National Park Service
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Natural Resource Stewardship and Science

Natural Resource Condition Assessment for Cowpens National Battlefield

Natural Resource Report NPS/ COWP/NRR—2012/521

ON THE COVER
Main Entrance
Photograph courtesy of Cowpens National Battlefield

Natural Resource Condition Assessment for Cowpens National Battlefield

Natural Resource Report NPS/ COWP/NRR—2012/521

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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
BBS – Breeding Bird Survey
COOP – Cooperative Observer Program
COWP – Cowpens National Battlefield
CRMS – Center for Remote Sensing Services (UGA Department of Geography)
CUPN – Cumberland/Piedmont Monitoring Network
CWOP – Citizen Weather Observer Program
DO – Dissolved Oxygen
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
NC – North Carolina
NHS – National Historic Site
NISI – Ninety Six National Historic Site
NLCD – National Landcover Dataset
NMP – National Military Park
NPCA – National Park Conservation Association
NPS – National Park Service
NRCA – Natural Resource Condition Assessment
NTU – Nephelometric Turbidity Unit
NWS – National Weather Service
POMS – Portable Ozone Monitoring Station
PPB – Parts per billion
PPM – Parts per million
RAWS – Remote Automated Weather Station
SAO – Surface Airways Observation Network
SC – South Carolina
SCDHEC – South Carolina Department of Health and Environmental Control
SCEPPC – South Carolina Exotic Pest Plants Council
SSURGO – Soil Survey Geographic
UGA – University of Georgia
USGS – United States Geological Survey
WX4U – Weather For Your Network

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. xii) for more information.

Executive Summary

This report provides a comprehensive assessment of the state of natural resources at Cowpens National Battlefield (COWP). 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 COWP, 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. No new field data was collected for this report. When available, published criteria were used to derive a condition assessment based on available data, and when appropriate, we identify opportunities for improved data collection to allow for stronger assessment in the future.

Cowpens National Battlefield represents a small region of protected land amidst a larger complex of rural residential area in the northwest region of the South Carolina Piedmont. The park regularly receives over 200,000 visitors per year, with lowest visitation during the winter months. Forested land comprises about 75% of the park, while grassy areas and fields that highlight the battlefield sections comprise 18%. There are approximately three kilometers of streams flowing through the park, all of which begin inside the park, and 37 wetlands totaling around 5 five hectares. Almost 600 plants have been documented at COWP, of which the latest vegetation survey determined 151, or one quarter, to be non-native. In addition, seven plant species at COWP are considered sensitive with either a state or global listing status, including the federally threatened dwarf-flowered heartleaf (*Hexastylis naniflora*). Recent inventory efforts for vertebrate species have reported seven fish, 84 birds, 16 mammals, and 33 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 species are of conservation concern.

Several broad classes of potential threats and stressors to natural resources can be identified for COWP. 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, seven (50%) were ranked good or excellent, three (21%) were ranked as fair or poor, and four (29%) 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.

