-established plots (Figure 16) and incidental sightings (Seriff 2006). Winter bird data were collected during unstructured, unconstrained surveys (Seriff 2006). This effort was augmented with four unconstrained fall and winter surveys by ornithologist Robin Carter (author of *Finding Birds in South Carolina;* Seriff 2006*; unpublished data*). Seventy-two species were observed during the breeding season, representing 83% of the expected breeding species (Seriff 2006).

An Avian Conservation Implementation Plan (ACIP) prepared for NISI suggested managing for several umbrella species that are recognized by Partners in Flight (PIF) as important indicator species for the southern Piedmont physiographic region. These recommended species were: Wood Thrush and Summer Tanager for forest interior species, Northern Bobwhite and Prairie Warbler for early successional species, and Swainson's Warbler, Louisiana Waterthrush, and Acadian Flycatcher for riparian species. Six of these seven species were reported during the baseline bird inventory at NISI (Seriff 2006). Summer Tanagers (*Piranga rubra*) were observed 18 times. This species prefers open hardwood or pine-oak stands, often near gaps or habitat edges (Robinson 1996). It is not known to be declining in its eastern range (Robinson 1996). Wood Thrush (*Hylocichla mustelina*) were observed 16 times. This interior forest species has been well-studied and has declined in abundance over much of its range since the 1970s (Roth et al. 1996). Although it also nests near edges and in small forest patches, it shows a marked preference for the interior of mature, mixed hardwood forests (Roth et al. 1996). The Wood Thrush is vulnerable to nest predation and nest parasitism, and experiences lower nest success in smaller fragments (Roth et al. 1996). Northern Bobwhites (*Colinus virginianus*) were reported five times and Prairie Warblers (*Dendroica discolor*) were not reported. Northern bobwhites are important game birds and have declined throughout much of their range as a result of habitat loss and land conversion (Brennan 1999). Acadian Flycatchers (*Empidonax virescens*) were reported 58 times. This species requires mature forest containing streams or swampy woodlands (Whitehead and Taylor 2002). Although it is believed to be relatively stable throughout its range, it has been accorded high management priority because it is sensitive to habitat fragmentation and cowbird parasitism (Whitehad and Taylor 2002). Louisiana Waterthrush (*Seiurus motacilla*) and Swainson's Warbler (*Limnothlypis swainsonii*) were reported three times and one time, respectively. The Louisiana Waterthrush nests in hardwood canopied riparian zones and prefers low order, high gradient flows with robust macroinvertebrate communities (Mattsson et al. 2009). Swainson's Warbler is an extremely cryptic and patchily distributed species that typically breed in mature bottomland hardwood forests (Anich et al. 2010). Although not known to be declining in its range, the species is of concern because of its overall low estimated population and because of habitat loss (Anich et al. 2010).

We used an index of biotic integrity to explore the quality of the NISI bird community. Bird community assemblage data can be used to assess ecological integrity and level of anthropogenic habitat disturbance (Bradford et al. 1998; Canterberry et al. 2000; O'Connell et al. 2000). O'Connell et al. (2003) developed a bird community index (BCI) for the region of the eastern U.S. containing Ninety Six National Historic Site. To use the BCI, bird species are assigned guilds based upon breeding season life history traits, and the relative proportions of species in nine guilds are used to create overall scores ranging from 0 (fully "humanistic") to 100 (fully "naturalistic," O'Connell et al. 2003). The index was developed to assess bird assemblages in reference to pristine or undisturbed habitats and greater values are awarded to sensitive species and species with specialist life history traits.

We applied the regional BCI to NISI baseline point count data. The BCI was developed using species lists compiled from sets of five 10-minute, unlimited radius point counts spaced along 1-km transects (O'Connell et al. 2003). Ninety Six point count data were collected at set plots using 10-minute, unlimited radius point counts over two breeding seasons. Each plot was sampled four or five times over the course of the survey. We applied the BCI to individual point counts and took the mean score for each plot. Eight of the 15 plot means scored in the highest "naturalistic" category, five scored in the "largely intact" category, and two scored in the "moderately disturbed" category (Figure 16a; O'Connell et al. 2003). Because these scores were calculated using bird lists from individual point counts, they are most useful for suggesting relative habitat quality differences among the plots. The grand mean score for all individually calculated point counts was 0.710 (SD±0.11), corresponding to a "largely intact" interpretation (O'Connell et al. 2003). To more closely replicate the 5-count method used to develop the BCI, and to provide for a better estimate of overall park habitat, we compiled lists from each point and its four nearest neighbors for instances when all counts were taken during the same day. We took the mean of these scores for each plot (Figure 16b). The grand mean of the resulting BCI scores was 0.802 (SD±0.07) corresponding to a "naturalistic" interpretation (O'Connell et al. 2003). This value was more informative for assessing the overall condition of bird habitat in the park.

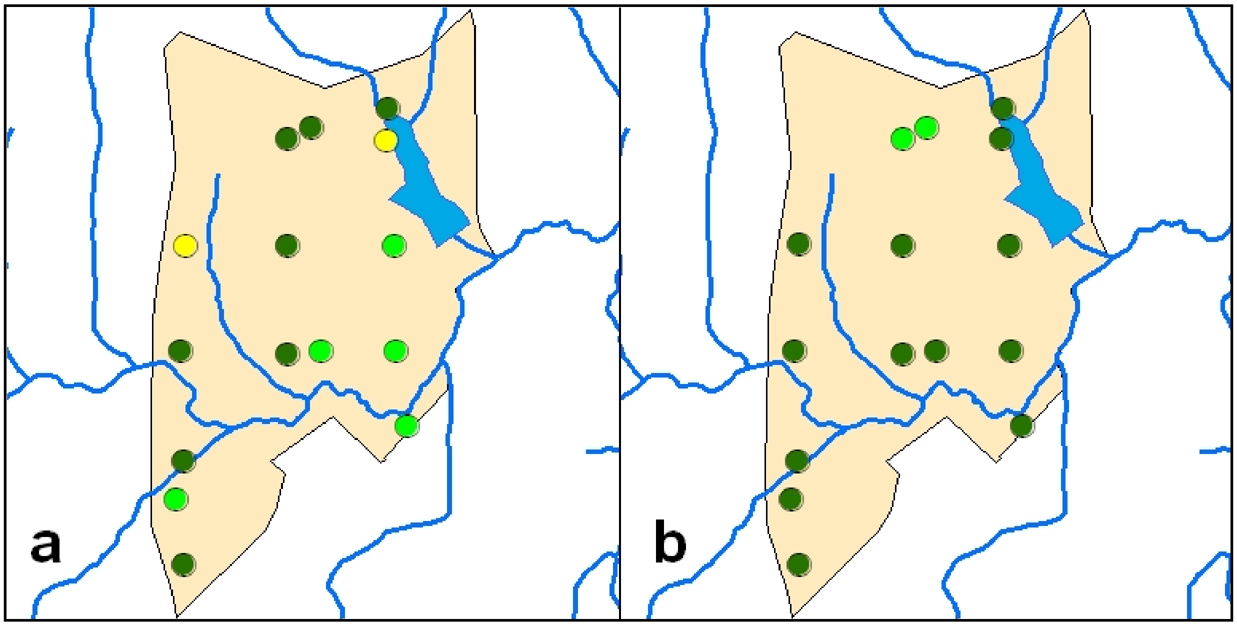

Figure 16. Mean BCI score interpretations for bird point count data from NISI calculated using both individual plot count bird lists (a) and 5-plot count bird lists (b). Dark green=naturalistic, light green=largely intact, yellow=moderately disturbed, red=humanistic.

We ranked the NISI bird community as good (Table 19). Thirteen of the 15 mean individual plot scores could be interpreted as naturalistic or largely intact (O'Connell et al. 2003). A grand park mean of scores taken from 5-plot bird lists corresponded to an interpretation of naturalistic (O'Connell et al. 2003). These scores were calculated based upon the presence of habitat specialists and sensitive species relative to habitat generalists and tolerant species. This result implies that NISI bird habitat had low anthropogenic disturbance, relative to pristine test sites used to develop the BCI (O'Connell et al. 2003).

The baseline bird survey conducted at NISI provided data useful for assessing and monitoring park birds (Seriff 2006). If future bird monitoring is conducted at NISI, we recommend that these efforts be conducted as similarly as possible to the baseline sample. If feasible in further efforts, estimating the distance to observed birds could be useful for estimating density and detectability of individual species.

Table 19. The condition of bird communities at NISI was ranked as good. The data used to make this assessment was good. No trend was assigned to bird community condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Bird Community		✓	✓	✓
		3 of 3: Good		

Mammal Communities

Mammals are important components of grassland and forest ecosystems where they affect plant communities, engineer landscapes, and play roles at multiple trophic levels (Ryszkowski 1975; Marti et al. 1993; Rooney and Waller 2003). Because of great variation in size, behavior, and life history, they are inherently difficult to sample. A baseline survey of non-volant mammals was conducted at NISI in 2006-2008 (Pivorun 2009). A 2005-2007 baseline bat survey at several piedmont National Park units included NISI (Loeb 2007). These studies reported 24 mammal species in the park, including one ungulate, four carnivores, six bats, one marsupial, two shrews, one lagamorph, and nine rodents, representing 67% of the 36 expected mammal species (Table 20).

During the 2006-2008 mammal survey, Pivorun (2009) sampled throughout the year at 21 sites chosen to include a variety of microhabitats. He used large and small Sherman live traps, Tomahawk box traps, pitfall buckets, remotely triggered cameras, and incidental observations to sample mammals (Pivorun 2009). Total combined trapping effort was 4900 trap nights including 4650 Sherman trap nights, 50 Tomahawk trap nights, and 200 pitfall trap nights (Pivorun 2009). Pivorun (2009) prepared a list of 29 expected mammals for the park, and his efforts reported 18 (62%) of these species. No state or federally threatened or endangered speciew were found in these samples. The most commonly trapped mammals were white-footed mice and hispid cotton rats, the most commonly camera-sampled mammals were raccoons and Virginia opossums (Pivorun 2009). Pivroun (2009) commented that these sampling efforts occurred during a period of drought, and that this may have affected results. The non-volant mammal survey results suggest that NISI contains mammal fauna typical for the region.

Loeb (2007) sampled during late winter, spring, and summer, months, using both mist netting and acoustic sampling with Anabat II detectors and reported six species of bats. Loeb (2007) used the literature and expert knowledge to prepare an expected species list of seven bats expected to occur in the park. Of these, the silver-haired bat (*Lasionycteris noctivagans*) and the hoary bat (*Lasiurus cenereus*) were only expected as winter migrants. This study verified 100% of the five bat species expected to occur in the park during summer and one of the two (50%) expected winter migrants (Loeb 2007). Six sites were sampled with mist nets during spring and summer and bats were captured at each site (Loeb 2007). Many of the bats captured in the summer samples were lactating females, and many lactating individuals were captured early in the evening near Star Fort Lake, suggesting the presence of good rearing habitat in this area (Loeb 2007). Bats were sampled acoustically at 13 of 15 sites in both summer efforts and in late winter/early spring efforts (Loeb 2007). Loeb (2007) commented that the diversity of park habitats, the presence of several water bodies in the park, and the relatively undeveloped surrounding habitat contribute to healthy bat populations in NISI. In analyses of bat diversity at 10 National Park units across the southeastern U.S., Loeb et al. (2009) found that NISI had the highest Shannon's diversity index value and the second highest Shannon's evenness value among the 10 parks. Loeb's (2007; 2009) results and interpretation suggest NISI provides high-quality bat habitat.

Around 67% of expected mammal species were reported from NISI, with 62% of non-volant mammals and 86% of bats observed. Four of eight (50%) expected carnivores were reported. Pivorun (2009) suggested that the striped skunk (*Mephistes mephistes*) and red fox (Vulpes

vulpes) are common in the region and were expected to be reported in NISI. The long-tailed weasel (*Mustela frenata*) and mink (*Mustela vison*) are cryptic, patchily distributed, and difficult to trap (Linehan et al. 2008; Pivorun 2009). The coyote (*Canis latrans*) is not native to the region and has probably expanded into the area in recent years (Hill et al. 1987). Three missing rodent species, house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), and black rat (*Rattus rattus*), are invasive species commonly associated with human dwellings and agriculture. The lack of these species in the NISI sample does not indicate decreased quality of mammal habitat in the park. Removing exotic species from consideration, 82% of the expected native rodents were reported from the park. The missing insectivores, least shrew (*Cryptotis parva*) and eastern mole (*Scalopus aquaticus*), are difficult to trap and may be present (Pivorun 2009). The missing bat, silver-haired bat (*Lasionycteris noctivagans*), was expected only as a winter migrant in NISI (Loeb 2007). Domestic cats and dogs were not reported in the park. The presence of a variety of expected native mammals from multiple taxonomic orders and trophic levels, and an observed lack of common invasive species, is consistent with the hypothesis that NISI contains good mammal habitat and supports much of the mammal diversity expected in the region.

Table 20. Mammal species expected to occur in Ninety Six National Historic Site and species actually reported from a non-volant mammal survey (2006-2008) and a bat survey (2005-2007). P=reported by Pivorun (2009); L=reported by Loeb (2007).

Scientific Name	Common Name	Reported
Order Artiodactyla		
Odocoileus virginianus	white-tailed deer	P
Order Carnivora		
Canis latrans	coyote	P
Lynx rufus	bobcat	P
Mephitis mephitis	striped skunk	
Mustela frenata	long-tailed weasel	
Mustela vison	mink	
Procyon lotor	raccoon	P
Urocyon cinereoargenteus	gray fox	P
Vulpes vulpes	red fox	
Order Chiroptera		
Eptesicus fuscus	big brown bat	L
*Lasionycteris noctivagans**	silver-haired bat	
Lasiurus borealis	red bat	L
*Lasiurus cinereus**	hoary bat	L
Lasiurus seminolus	Seminole bat	L
Nycticeius humeralis	evening bat	L
Pipistrellus subflavus	eastern pipistrelle	L
Order Didelphimorphia		
Didelphis virginiana	Virginia opossum	P
Order Insectivora		
Blarina carolinensis	southern short-tailed shrew	P
Cryptotis parva	least shrew	
Scalopus aquaticus	eastern mole	
Sorex longirostris	southeastern shrew	P
Order Lagomorpha		
Sylvilagus floridanus	eastern cottontail	P
Order Rodentia		
Castor candensis	beaver	P
Glaucomys volans	southern flying squirrel	P
Microtus pinetorum	woodland vole	P
Mus musculus	house mouse	
Ochrotomys nuttalli	golden mouse	P
Ondatra zibethicus	muskrat	
Oryzomys palustris	rice rat	P
Peromyscus gossypinus	cotton mouse	P
Peromyscus leucopus	white-footed mouse	P
Rattus norvegicus	Norway rat	
Rattus rattus	black rat	
Reithrodontomys humulis	eastern harvest mouse	
Sciurus carolinensis	gray squirrel	P
Sigmodon hispidus	hispid cotton rat	P

* Expected winter migrant

The non-volant mammal sampling effort in the park had relied heavily on Sherman live traps, with a smaller component of unfenced pitfall traps (Pivorun 2009). Non-bat mammal sampling from a single study included 4,900 trap nights, of which 4,650 trap nights were with Sherman traps (Pivorun 2009). Studies sampling non-volant mammal assemblages in the southeast often conducted over 9,000 trap nights, using multiple trapping methods including drift fences with pitfalls (Mengak and Guynn 1987; Bellows et al. 2001; Kilpatrick et al. 2004; Osbourne et al. 2005; Linehan et al. 2008). Small mammal trapping efficiency varies among trap type and among species (Briese and Smith 1974; Bury and Corn 1987; Mengak and Guynn 1987); therefore significant effort with multiple trapping methods is desirable when sampling mammal assemblages. Pitfall traps with drift fence arrays may be particularly effective at sampling shrews (Briese and Smith 1974; Bury and Corn 1987). Traditional lethal snap mouse traps are effective at sampling small rodents (Mengak and Guynn 1987; Linehan et al. 2008), but may be undesirable in some settings. Successful trapping programs have specifically targeted edge and riparian habitats as well as open field and upland habitats (Osbourne et al. 2005; Linehan et al. 2008).

The recent mammal inventory of Ninety Six National Historic Site included significant trapping efforts with Sherman live traps and produced an excellent baseline for understanding mammal assemblages in the park. If further sampling is conducted at NISI, and particularly if efforts have the goal of documenting most of the non-volant mammals present, we recommend the use of significant trapping effort with multiple trapping methods. Comprehensive sampling should include at least small and large live traps, baited camera stations, and drift fence pitfall arrays. Drift fence pitfall arrays are labor intensive to install and are easily visible if placed in areas with high human visitation. However, once in place they can be used over long time periods with minimal maintenance and can be periodically deactivated during non-sampling periods. Furthermore, this sampling method is also effective for sampling herpetofauna and can thus accomplish multiple goals (Bury and Corn 1987; Greenberg et al. 1994; Metts et al. 2001). We recommend that future mammal sampling at NISI specifically target edge and riparian habitats in addition to forested and open habitats.

We did not assign a condition rank to the mammal community of Ninety Six National Historic Site (Table 21). The quality of the data was fair. Although we believe the mammal sampling efforts were good quality and documented a significant proportion of park mammals, we felt the data did not meet thematic requirements for data quality (Table 21). We believe that additional sampling methods would more completely document a representative sample of NISI mammal assemblage. Efforts to date have created an excellent baseline to further explore NISI mammal diversity.

Table 21. No condition was assigned to mammal communities at Ninety Six National Historic Site. The quality of mammal data was fair. No trend was assigned to mammal community condition.

Attribute	Condition & Trend	Data Quality: Thematic	Data Quality: Spatial	Data Quality: Temporal
Mammal Community			✓	✓
		2 of 3: Fair		

Herpetofaunal Community

Amphibians and reptiles are important components of southeastern US ecosystems. The southeastern US contains the highest diversity of herpetofauna in North America (Gibbons and Buhlmann 2001). Global declines in amphibians (Stuart et al. 2004) and reptiles (Gibbons et al. 2000) have been noted for decades, and herpetofauna have become the focus of increasing management concern and effort. Known threats to herpetofauna include habitat loss and fragmentation, habitat degradation, pollution, disease, and invasive species (Gibbons et al. 2000; Semlitsch 2000). Wetland habitats are of particular importance to amphibians (Semlitsch 2000) and are important to many species of reptiles as well (Gibbons et al. 2000).

There has been one herpetofauna survey at Ninety Six National Historic Site. Reed and Gibbons (2005) used unconstrained searches in all park habitats, road cruising, coverboards, and a few baited turtle hoop nets. This effort consisted of 15 trips and 25 person-days in the park and reported 31 species: 19 reptiles and 12 amphibians (Reed and Gibbons 2005; Table 22). No state or federally listed threatened or endangered species were reported from the park. Two species, common snapping turtle (*Chelydra serpentina*) and northern cricket frog (*Acris crepitans*), were included in the South Carolina Comprehensive Wildlife Conservation Strategy as species of conservation priority (SCDNR 2005). Reed and Gibbons (2005) reported good success finding herpetofauna in the bottomland habitats in the south of the park. They also noted that the north end of the Star Fort Lake, the small pond, and a temporary pond near Gouedy Trail supported good populations of amphibians (Reed and Gibbons 2005).

The herpetofaunal species richness reported from the combined NISI survey results included around 52% of the species expected by Reed and Gibbons (2005; Table 23). Reed and Gibbons (2005) used museum specimen searches, published range maps, and expert knowledge to compile a list of 60 species likely to occur in NISI (Table 22). The richness reported from NISI was within the broad range observed from other studies in protected forests in the South Carolina piedmont and upper coastal plain. Mosely et al. (2003) reported 21 species from Dilane Plantation on the upper coastal plain following efforts with drift fence pitfall arrays, pipe refugia, and coverboards. Floyd et al. (2002) used drift fences and pitfalls to sample 29 species from the Clemson Experimental Forest in north-western South Carolina. Metts et al. (2001) reported 49 species from the Clemson Forest following sampling with drift fences, minnow and hoop traps, and coverboards. In the NISI survey, anurans and turtles were the best represented groups with 90% and 100% of expected species observed, respectively (Table 23). Salamanders (27%) and snakes (36%) were relatively poorly represented. Reed and Gibbons (2005) claimed to be "spectacularly unsuccessful finding stream salamanders of the genera *Desmognathus*, *Eurycea*, *Gyrinophilus*, and *Pseudotriton*", though they expected species from these groups and believed some to be present. They also failed to find several expected species of snakes for which park habitat is well-suited (Reed and Gibbons 2005).

Efforts at documenting herpetofaunal diversity in NISI have relied significantly upon active searching (Reed and Gibbons 2005). Because behavior and habitat associations vary widely among herpetofaunal species, multiple methods should be used when sampling an assemblage (Gibbons et al. 1997; Tuberville et al. 2005). Total effort expended, sample method, sample timing, and the microhabitat sampled all affect the results of herpetofaunal surveys (Greenberg et al. 1994; Gibbons et al. 1997; Metts et al. 2001; Floyd et al. 2002; Ryan et al. 2002). Drift fencing with pitfall traps is among the most effective and commonly used methods of sampling herpetofauna assemblages, and may be particularly useful for sampling salamanders (Greenberg et al. 1994; Ryan et al. 2002; Wilson and Gibbons 2009). Funnel trapping on drift fences is also effective at sampling some herpetofauna, and may be particularly effective for sampling species such as large snakes that are relatively poorly sampled by pitfalls (Greenberg et al. 1994; Todd et al. 2007).

If further herpetofaunal sampling is conducted at NISI, and especially if efforts have the goal of documenting most of the species present, we recommend the use of significant effort with several sampling methods. Active searching by experts is an important tool for documenting the presence of species, and this method has produced an early understanding of herpetofaunal diversity in the park. We recommend that future comprehensive inventories include active searches as well as sampling with drift fences combined with pitfalls and funnel traps. Drift fence pitfall arrays are labor intensive to install and are easily visible if placed in areas with high human visitation. However, once in place they can be used over long time periods with minimal maintenance and can be periodically deactivated during non-sampling periods. Furthermore, this method is also effective at sampling small mammals, a community that may be of interest to park managers. We recommend that future efforts include sampling near the larger wetlands identified by Roberts and Morgan (2007; Figure 14).

Table 22. Herpetofauna species likely to occur in Ninety Six National Historic Site by Reed and Gibbons (2005), and species actually reported. X=species reported by Reed and Gibbons (2005).

Scientific Name	Common Name	Obs	Scientific Name	Common Name	Obs
Anurans			**Snakes**		
Acris crepitans	northern cricket frog	X	*Agkistrodon contortrix*	copperhead	X
Bufo fowleri	Fowler's toad	X	*Carphophis amoenus*	worm snake	
Gastrophryne carolinensis	eastern narrowmouth toad	X	*Cemophora coccinea*	scarlet snake	
Hyla cinerea	green treefrog	X	*Coluber constrictor*	black racer	X
Pseudacris crucifer	spring peeper	X	*Crotalus horridus*	canebrake rattlesnake	
Pseudacris feriarum	upland chorus frog	X	*Diadophis punctatus*	ringneck snake	X
Rana catesbeiana	bullfrog	X	*Elaphe guttata*	corn snake	
Rana clamitans	green frog	X	*Elaphe obsoleta*	rat snake	X
Rana utricularia	southern leopard frog	X	*Heterodon platirhinos*	eastern hognose snake	
Scaphiopus holbrookii	eastern spadefoot toad		*Lampropeltis calligaster*	mole kingsnake	
Lizards			*Lampropeltis getula*	eastern kingsnake	X
Anolis carolinensis	green anole	X	*Lampropeltis triangulum*	scarlet kingsnake or milksnake	
Cnemidophorus sexlineatus	six-lined racerunner		*Nerodia erythrogaster*	plainbelly water snake	X
Eumeces fasciatus	five-lined skink	X	*Nerodia sipedon*	northern banded water snake	X
Eumeces inexpectatus	southeastern five-lined skink		*Opheodrys aestivus*	rough green snake	
Eumeces laticeps	broadhead skink		*Pituophis melanoleucus*	pine snake	
Ophisaurus attenuatus	slender glass lizard		*Regina septemvittata*	queen snake	
Sceloporus undulatus	fence lizard	X	*Sistrurus miliarius*	pigmy rattlesnake	
Scincella lateralis	ground skink	X	*Storeria dekayi*	brown snake	X
Salamanders			*Storeria occipitomaculata*	redbelly snake	X
Ambystoma maculatum	spotted salamander	X	*Tantilla coronata*	southeastern crowned snake	
Ambystoma opacum	marbled salamander	X	*Thamnophis sauritus*	ribbon snake	
Ambystoma tigrinum	eastern tiger salamander		*Thamnophis sirtalis*	garter snake	
Desmognathus fuscus	northern dusky salamander		*Virginia striatula*	rough earth snake	
Eurycea cirrigera	southern two-lined salamander		*Virginia valeriae*	smooth earth snake	
Eurycea guttolineata	three-lined salamander		**Turtles**		
Hemidactylium scutatum	four-toed salamander		*Chelydra serpentina*	common snapping turtle	X
Notophthalmus viridescens	red spotted newt		*Chrysemys picta*	eastern painted turtle	X
Plethodon glutinosus complex	slimy salamander	X	*Kinosternon subrubrum*	eastern mud turtle	X
Pseudotriton montanus	mud salamander		*Sternotherus odoratus*	common musk turtle	X
Pseudotriton ruber	red salamander		*Terrapene carolina*	eastern box turtle	X
			Trachemys scripta	yellow-bellied slider	X

Table 23. Number of species of herpetofauna expected at Ninety Six National Historic Site, and numbers and percentages of species actually observed during a recent inventory (Reed and Gibbons 2005).

	# Expected	# Observed	% Expected Observed
All species	60	31	52
Amphibians	21	12	57
Reptiles	39	19	49
Anurans	10	9	90
Salamander	11	3	27
Lizard	8	4	50
Snake	25	9	36
Turtle	6	6	100

We did not assign a condition to the herpetofaunal community at Ninety Six National Historic Site (Table 24). We feel that although efforts to date have identified a significant proportion of the expected diversity, further effort with additional trapping methods is necessary to provide a true representative sample of NISI herpetofauna. The park demonstrably contains a diverse assemblage of regional frogs and turtles, but a similarly rich group of salamanders and snakes has not been found. The quality of the data was fair (Table 24). We did not check the thematic component of data quality because we believe the effort was not sufficient to adequately document a representative sample of NISI reptiles and amphibians.

Table 24. No condition was assigned to reptile and amphibian communities at Ninety Six National Historic Site. The quality of herptetofaunal data was fair. No trend was assigned to reptile and amphibian community condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Herpetofauna Community			✓	✓
		2 of 3: Fair		

Rare Plants

Although there are no federally-listed plant species at NISI, White and Govus (2003) identified eight focal species based on their local rarity or habitat vulnerability (Table 25). Of these, Oglethorpe oak (*Quercus oglethorpensis*) possessed the highest global ranking status. Two other state-listed species, American columbo (*Frasera caroliniensis*) and green-fringed orchid (*Platanthera lacera*) were discussed briefly in the vegetation summary.

Table 25. List of focal and conservation-listed species at NISI (White and Govus 2003).

Species		NatureServe (2009) Ranking
*Quercus oglethorpensis**	Oglethorpe Oak	G3,S3
Frasera caroliniensis	American columbo	S2
*Platanthera lacera**	Green-fringed orchid	S2
*Carex amphibola**	Eastern narrowleaf sedge	--
*Carex gracilescens**	Slender looseflower sedge	S1
Aristolochia serpentaria	Virginia snakeroot	G4
Eleocharis quadrangulata	Squarestem spikerush	G4
Gymnopogon ambiguus	Bearded skeletongrass	G4
Ligusticum canadense	Canadian licoriceroot	G4

*SC Species of concern

Oglethorpe Oak

Oglethorpe oak (Figure 17) is extremely rare throughout its range, and was only recently described in 1940 from populations in Georgia (Duncan 1940). Its range is currently restricted to four counties in South Carolina (USDA 2009; Figure 18), and it is listed as a species of concern in LA, MS, AL, GA, and SC. In 1985, Haehnle and Jones cited only 140 remaining sites, while noting that much of the threat to this species occurred before its discovery when much of the forested land containing Oglethorpe habitat was converted to agricultural use. Pasture, residential use, and pine plantation are the most common conversions affecting this species today, in addition to inundation due to reservoir construction. In particular, construction of the J. Strom Thurmond Dam along the Savannah River in the early 1950's is thought to have had a large negative impact on the extent of these oaks. Much of the remaining habitat area is along fencerows or roadsides, which possibly served as refugia for the species during the main periods of habitat conversion before 1940 (Haehnle and Jones 1985). At NISI, Oglethorpe oak is probably most predominantly threatened by Japanese honeysuckle, which can potentially overtake and kill juveniles and seedlings (NatureServe 2009). It is unknown, however, how often Japanese honeysuckle occurs in areas of Oglethorpe presence at NISI.

Figure 17. Oglethrope oak (*Quercus oglethorpensis*). [© Cody Parmer, discoverlife.org]

Although White and Govus (2003) report that Oglethorpe Oak is most commonly found in the Successional Water Oak Forest, this community is fortunately not as susceptible to invasive species as most of the other successional communities in the park. The Southern Piedmont Oak Bottomland, where it occurs to a lesser degree, is reported by White and Govus (2003) to be frequently infested by Chinese privet, which has the potential to form dense thickets and eventually outcompete native vegetation (Batcher 2000). The Successional Loblolly Pine – Sweetgum, where the oak also occurs occasionally, is highly susceptible to invasion by Japanese honeysuckle, which has been specifically linked to mortality of Oglethorpe oak (NatureServe 2009).

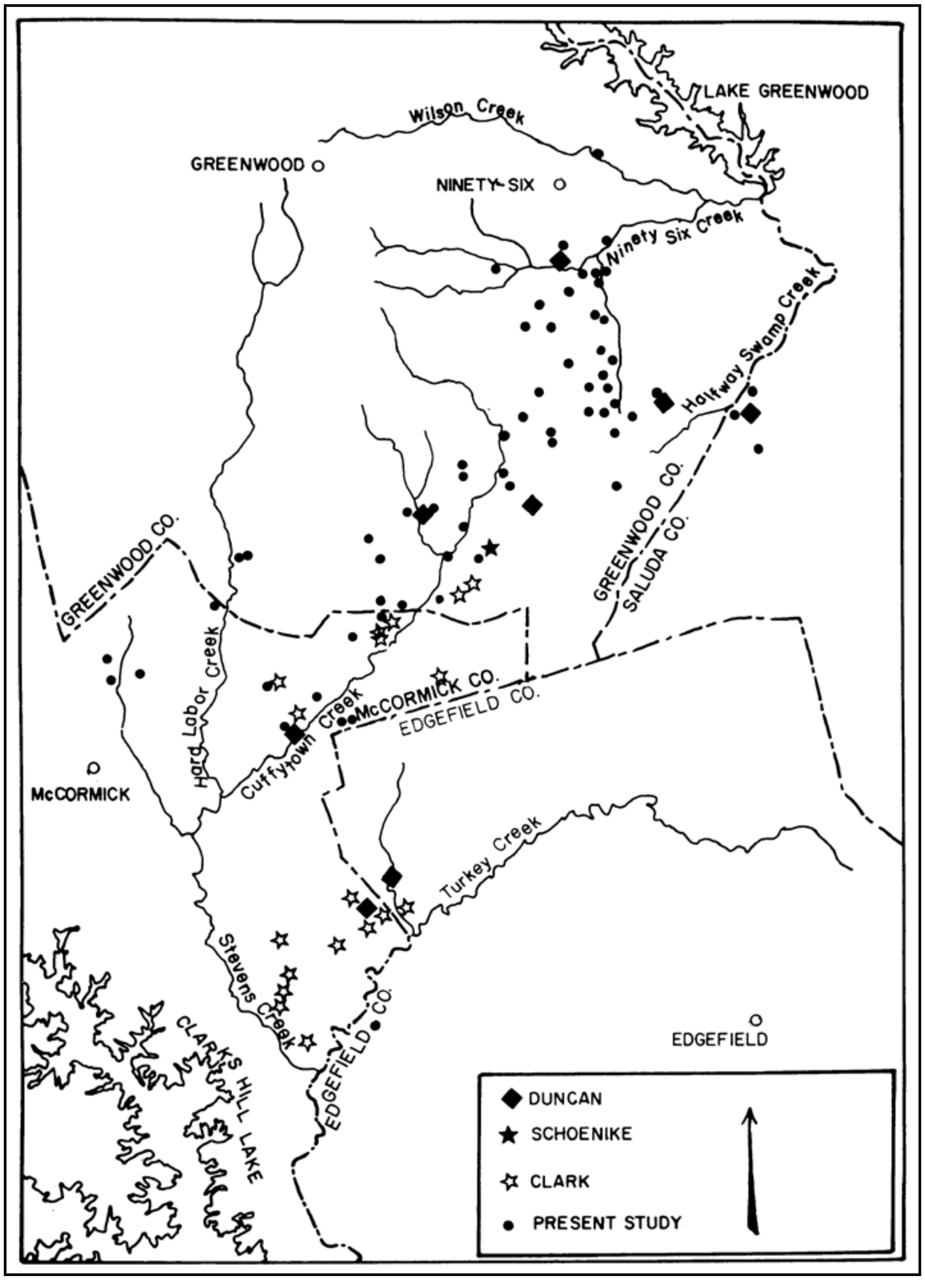

Figure 18. Distribution of Oglethorpe oak (Quercus oglethorpensis) in South Carolina [taken from Haehnle and Jones, 1985].

American Columbo

White and Govus (2003) also identify American columbo (*Frasera caroliniensis*) as an important rare species occurring at NISI (Figure 19). They note that Greenwood County is the only county in SC where American columbo has been observed (USDA 2009). At NISI, White and Govus (2003) identified it mainly in clonal colonies within the Piedmont Basic Mesic Mixed Hardwood Forest. Although its range extends across the eastern US, the plant is overall quite rare and is state-listed or threatened in eight states. The Southern Appalachian Species Viability Project lists habitat loss and fragmentation as the biggest threats to American columbo, with intensive forest management in general as the largest threats to its continued existence (NatureServe 2009). A monitoring project is currently underway through Landers University in Greenwood, SC (T. Leibfreid, pers. comm.). Because this species occurs at NISI mainly in a natural community, there is a reduced risk of being threatened by invasives. Govus (pers. comm.) recommends seed collection to help ensure the persistence of the populations.

Figure 19. American columbo (*Frasera caroliniensis*). [© George Yatskievych, discoverlife.org]

Green-Fringed Orchid

In addition to the work by White and Govus (2003), a single occurrence of green-fringed orchid (*Platanthera lacera*) was documented by Clemson naturalist Rusty Wilson (Figure 20). Green-fringed orchid is listed as S2 (imperiled) in South Carolina (NatureServe 2009) and is also county record (McAninch, pers. comm.). At NISI, it occurs in the southwest portion inside a small patch of Piedmont Basic Mesic Mixed Hardwood Forest.


Figure 20. Green-fringed orchid (*Platanthera lacera*). [© George Yatskievych, discoverlife.org]

Summary
Overall, little specific information is available on the distribution and threats to Oglethorpe oak, American columbo, and the green-fringed orchid at NISI other than what is mentioned by White and Govus (2003). Oglethorpe Oak is perhaps the main rare species found at NISI and occurs commonly in a forest type where invasives are not a main threat. American columbo and green-fringed orchid both occur in the Piedmont Basic Mesic Mixed Hardwood Forest, which is also one of the remaining undisturbed vegetation types in the park unit. As a result, the overall condition status for rare plants is assigned a ranking of "good" (Table 26).

Since no additional information is available on the trend of this species, the trend is assigned as "stable" (Table 26). In addition, a lack of recent specific information, as well as a lack of spatially-explicit occurrences for these species, results in a missing data quality ranking for the temporal and spatial categories of this assessment, respectively. Further monitoring devoted specifically to the distribution of these species, their potential threats within the park unit, and management options, would result in an improved data quality ranking and better protection for these important species.

Table 26. The condition status for rare plants at NISI is good. The data quality used to make this assessment was poor. A trend of stable was assigned to this condition. (*) Because of the disparity between the data quality and condition status, extra consideration is warranted when interpreting this ranking.

		Data Quality		
Attribute	Condition & Trend	Thematic	Spatial	Temporal
Rare Plants	*	✓		
		1 of 3: Poor		

Landscape Dynamics

Landscape dynamics is a broad category that can potentially utilize a variety of metrics or measures to describe land characteristics and how they change over time. Because NISI is a relatively new park unit, landscape change may be particularly relevant to assess how areas are responding to park management, or how the development of surrounding areas can affect changes within the park. Common ecosystem threats associated with development include 1) invasion of exotic plants and animals, 2) additional sources of air and depositional pollution, and 3) degraded water quality and altered hydrology. Factors such as these can interact to debilitate protected resources inside the park unit.

Landcover Class Comparisons

NLCD

To understand how landscape changes could affect the park unit, it is useful to compare changes in the surrounding area over time. To that end, the Multi-Resolution Land Characteristics Consortium (MRLC) constructed a retrofitted landcover change map to compare the 1992 to 2001 National Land Cover Dataset (NLCD) layers, while correcting for differences in mapping methodologies and classification types between the two time periods (MRLC 2009). After this correction, the retrofitted layer shows which areas have transitioned to new landcovers, and which have not changed at a 30m resolution. By separating data for the NISI boundary, it is possible to see how the landcover has changed over this nine year period, which shows the only significant transition over this time period is a shift of ~22 ha in the northern sections of the park from forest to fescue cultivated meadow around Star Fort Lake and near the visitor’s center.

CRMS

A further comparison is possible using the difference between the 2001 NLCD data and the 2002 CRMS classification which, although the latter has been divided to more detailed classes, can be reclassed back to alliance levels—a more general classification—for the purpose of comparison. Table 27 shows this comparison, and as expected, there is little difference over the 1-yr period. What little difference there is may be the result of classification errors. Most classes for the 2002 CRMS data are represented in slightly greater proportion than classes in the 2001 NLCD data, at the cost of 13% lower deciduous cover. This difference most likely represents the separate classification schemes (general vs. detailed) used for each version of the data.

Table 27. Class comparison of 2001 NLCD with 2002-2003 CRMS data.

Landcover	**2001 NLCD**	**2002 CRMS**	**Difference**
	---acres---		
Coniferous	293 (31%)	333 (35%)	+4%
Deciduous	340 (36%)	215 (23%)	-13%
Mixed	3 (<1%)	9 (1%)	+1%
Scrub/Shrubland	0 (<1%)	11 (1%)	+1%
Graminoid	121 (13%)	142 (15%)	+2%
Palustrine	106 (11%)	164 (17%)	+6%
Other/Impervious	85 (9%)	74 (8%)	-1%
Total	**948**	**948**	**--**

Summary

Despite the available data from the CRMS and NLCD landcover classifications, we did not assign a condition ranking to landscape dynamics at NISI (Table 28). The stability of landcover classes between time periods in the NLCD change product led to an assignment of a “stable” trend. In addition, the lack of any available landscape data after the 2002 CRMS classification resulted in no “temporal” ranking for data quality. Because of the consistency of landcover classes represented by the NLCD change product over the nine year period from 1992 to 2001, we assigned a trend of “stable.” As of this writing, the NPS is developing tools for monitoring landscape change for all national park units with significant natural resources (NPS 2011). Landscape data from the NLCD, and especially the vegetation classification performed for NISI by the CRMS, will provide a meaningful resource from which to conduct further assessment. The new landscape dynamics monitoring protocol will undoubtedly provide a basis by which to assess landscape conditions for all NPS units.

Table 28. The condition status for landscape dynamics at NISI is not ranked. The data quality of this ranking is fair. A trend of stable was assigned to this condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Landscape Dynamics	⇨	✓	✓	
		2 of 3: Fair		

Conclusions

Summary

Based on a review of available ecological information at NISI, we have addressed the current condition of fourteen natural resources categories in the park. We have provided qualitative condition ranks for 10 of the 14 attributes. Four attributes were discussed and not ranked. Five attributes (35.7%) were ranked as good, four (28.6%) were ranked as fair, and one (7.1%) was ranked as poor. The single poor ranking was given to invasive plants. Summarized into broad level 1 categories (Table 1) the rankings were:

1) Air and Climate (two attributes)—100% Fair
2) Water (three attributes)—33% Fair, 67% Good
3) Biological Integrity (eight attributes)—12.5% Poor, 12.5% Fair, 37.5% Good, 37.5% Not Ranked
4) Landscapes (one attribute)—100% Not Ranked.

We also characterized the quality of information available for use for each attribute, including those not ranked. We considered the temporal, thematic, and spatial quality of available data for each attribute. Data for rare plants were ranked as poor. Data for invasive plants, mammal communities, herpetofaunal communities, and landscape use were ranked as fair. Data for remaining attributes were ranked as good.

Natural Resource Conditions

Natural resource attributes at NISI were chosen based on data availability, park-level importance, and network vital sign status. The level of data completeness varied greatly among natural resource categories, though this aspect was considered independently when assigning condition rankings. Where appropriate, suggestions are offered to improve natural resource datasets.

Ozone

Interpolated estimates of ozone over the past decade have all shown elevated concentrations at NISI, though a three week period of monitoring during 2005 showed lower values. This could be simply because of an incomplete monitoring season with a smaller resulting distribution of values, or it could represent an actual decrease in ozone values over recent years. Both possibilities are likely, as an extensive history of ozone monitoring at nearby Cowpens NB showed a clear improving trend at that park unit. Despite this, NISI received a “fair” condition status ranking due to the consistency of ozone concentrations near threshold levels.

Although relatively undeveloped now, growth of the region surrounding NISI could pose additional risk to air quality considerations like ozone at the park unit. A new public school is under construction very close to the park and will result in an increase in bus and auto traffic adjacent to and near NISI. This will most certainly affect air quality, but may also negatively impact animal species. Continued air quality monitoring and animal inventories will help identify these effects.

Data quality
Although Cowpens NB is an important source of reference data for ozone levels at NISI, the difference in setting of the two park units belies some of the comparative value of this data. It is likely, however, that air quality variables such as ozone at NISI would fall below measurements taken at Cowpens NB due to the more developmentally isolated nature of NISI, though only additional monitoring at the latter could definitively make this determination.

Foliar injury

Risk of ozone damage to vegetation is closely tied to ozone concentrations, though it is also affected by exposure duration, species sensitivity, and soil moisture conditions. The severity of the Sum06 and W126 foliar injury metrics was consistent among all interpolated estimates over five year periods from 1995 through 2007, which respectively fell into the high and medium risk categories. For the N100 metric, however, its severity was variable among periods, alternating between low and no risk of foliar injury. The overall impression of these metrics is a moderate risk, resulting in a condition assignment of "fair." Soil moisture showed little association with foliar injury risk.

Data quality
Because foliar injury metrics at NISI are derived solely from interpolated data, they do not provide as accurate depiction of injury risk as would monitoring onsite. Due to the potential risk of foliar injury at NISI predicted by recent estimates, on-the-ground assessments combined with soil moisture monitoring would be an essential follow-up plan to gauge how much the vegetation communities at NISI are being impacted by ozone exposure. In addition, crosschecking periodic vegetation inventories at NISI with the master list of ozone sensitive species will aid in assessment efforts. As of this writing, NISI is scheduled to rotate onto the CUPN's vital signs monitoring schedule in 2013, so there is planned on-the-ground monitoring of ozone levels and foliar injury by the CUPN.

Hydrology

Comprised of three condition rankings, overall water quality at NISI is in good condition. Surface water, or water quantity, is mainly influenced by flow alterations and is largely irrelevant at NISI because of its scale and overall short flow length within the park unit. However, Henley Creek which passes through NISI from the outside, has a much higher flow rate than Tolbert Branch and discharge from Star Fort Lake, and may be susceptible to flow alterations (e.g. runoff) due to development surrounding the park unit. But due to the effective absence of any type of unnatural flow alteration to streams within NISI, this water quantity received a ranking of "good."

Water chemistry addresses various water quality parameters measured at different streams. Overall, water chemistry presented no chronic issues and received a condition status ranking of "good." Star Fort Lake resulted in a few samples that were atypically low for ANC, specific conductance, and dissolved oxygen, while pH values were marginally alkaline during summer sampling. Most of these abnormalities may be typical of lake water due to its stagnation, thus reflecting natural conditions.

The third hydrology condition ranking was for microorganisms, which was based on fecal coliform monitoring during the first sampling period and *E. coli* concentrations for the subsequent two. One sample for each parameter was found to exceed recommended levels at each of the Henley sampling locations. Although these two samples would seem to provide minimal evidence of elevated microorganism levels, a cautious assessment is appropriate when so few samples are available, and thus this aspect of water quality received a condition status ranking of "fair." It is virtually certain that sources outside the park are partly responsible for contamination due to the boundary placement of the sample sites. Inside the park unit, the most likely source is wildlife fecal contamination.

Data quality
Data for these three attributes is collected at four stations quarterly every other year by CUPN. Although the current dataset is sparse due to monitoring originating in 2004, this monitoring regime represents an important beginning for NISI to develop water quality baselines.

Invasive Plants

Exotic species are perhaps one of the most pressing ecological threats at NISI, and as a result this condition received the only "poor" status ranking. Due to the high number of non-native species and numerous human-modified vegetation communities, areas harboring native plants are especially vulnerable to competition from nearby sources of invasives. Bottomland forests and floodplain canebrake areas are perhaps the most in need of protection, due to their unique species assemblages and susceptibility to highly noxious weeds like Chinese privet.

Data quality
The most recent vegetation inventory on which this assessment is based was conducted in 2003. Since that time, management for exotics may (hopefully) have reduced the threat of invasives to sensitive areas. Frequent inventory updates or simply just focused monitoring of specific infested and sensitive areas could help mitigate the impact of problem species. In addition, information on which specific exotics pose the largest threat to native plants and communities in relation to their abundance at NISI could help in developing treatment priorities. As of this writing, the CUPN is developing an "Early Detection Protocol" for invasive plants and has collected additional data during vegetation monitoring in 2011.

Insect Pests

Southern pine beetle is likely the most relevant insect pest at NISI, though overall risk for this pest is still quite low. Because of the large amount of forested land in the park unit, much of which contains successional pine, stands are susceptible to infestation. Vulnerability maps by the USFS modeled an overall low to moderate infestation risk in these successional areas. Monitoring focused on areas affected by drought, fires, or lightning strikes will ensure the quickest response to new infestations. Overall, other possible insect pests such as gypsy moth and ips beetle appear to present little risk at NISI, and as a result this attribute is assigned a condition status ranking of "good."

Data quality
This assessment is based largely on risk prediction maps for southern pine beetle infestation and gypsy moth trapping inside the park unit. Vegetation monitoring at established plots, or devoted

monitoring for beetle infestation, would help construct a history of infested areas, as well as help identify sensitive stands. The “Early Detection Protocol” being developed for invasive plants by the CUPN will also be applicable to insect pests. Data on this attribute was also collected during vegetation monitoring in 2011.

Vegetation Communities

Despite its small size, NISI contains some primary examples of regionally significant vegetation communities such as floodplain canebrake and Southern Interior Oak Bottomland Forest. Several areas of undisturbed forest such as cattail marsh and hardwood forests provide habitat for unique understory species, and a recent inventory found 46 wetland areas throughout the park unit. This attribute did not receive a ranking in the current report, but with the completion of the vegetation monitoring protocol by the CUPN—currently underway—a systematic approach to using this vegetation data is likely.

Data quality

The vegetation maps and inventories are fairly extensive, though they will require frequent updates to reflect natural changes and management activities.

Fish Communities

Ninety Six National Historic Site contains several stream and stream segments from 1st to 4th order. The most important streams for fish habitat are Tolbert Branch and Henley Creek. The park also contains a 27-acre impounded lake and a small vegetated pond, both containing fish. A 2005 survey of three stream locations, the lake, and the small pond reported 22 species of fish from five families. No state or federally listed threatened or endangered species were reported. An index of biotic integrity was applied to the samples from Tolbert Branch and from Henley Creek, and indicated excellent condition for Tolbert and poor condition from Henley. Though Henley is larger and was sampled over a longer reach, fewer individuals and fewer species were sampled there. The reason for the lower score for Henley Creek is not known, but the watershed lies mostly outside park boundaries and higher bacterial levels were noted for Henley relative to other creeks in the park. The condition of NISI fish communities was ranked as fair. No trend was assigned to this condition.

Data quality

The available fish data were good. Samples were collected recently using appropriate methods. Efforts adequately sampled the available habitat.

Bird Communities

One hundred and twenty three bird species were reported from a recent survey in the park, suggesting that NISI supports a relatively diverse bird assemblage. A bird community index applied to breeding bird count data indicated that habitat ranged from “moderately disturbed” to “naturalistic,” with most locations being either “largely intact” or “naturalistic.” The forested habitat in the park is demonstrably able to support breeding by a number of interior forest bird specialists. The condition of the NISI bird community was ranked as good. No trend was assigned to this condition.

Data quality
The available bird data were of good quality. Samples were collected recently using appropriate standardized methods. Samples were collected at a grid of established plots adequately representing available park habitats.

Mammal Communities

The reported mammal community in NISI included about 67% of expected species and is reasonably typical of assemblages expected in the region. Ungulates, carnivores, rodents, and shrews were found in the recent survey. Evidence suggests that bat habitat and bat populations are thriving in the park, with six of seven expected species reported. Because the non-volant mammal sampling effort to date has been limited in type, new species are likely to be reported in future efforts. The condition of the mammal community was not ranked.

Data quality
The available mammal data were fair. Bat samples were collected recently using appropriate methods in representative park habitats. Non-bat samples were collected recently and in representative park habitats. The sampling effort for non-volant mammals included 4,900 trap nights but and relied heavily upon Sherman live traps. This amount of effort, though significant for the time frame of the study, was lower than the amount commonly used in studies sampling mammal assemblages. Furthermore, studies to date have not used the diversity of trapping methods recommended to appropriately sample mammal assemblages.

Herpetofaunal Communities

The reported herpetofaunal community in NISI includes about 52% of the expected species of reptiles and amphibians, with frogs and turtles being relatively well represented and salamanders and snakes being relatively poorly represented. Because the sampling effort to date has relied heavily upon active searching, these results may not represent an accurate understanding of the park herpetofaunal assemblage. The condition of the herpetofaunal community was not ranked.

Data quality
The available herpetofaunal data were fair. Most samples were collected recently and in representative park habitats. Sampling has relied primarily upon active searching and an excellent start has been made at understanding herpetofaunal diversity in NISI. However, studies to date have not used the diversity of trapping methods recommended to appropriately sample the expected diversity of park reptiles and amphibians.

Rare Plants

Of the eight focal species identified at NISI, Oglethorpe Oak, American columbo, and the green-fringed orchid were the ones addressed in this report. The latter two occur in undisturbed vegetation communities, while the Oglethorpe Oak predominantly occurs in the Successional Water Oak, Southern Piedmont Oak Bottomland Forest, and Successional Loblolly Pine – Sweetgum Forest communities. With the exception of the bottomland forest, these communities represent human-modified vegetation types that may predispose the tree to competition from exotic species. Japanese honeysuckle, in particular, has been shown to outcompete native seedlings of this species, and it is likely that invasives in general are the largest threat to the persistence of this species in the park unit. At the moment, however, the condition status of rare plants receives a ranking of "good."

Data quality
Unfortunately, this condition received the poorest data quality ranking due to a lack of spatial information and the amount of time since the last vegetation inventory. Periodic surveys devoted to locating the remaining occurrences of these species can help identify trends in their populations, and in turn aid in their recovery.

Landscape Dynamics

Numerous factors are involved in an explanation of landscape dynamics and their effects on the park unit. The current assessment compared landcover datasets from three years—1992, 2001, and 2002—and showed minimal changes over time. No condition rank was assigned to the status of this attribute, though currently the NPS is also developing tools and methods to standardize this assessment as part of the NPScape program.

Data quality
Several sources of data are readily available and are important for this condition assessment, including recent vegetation maps of NISI produced by CRMS and NLCD layers. Although the level of current data is adequate, guidelines for their analysis are essential to provide an objective assessment.

Natural Resource Synthesis

The natural resource attributes selected for this condition ranking are intended as a comprehensive summary of the ecological status of NISI. Although each condition is assigned a rank separately, a large part of their importance relies on their potential to interact and influence other attributes, either positively or negatively. A significant challenge to preserving natural resources is considering these interactions and prioritizing management efforts to effect the most beneficial of outcomes.

With this in mind, it is important to emphasize the potential interaction effects from the threat of invasive plants at NISI, which received the only "poor" condition status of any of the ranked attributes. Perhaps their most apparent risk is the potential for incursion to other natural/focal vegetation communities, where they are especially competitive and can alter the vegetation structure of the areas they invade, which can in turn affect other guilds such as birds, mammals, and herpetofauna that may rely on a specific habitat type. The risk from their competition is especially pertinent for sensitive species found in the park, such as Oglethorpe Oak, which is known to occur in areas with invasives. As noted in the invasive plants section, the pervasiveness of exotic plant species throughout various habitats makes their treatment challenging, such that the most efficient approach might be to protect currently unimpacted sensitive areas and species from invasion.

Landscape dynamics is another attribute that follows a complex relationship with other ecosystem processes. Potential landscape patterns, such as development or fragmentation, can serve as vectors for invasion of exotic species, while connected forest landscapes could act as corridors for insect or disease entry. Landscape changes can also result in additional sources of air pollution, which contributes to generation of ozone. This, in turn, has the potential to affect vegetation communities through foliar injury. Encroachment of surrounding development may also have effects on water quality of streams at NISI via atmospheric deposition.

This project represents the first iteration in the development of a comprehensive natural resource monitoring program at NISI. Beyond this report, continued monitoring of resources and attention to data gaps, as well as the development of additional condition assessment protocols will aid in the undertaking of future natural resource assessments.

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Appendices

Appendix A. NPS Ecological Monitoring Framework table, with highlighted categories representing relevant vital signs specifically selected for Ninety Six National Historic Site. '*' denotes an official vital sign as identified by the CUPN for NISI by the network monitoring plan. Highlighted entries with a '†' are significant natural resources mentioned elsewhere, or low priority vital signs mentioned in the original list of considerations in Appendix Q CUPN. Measures listed in column 4 are suggested measures or ones already available from existing data.

Ecological Monitoring Framework—Ninety Six National Historic Site			
Level 1 Category	**Level 2 Category**	**Level 3 Category**	**Specific Resource / Area of Interest**
Air and Climate	Air Quality	Ozone*	Official Vital Sign: "Ozone and foliar injury" ; Measures: Ozone levels and impact on native plants; Sum06, W126, and N100 injury metrics
		Wet and Dry Deposition	
		Visibility and Particulate Matter	
		Air Contaminants	
	Weather and Climate	Weather and Climate*	Official Vital Sign: "Climate/ Weather" Protocol still in development
Geology and Soils	Geomorphology	Windblown Features and Processes	
		Glacial Features and Processes	
		Hillslope Features and Processes	
		Coastal/Oceanographic Features and Processes	
		Marine Features and Processes	
		Stream/River Channel Characteristics	
		Lake Features and Processes	
	Subsurface Geologic Processes	Geothermal Features and Processes	
		Cave/Karst Features and Processes	
		Volcanic Features and Processes	
		Seismic Activity	
	Soil Quality	Soil Function and Dynamics	
	Paleontology	Paleontology	
Water	Hydrology	Groundwater Dynamics	
		Surface Water Dynamics*	Official Vital Sign: "Water Quality and Quantity"; Measures: Discharge

Appendix A. Continued.

		Marine Hydrology	
	Water Quality	Water Chemistry*	Official Vital Sign: “Water Quality and Quantity” ; Measures: Temp, pH, specific conductivity, DO, ANC;
		Nutrient Dynamics	
		Toxics	
		Microorganisms*	Official Vital Sign: “Water Quality and Quantity”; Measures: *E. coli* and total coliform
		Aquatic Macroinvertebrates and Algae	
Biological Integrity	Invasive Species	Invasive/Exotic Plants*	Official Vital Sign: “Invasive Plants”; (70 non-native species; 11 highly invasive) Measures: Abundance, Competition, Invasibility, I-Rank metric
		Invasive/Exotic Animals	
	Infestations and Disease	Insect Pests*	Official Vital Sign: “Forest Pests”; Measures: Current/Historical Abundance, Range of Damage, Risk of Infestation
		Plant Diseases	
		Animal Diseases	
	Focal Species or Communities	Marine Communities	
		Intertidal Communities	
		Estuarine Communities	
		Wetland Communities*	Official Vital Sign: “Vegetation Community”; Meausures: Vegetation structure, composition, extent, focal communities
		Riparian Communities*	Official Vital Sign: “Vegetation Community”; Meausures: Vegetation structure, composition, extent, focal communities
		Freshwater Communities	
		Sparsely Vegetated Communities	
		Cave Communities	
		Desert Communities	
		Grassland/Herbaceous Communities	
		Shrubland Communities*	Official Vital Sign: “Vegetation Community”; Meausures: Vegetation structure, composition, extent, focal communities

Appendix A. Continued.

		Forest/Woodland Communities*	Official Vital Sign: "Vegetation Community"; Meausures: Vegetation structure, composition, extent, focal communities
		Marine Invertebrates	
		Freshwater Invertebrates	
		Terrestrial Invertebrates	
		Fishes†	Not an official Vital Sign: Measures: North Carolina fish IBI, Species Richness,
		Amphibians and Reptiles†	Not an official Vital Sign: Measures: Richness, % expected reported
		Birds†	Not an official Vital Sign: Measures: Bird Community Index, presence of indicator sp.
		Mammals†	Not an official Vital Sign: Measures: Richness, % expected reported
		Vegetation Complex (use sparingly)	
		Terrestrial Complex (use sparingly)	
	At-risk Biota	T&E Species and Communities*	Official Vital Sign "Vegetation Community" Measures: Species abundance and change (Oglethorpe Oak—G3)
Human Use	Point Source Human Effects	Point Source Human Effects	
	Non-point Source Human Effects	Non-point Source Human Effects	
	Consumptive Use	Consumptive Use	
	Visitor and Recreation Use	Visitor Use	
	Cultural Landscapes	Cultural Landscapes	
Landscapes (Ecosystem Pattern and Processes)	Fire and Fuel Dynamics	Fire and Fuel Dynamics	
	Landscape Dynamics	Land Cover and Use*	Official Vital Sign: "Landscape Dynamics" Measures: Changes in landcover over time, correlation of landcover with species of concern, adjacent land use patterns, areas managed as biodiversity hotspots or wildlife corridors
	Extreme Disturbance Events	Extreme Disturbance Events	
	Soundscape	Soundscape	
	Viewscape	Viewscape/Dark Night Sky	
	Nutrient Dynamics	Nutrient Dynamics	
	Energy Flow	Primary Production	

Appendix B. List of plants documented for NISI (White and Govus 2003).

Species	Common Name	Species	Common Name
Acer barbatum	Florida maple	*Juncus effusus*	Common rush
Acer leucoderme	Chalk maple	*Juncus tenuis*	Poverty rush
Acer negundo	Boxelder	*Juniperus virginiana*	Eastern red-cedar
Acer rubrum	Red maple	*Krigia virginica*	Virginia dwarfdandelion
Achillea millefolium	Common yarrow	*Leersia virginica*	White grass
Acorus calamus	Sweetflag	*Lemna minor*	Common duckweed
Ageratina aromatica	Lesser snakeroot	*Lepidium ruderale*	Roadside pepperweed
Agrimonia parviflora	Harvestlice	*Lepidium virginicum*	Virginia pepperweed
Agrostis hyemalis	Winter bentgrass	*Lespedeza cuneata*	Chinese lespedeza
Aira elegans	Annual silver hairgrass	*Lespedeza repens*	Creeping lespedeza
Albizia julibrissin	Mimosa	*Leucanthemum vulgare*	Oxeyedaisy
Allium canadense	Meadow garlic	*Ligusticum canadense*	Canadian licoriceroot
Allium vineale	Wild garlic	*Ligustrum vulgare*	European privet
Ambrosia artemisiifolia	Annual ragweed	*Lindernia dubia*	Moistbank pimpernel
Anagallis arvensis	Scarlet pimpernel	*Liquidambar styraciflua*	Sweetgum
Andropogon glomeratus	Bushy bluestem	*Liriodendron tulipifera*	Tulip poplar
Andropogon ternarius	Splitbeard bluestem	*Lolium arundinaceum*	Tall fescue
Andropogon virginicus	Broomsedge	*Lolium perenne ssp. multiflorum*	Italian ryegrass
Antennaria plantaginifolia	Plantainleaf pussytoes	*Lonicera japonica*	Japanese honeysuckle
Apios americana	Groundnut	*Lonicera sempervirens*	Trumpet honeysuckle
Apocynum cannabinum	Indianhemp	*Ludwigia leptocarpa*	Anglestem waterprimrose
Arabidopsis thaliana	Mouseear cress	*Luzula echinata*	Hedgehog woodrush
Arisaema triphyllum	Jack in the pulpit	*Lycopodium digitatum*	Fan clubmoss
Aristolochia serpentaria	Virginia snakeroot	*Maclura pomifera*	Osage orange
Arnoglossum atriplicifolium	Pale Indian plantain	*Magnolia grandiflora*	Southern magnolia
Arundinaria gigantea	Giant cane	*Malaxis unifolia*	Green addersmouth orchid
Asclepias tuberosa	Butterfly milkweed	*Manfreda virginica*	False aloe
Asclepias viridiflora	Green milkweed	*Melia azedarach*	Chinaberry
Asimina triloba	Common pawpaw	*Melica mutica*	Twoflower melicgrass
Asparagus officinalis	Asparagus	*Melothria pendula*	Guadeloupe cucumber
Asplenium platyneuron	Ebony spleenwort	*Menispermum canadense*	Common moonseed
Azolla caroliniana	Carolina mosquitofern	*Microstegium vimineum*	Japanese stiltgrass
Barbarea verna	Winter cress	*Mikania scandens*	Climbing hempvine
Belamcanda chinensis	Blackberry lily	*Mitchella repens*	Partridgeberry
Bidens tripartita	Threelobe beggarticks	*Modiola caroliniana*	Carolina bristlemallow
Boehmeria cylindrica	Smallspike false nettle	*Morus rubra*	Red mulberry
Botrychium	Grape fern	*Murdannia keisak*	Asian spiderwort
Botrychium virginianum	Rattlesnake fern	*Myosotis macrosperma*	Largeseed forget-me-not

Appendix B. Continued.

Species	Common Name	Species	Common Name
Brachyelytrum erectum	Bearded shorthusk	*Nyssa sylvatica*	Blackgum
Briza minor	Little quakinggrass	*Oenothera biennis*	Common Eveningprimrose
Bromus catharticus	Rescuegrass	*Ophioglossum*	Adderstongue
Bromus commutatus	Hairy brome	*Ornithogalum umbellatum*	Star-of-Bethlehem
Bromus japonicus	Japanese brome	*Osmunda cinnamomea*	Cinnamon fern
Bumelia lycioides	Buckthorn bumelia	*Oxalis dillenii*	Dillen's wood sorrel
Callicarpa americana	American beautyberry	*Oxalis stricta*	Upright wood sorrel
Callisia rosea	Piedmont roseling	*Oxalis violacea*	Violet wood sorrel
Campsis radicans	Trumpet creeper	*Panicum anceps*	Beaked panicum
Cardamine bulbosa	Bulbous bittercress	*Panicum rigidulum var. combsii*	Comb's panicgrass
Cardamine hirsuta	Bittercress	*Parthenocissus quinquefolia*	Virginia creeper
Carex albolutescens	Greenwhite sedge	*Paspalum dilatatum*	Dallasgrass
Carex amphibola	Eastern narrowleaf sedge	*Paspalum notatum var. saurae*	Bahiagrass
Carex annectens	Yellowfruit sedge	*Passiflora incarnata*	Purple passionflower
Carex blanda	Woodland sedge	*Peltandra virginica*	Green arrow arum
Carex caroliniana	Carolina sedge	*Phytolacca americana*	American pokeweed
Carex cephalophora	Oval-leaf sedge	*Pinus echinata*	Yellow pine
Carex complanata	Blue sedge	*Pinus elliottii*	Slash pine
Carex corrugata	Eastern narrowleaf sedge	*Pinus taeda*	Loblolly pine
Carex crinita	Fringed sedge	*Plantago lanceolata*	Narrowleaf plantain
Carex flaccosperma	Thinfruit sedge	*Plantago major*	Broadleaf plantain
Carex frankii	Frank's sedge	*Plantago rugelii*	Blackseed plantain
Carex gracilescens	Slender looseflower sedge	*Plantago virginica*	Virginia plantain
Carex grisea	Eastern narrowleaf sedge	*Platanus occidentalis*	Sycamore
Carex laevivaginata	Wooly sedge	*Pleopeltis polypodioides*	Resurrection fern
Carex leptalea	Bristlystalked sedge	*Poa annua*	Annual bluegrass
Carex lupulina	Hop sedge	*Poa autumnalis*	Autumn bluegrass
Carex lurida	Shallow sedge	*Poa compressa*	Canada bluegrass
Carex oxylepis	Sharpscale sedge	*Podophyllum peltatum*	Mayapple
Carex retroflexa	Reflexed sedge	*Polygonum caespitosum var. longisetum*	Oriental ladysthumb
Carex rosea	Rosy sedge	*Polygonum hydropiperoides*	Swamp smartweed
Carex scoparia	Broom sedge	*Polygonum setaceum*	Bog smartweed
Carex squarrosa	Squarrose sedge	*Polystichum acrostichoides*	Christmas fern
Carex tribuloides	Blunt broom sedge	*Poncirus trifoliata*	Hardy orange
Carex vulpinoidea	Fox sedge	*Populus deltoides*	Plains cottonwood
Carpinus caroliniana	American hornbeam	*Prenanthes*	Rattlesnakeroot
Carya alba	Mockernut hickory	*Proserpinaca palustris*	Marsh mermaidweed
Carya cordiformis	Bitternut hickory	*Prunella vulgaris*	Heal all
Carya glabra	Pignut hickory	*Prunus angustifolia*	Chickasaw plum
Carya illinoinensis	Pecan	*Prunus persica*	Peach
Carya ovata	Shagbark hickory	*Prunus serotina*	Black cherry

Appendix B. Continued.

Species	Common name	Species	Common name
Cassia fasciculata	Partridge pea	*Prunus umbellata*	Flatwood plum
Celtis laevigata	Southern hackberry	*Pseudognaphalium obtusifolium*	Rabbittobacco
Cephalanthus occidentali	Buttonbush	*Pueraria montana var. lobata*	Kudzu
Cercis canadensis	Eastern redbud	*Pyrus communis*	Pear
Chaerophyllum tainturieri	Hairyfruit chervil	*Quercus alba*	White oak
Chasmanthium latifolium	Indian woodoats	*Quercus coccinea*	Scarket oak
Chasmanthium laxum var. sessiliflorum	Slender woodoats	*Quercus falcata*	Southern red oak
Chimaphila maculata	Striped prince's pine	*Quercus lyrata*	Overcup oak
Chrysogonum virginianum var. australe	Gulf Coast Green-and-Gold	*Quercus marilandica*	Blackjack oak
Cicuta maculata	Spotted water hemlock	*Quercus michauxii*	Swamp chestnut oak
Cirsium vulgare	Bull thistle	*Quercus nigra*	Water oak
Claytonia virginica	Spring beauty	*Quercus oglethorpensis*	Oglethorpe oak
Clitoria mariana	Atlantic pigeonwings	*Quercus pagoda*	Cherrybark oak
Cocculus carolinus	Carolina coralbead	*Quercus phellos*	Willow oak
Commelina virginica	Virginia dayflower	*Quercus rubra*	Northern red oak
Conopholis americana	American squawroot	*Quercus shumardii*	Shumard oak
Cornus amomum	Silky dogwood	*Quercus stellata*	Post oak
Cornus florida	Flowering dogwood	*Quercus velutina*	Black oak
Crataegus uniflora	Dwarf hawthorn	*Ranunculus abortivus*	Littleleaf buttercup
Cynodon dactylon	Bermudagrass	*Ranunculus pusillus*	Weak buttercup
Cyperus echinatus	Globe flatsedge	*Ranunculus recurvatus*	Blisterwort
Cyperus erythrorhizos	Redroot flatsedge	*Rhus copallina*	Dwarf sumac
Cyperus odoratus	Fragrant flatsedge	*Rhus glabra*	Smooth sumac
Dactylis glomerata	Cocksfoot	*Rhynchosia*	Snoutbean
Danthonia sericea	Downy oatgrass	*Rubus argutus*	Sawtooth blackberry
Danthonia spicata	Poverty oatgrass	*Rubus bifrons*	Himalayan berry
Daucus carota	Queen Anne's lace	*Ruellia caroliniensis*	Carolina wild petunia
Desmodium rotundifolium	Prostrate ticktrefoil	*Rumex crispus*	Curly dock
Dichanthelium acuminatum var. fasciculatum	Western panicgrass	*Salix nigra*	Black willow
Dichanthelium boscii	Bosc's panicgrass	*Salvia lyrata*	Lyreleaf sage
Dichanthelium clandestinum	Deertongue panicgrass	*Sambucus canadensis*	American elder
Dichanthelium depauperatum	Starved panicgrass	*Sanguinaria canadensis*	Bloodroot
Dichanthelium dichotomum	Cypress panicgrass	*Sanicula canadensis*	Canadian blacksnakeroot
Dichanthelium dichotomum var. dichotomum	Cypress panicgrass	*Sassafras albidum*	Sassafras
Dichanthelium laxiflorum	Openflower rosette grass	*Saururus cernuus*	Lizards tail

Appendix B. Continued.

Species	Common name	Species	Common name
Dichanthelium oligosanthes	Heller's rosette grass	*Scirpus cyperinus*	Bulrush
Dichanthelium ravenelii	Ravenel's rosette grass	*Scleria oligantha*	Littlehead nutrush
Diospyros virginiana	Persimmon	*Scutellaria integrifolia var. integrifolia*	Hyssop skullcap
Duchesnea indica	Indian strawberry	*Senecio anonymus*	Small's ragwort
Elaeagnus umbellata	Silverberry	*Setaria glauca*	Yellow foxtail
Eleocharis obtusa	Blunt spikesedge	*Sherardia arvensis*	Field madder
Eleocharis quadrangulata	Squarestem spikerush	*Sisyrinchium angustifolium*	Narrowleaf blueeyed grass
Elephantopus carolinianus	Carolina elephantsfoot	*Sisyrinchium mucronatum*	Blue-eyed grass
Elephantopus tomentosus	Devil's grandmother	*Smallanthus uvedalius*	Hairy leafcup
Elymus hystrix var. hystrix	Eastern bottlebrush grass	*Smilax bona-nox*	Saw greenbrier
Elymus virginicus	Virginia wildrye	*Smilax glauca*	Cat greenbrier
Epifagus virginiana	Beechdrops	*Smilax rotundifolia*	Roundleaf greenbrier
Eragrostis capillaris	Lace grass	*Solanum carolinense*	Carolina horsenettle
Erigeron strigosus	Prairie fleabane	*Sorghum halepense*	Johnsongrass
Euonymus americana	American strawberrybush	*Sphenopholis nitida*	Shiny wedgescale
Euphorbia corollata	Flowering spurge	*Sphenopholis obtusata*	Prairie wedgegrass
Euphorbia pubentissima	False flowering spurge	*Spiranthes*	Ladies tresses
Facelis retusa	Annual trampweed	*Spirodela polyrhiza*	Giant duckweed
Fagus grandifolia	American beech	*Symphyotrichum dumosum*	Rice button aster
Festuca arundinacea	Tall fescue	*Thalictrum revolutum*	Waxyleaf meadow-rue
Festuca subverticillata	Nodding fescue	*Tillandsia usneoides*	Spanish moss
Frasera caroliniensis	American columbo	*Tipularia discolor*	Crippled cranefly
Fraxinus pennsylvanica	Green ash	*Toxicodendron radicans*	Poison ivy
Galium circaezans	Licorice bedstraw	*Tridens flavus*	Purpletop
Galium obtusum	Bluntleaf bedstraw	*Trifolium arvense*	Hairy clover
Galium obtusum ssp. filifolium	Bluntleaf bedstraw	*Trifolium campestre*	Field clover
Galium uniflorum	Oneflower bedstraw	*Trifolium pratense*	Red clover
Gamochaeta americana	American everlasting	*Triodanis perfoliata var. biflora*	Small Venus' looking glass
Gamochaeta falcata	Narrowleaf purple everlasting	*Triodanis perfoliata var. perfoliata*	Clasping Venus' lookingglass
Gelsemium sempervirens	Evening trumpetflower	*Typha latifolia*	Cattail
Geranium carolinianum	Carolina geranium	*Ulmus alata*	Winged elm
Geranium maculatum	Spotted geranium	*Ulmus rubra*	Slippery elm
Geum canadense	White avens	*Uvularia perfoliata*	Perfoliate bellwort
Gleditsia triacanthos	Honey locust	*Vaccinium arboreum*	Farkleberry
Glyceria striata	Fowl mannagrass	*Vaccinium elliottii*	Elliott's blueberry
Goodyera pubescens	Downy rattlesnake plantain	*Verbascum blattaria*	Moth mullein

Appendix B. Continued.

Species	Common name	Species	Common name
Gymnopogon ambiguus	Bearded skeletongrass	*Verbena brasiliensis*	Brazilian vervain
Helenium amarum	Bitter sneezeweed	*Verbena rigida*	Tuberous vervain
Hexastylis arifolia	Little brown jug	*Verbesina alternifolia*	Wingstem
Hibiscus syriacus	Rose-of-sharon	*Verbesina occidentalis*	Yellow crownbeard
Hieracium venosum	Rattlesnakeweed	*Verbesina virginica*	White crownbeard
Hordeum pusillum	Little barley	*Veronica arvensis*	Corn speedwell
Houstonia purpurea	Purple bluets	*Viburnum prunifolium*	Blackhaw
Houstonia pusilla	Tiny bluet	*Viola* sp.	Violet
Hydrangea arborescens	Wild hydrangea	*Vitis aestivalis*	Summer grape
Hydrocotyle umbellata	Umbrella pennyroyal	*Vitis rotundifolia*	Muscadine
Hypericum mutilum	Small flowered St. Johns-wort	*Vulpia myuros*	Rattail fescue
Hypericum punctatum	Spotted St. Johnswort	*Vulpia sciurea*	Squirreltail fescue
Ilex decidua	Possumhaw	*Wisteria floribunda*	Japanese wisteria
Ilex opaca	American holly	*Woodwardia areolata*	Netted chainfern
Ipomoea purga	Jalap	*Youngia japonica*	Oriental false hawksbeard
Isoetes virginica	Virginia quillwort	*Yucca filamentosa*	Adam's needle
Juglans nigra	Black walnut	*Zephyranthes atamasca*	Atamasco lily

Appendix C. Bird species reported from Ninety Six National Historic Site (Seriff 2006; R. Carter unpublished data).

Common Name	Scientific Name	Common Name	Scientific Name
Acadian Flycatcher	*Empidonax virescens*	Downy Woodpecker	*Picoides pubescens*
American Coot	*Fulica americana*	Eastern Bluebird	*Sialia sialis*
American Crow	*Corvus brachyrhynchos*	Eastern Kingbird	*Tyrannus tyrannus*
American Goldfinch	*Carduelis tristis*	Eastern Meadowlark	*Sturnella magna*
American Redstart	*Setophaga ruticilla*	Eastern Phoebe	*Sayornis phoebe*
American Robin	*Turdus migratorius*	Eastern Screech-Owl	*Otus asio*
American Woodcock	*Scolopax minor*	Eastern Towhee	*Pipilo erythrophthalmus*
Baltimore Oriole	*Icterus galbula*	Eastern Wood-Pewee	*Contopus virens*
Barn Swallow	*Hirundo rustica*	European Starling	*Sturnus vulgaris*
Barred Owl	*Strix varia*	Field Sparrow	*Spizella pusilla*
Bay-breasted Warbler	*Dendroica castanea*	Fish Crow	*Corvus ossifragus*
Belted Kingfisher	*Ceryle alcyon*	Fox Sparrow	*Passerella iliaca*
Black Vulture	*Coragyps atratus*	Golden-crowned Kinglet	*Regulus satrapa*
Black-and-white Warbler	*Mniotilta varia*	Grasshopper Sparrow	*Ammodramus savannarum*
Blackburnian Warbler	*Dendroica fusca*	Gray Catbird	*Dumetella carolinensis*
Black-crowned Night-Heron	*Nycticorax nycticorax*	Great Blue Heron	*Ardea herodias*
Blackpoll Warbler	*Dendroica striata*	Great Crested Flycatcher	*Myiarchus crinitus*
Black-throated Blue Warbler	*Dendroica caerulescens*	Great Egret	*Ardea alba*
Black-throated Green Warbler	*Dendroica virens*	Great Horned Owl	*Bubo virginianus*
Blue Grosbeak	*Guiraca caerulea*	Greater Scaup	*Aythya marila*
Blue Jay	*Cyanocitta cristata*	Green Heron	*Butorides virescens*
Blue-gray Gnatcatcher	*Polioptila caerulea*	Green-winged Teal	*Anas crecca*
Blue-headed Vireo	*Vireo solitarius*	Hairy Woodpecker	*Picoides villosus*
Blue-winged Teal	*Anas discors*	Hermit Thrush	*Catharus guttatus*
Bobolink	*Dolichonyx oryzivorus*	Hooded Merganser	*Lophodytes cucullatus*
Broad-winged Hawk	*Buteo platypterus*	Hooded Warbler	*Wilsonia citrina*
Brown Creeper	*Certhia americana*	House Finch	*Carpodacus mexicanus*
Brown Thrasher	*Toxostoma rufum*	House Sparrow	*Passer domesticus*
Brown-headed Cowbird	*Molothrus ater*	House Wren	*Troglodytes aedon*
Brown-headed Nuthatch	*Sitta pusilla*	Indigo Bunting	*Passerina cyanea*
Bufflehead	*Bucephala albeola*	Kentucky Warbler	*Oporornis formosus*
Canada Goose	*Branta canadensis*	Killdeer	*Charadrius vociferus*
Canvasback	*Aythya valisineria*	Least Flycatcher	*Empidonax minimus*
Carolina Chickadee	*Poecile carolinensis*	Lesser Scaup	*Aythya affinis*
Carolina Wren	*Thryothorus ludovicianus*	Lesser Yellowlegs	*Tringa flavipes*
Cedar Waxwing	*Bombycilla cedrorum*	Little Blue Heron	*Egretta caerulea*
Chestut-sided Warbler	*Dendroica pensylvanica*	Louisiana Waterthrush	*Seiurus motacilla*
Chimney Swift	*Chaetura pelagica*	Magnolia Warbler	*Dendroica magnolia*
Chipping Sparrow	*Spizella passerina*	Mallard	*Anas platyrhynchos*

Appendix C. Continued.

Common Name	Scientific Name	Common Name	Scientific Name
Chuck-will's-widow	*Caprimulgus carolinensis*	Mourning Dove	*Zenaida macroura*
Common Grackle	*Quiscalus quiscula*	Northern Bobwhite	*Colinus virginianus*
Common Nighthawk	*Chordeiles minor*	Northern Cardinal	*Cardinalis cardinalis*
Common Snipe	*Gallinago gallinago*	Northern Flicker	*Colaptes spp.*
Common Yellowthroat	*Geothlypis trichas*	Northern Harrier	*Circus cyaneus*
Dark-eyed Junco	*Junco hyemalis*	Northern Mockingbird	*Mimus polyglottos*
Double-crested Cormorant	*Phalacrocorax auritus*	Northern Parula	*Parula americana*
Northern Pintail	*Anas acuta*	Snow Goose	*Chen caerulescens*
Orchard Oriole	*Icterus spurius*	Song Sparrow	*Melospiza melodia*
Osprey	*Pandion haliaetus*	Spotted Sandpiper	*Actitis macularia*
Ovenbird	*Seiurus aurocapillus*	Summer Tanager	*Piranga rubra*
Palm Warbler	*Dendroica palmarum*	Swainson's Thrush	*Catharus ustulatus*
Pied-billed Grebe	*Podilymbus podiceps*	Swainson's Warbler	*Limnothlypis swainsonii*
Pileated Woodpecker	*Dryocopus pileatus*	Swamp Sparrow	*Melospiza georgiana*
Pine Warbler	*Dendroica pinus*	Tennessee Warbler	*Vermivora peregrina*
Prothonotary Warbler	*Protonotaria citrea*	Tufted Titmouse	*Baeolophus bicolor*
Purple Finch	*Carpodacus purpureus*	Turkey Vulture	*Cathartes aura*
Purple Martin	*Progne subis*	Veery	*Catharus fuscescens*
Red-bellied Woodpecker	*Melanerpes carolinus*	Vesper Sparrow	*Pooecetes gramineus*
Red-breasted Nuthatch	*Sitta canadensis*	Whip-poor-will	*Caprimulgus vociferus*
Red-eyed Vireo	*Vireo olivaceus*	White Ibis	*Eudocimus albus*
Redhead	*Aythya americana*	White-breasted Nuthatch	*Sitta carolinensis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*	White-eyed Vireo	*Vireo griseus*
Red-shouldered Hawk	*Buteo lineatus*	White-throated Sparrow	*Zonotrichia albicollis*
Red-tailed Hawk	*Buteo jamaicensis*	Wild Turkey	*Meleagris gallopavo*
Red-winged Blackbird	*Agelaius phoeniceus*	Winter Wren	*Troglodytes troglodytes*
Ring-necked Duck	*Aythya collaris*	Wood Duck	*Aix sponsa*
Rose-breasted Grossbeak	*Pheucticus ludovicianus*	Wood Thrush	*Hylocichla mustelina*
Ruby-crowned Kinglet	*Regulus calendula*	Worm-eating Warbler	*Helmitheros vermivorus*
Ruby-throated Hummingbird	*Archilochus colubris*	Yellow-bellied Sapsucker	*Sphyrapicus varius*
Ruddy Duck	*Oxyura jamaicensis*	Yellow-billed Cuckoo	*Coccyzus americanus*
Rusty Blackbird	*Euphagus carolinus*	Yellow-breasted Chat	*Icteria virens*
Savannah Sparrow	*Passerculus sandwichensis*	Yellow-rumped Warbler	*Dendroica coronata*
Scarlet Tanager	*Piranga olivacea*	Yellow-throated Vireo	*Vireo flavifrons*
Sharp-shinned Hawk	*Accipiter striatus*	Yellow-throated Warbler	*Dendroica dominica*

Appendix D. Community types in NISI outlined from US National Vegetation Classification. [Grossman et al. 1998].

Vegetation Type	System	Total Area	Mean Patch Size	Number Patches
		----acres-----		
Southeastern Coastal Plain Flat Terrace Forest	Atlantic Coastal Plain Small Brownwater River Floodplain Forest	133	7.8	17
Successional Loblolly Pine – Sweetgum Forest	Early Successional	333	7.7	43
Successional Black Walnut Forest	Early Successional	4	1.0	4
Successional Sweetgum Forest	Early Successional	70	1.6	43
Successional Water Oak Forest	Early Successional	159	3.6	44
Blackberry – Greenbrier Successional Shrubland Thicket	Early Successional	2		5
Privet Shrubland	Exotic Species Dominated	1	0.3	3
Wisteria Vineland	Exotic Species Dominated	1	0.5	2
Cultivated Meadow	Exotic Species Dominated	140	5.8	24
Golden Bamboo Shrubland	Exotic Species Dominated	<1	<1	1
Southern Cattail Marsh	Pond	1	1.0	1
Piedmont Dry – Mesic Oak – Hickory Forest	Southern Piedmont Dry Oak – (Pine) Forest	1	0.5	2
Interior Southern Red Oak – White Oak Forest	Southern Piedmont Dry Oak – (Pine) Forest	14	1.2	12
Southern Piedmont Oak Bottomland Forest	Southern Piedmont Large Floodplain Forest	31	6.2	5
Piedmont Basic Mesic Mixed Hardwood Forest	Southern Piedmont Mesic Forest	9	1.8	5
Floodplain Canebrake[2]	Southern Piedmont Small Floodplain and Riparian Forest	1	1.0	1
Successional Tuliptree – Hardwood Forest	Successional	3	3.0	1
Broomsedge Old Field	Successional	2	2.0	1
Other	--	45	1.7	27
Total		905	3.8	241

[1] - The single patch of Southern Piedmont Mesic Subacid Oak – Hickory Forest at NISI is classified as a secondary community within a dominant Tuliptree – Sweetgum/Spicebush/Jack-in-the-Pulpit Small Stream Forest.

[2] - The single patch of Floodplain Canebrake is classified as a secondary vegetation type within a Southern Piedmont Oak Bottomland Forest.

[3] - Tuliptree – Sweetgum/Spicebush/Jack-in-the-Pulpit Small Stream Forest is not counted as one of the 13 vegetation communities at NISI, but is included in the CRMS vegetation classification map used to calculate landscape metrics.

† A measure of shape complexity, Mean Patch Fractal Dimension approaches 1 for simple shapes and 2 for more complex shapes.

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