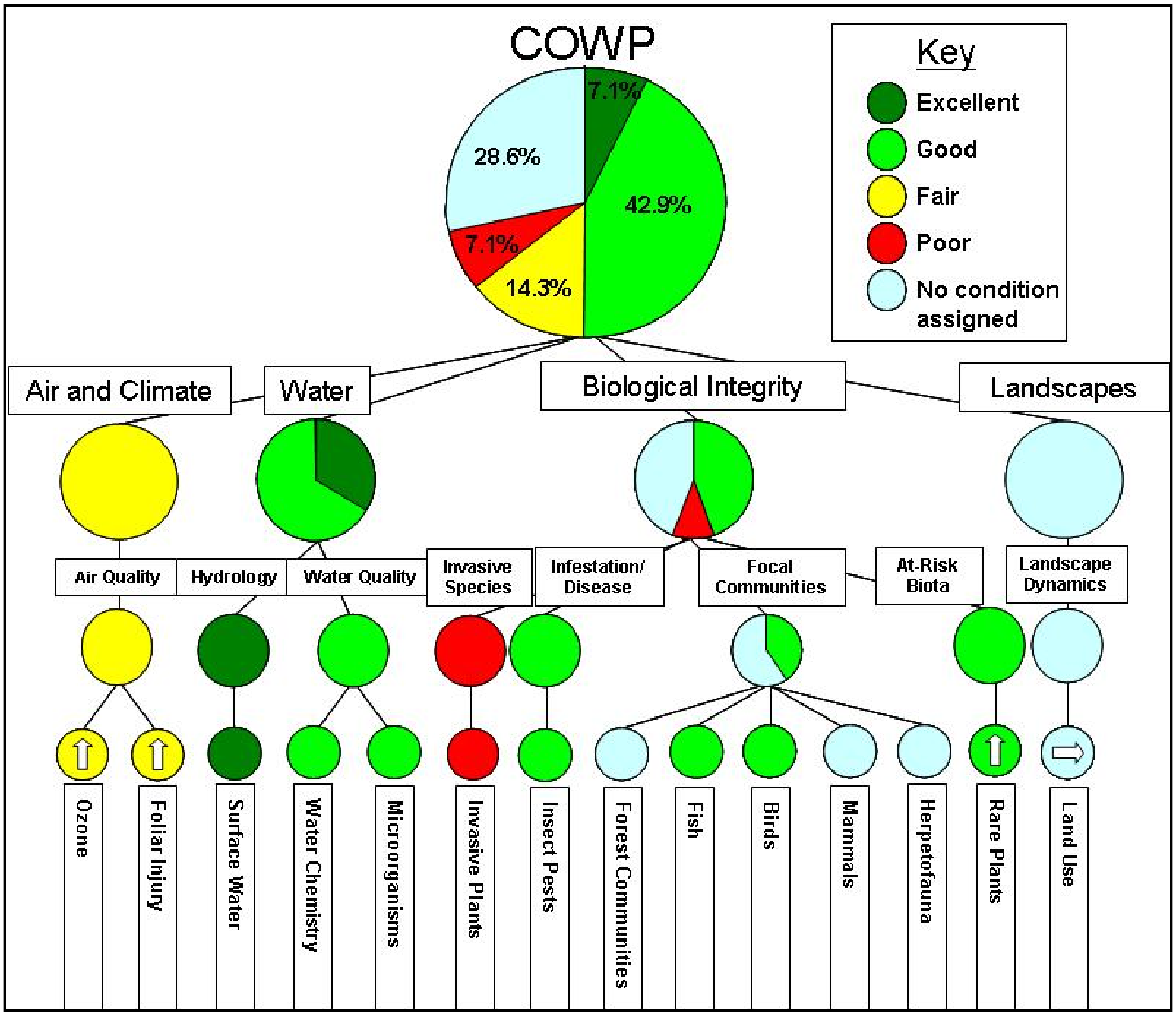


Figure 1. Summary of ecological condition status for Cowpens National Battlefield. Fourteen attributes from four broad categories were assessed. Numbers within segments of the park-wide pie chart represent the percentage of attributes (out of 14) ranked as that status.

Purpose

The objective of this Natural Resource Condition Assessment (NRCA) was to analyze existing data to provide an assessment of the current conditions of key ecological attributes at Cowpens National Battlefield (COWP). 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). Cowpens National Battlefield 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; Leibfreid et al. 2005), and 3) input from COWP staff (Table 1). 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 assessed for this report.

Ecological Monitoring Framework—COWP			
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
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, habitat
		Bird Communities	Diversity, habitat
		Mammal Communities	Richness
		Herpetofaunal Communities	Richness
	At-risk Biota	T&E Species and Communities	Dwarf-flowered heartleaf
Landscape	Landscape Dynamics	Land Cover and Land Use Change	Changes within/without COWP

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 COWP (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 Cowpens National Battlefield.

Attribute	Assessment Measure	Data Sources	Data Description	Data Period
Ozone	3-yr mean 4th highest maximum 8-hour average ozone concentration; 2nd highest 1-hr ozone concentration	Gaseous Pollutant Monitoring Program (GPMP) station in COWP; NPS Air Resources Division (ARD) APPR's	Hourly measurements of ozone concentration within COWP available from Air Resource Specialists (ARS), Inc.	1987-2008
	National IDW 4^{th} 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	1995-1999 data, 1999-2003 data, 2003-2007 data
	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 (Sum06, W126, and N100 metrics); Foliar Injury Risk Assessments	1995-2007 data
Surface Water Dynamics	Flow (l/sec)	NPStoret data for COWP	Raw water quality monitoring data from quarterly sampling at four stations within COWP	2002-2007
Water Chemistry	Temperature (max, mean), pH (mean), Specific conductance (mean), DO (mean), ANC (mean)	NPStoret data for COWP	Raw water quality monitoring data from quarterly sampling at four stations within COWP	2002-2007
		NPS Water Quality Monitoring Report for the CUPN (Meiman, 2005/2007/2009)	Summarized water quality data for COWP	2002-2007
Microorganisms	*E. Coli*, Total coliforms, Fecal coliforms (# colonies/100mL)	NPStoret data for COWP; NPS Water Quality Monitoring Report for the CUPN (Meiman, 2005/2007/2009)	Raw water quality monitoring data from quarterly sampling at four stations within COWP; Summarized water quality data for COWP	2002-2007
Invasive/Exotic Plants	Presence, relative predominance, and invasibility of exotics	NatureServe vegetation assessment (White, 2004); NatureServe database	Survey and discussion of COWP vegetation; Invasibility I-ranks	2004

Table 3. Data sources used to assess ecological condition of natural resources in Cowpens National Battlefield (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 COWP lands.	2007-2008
	Risk of infection by southern pine beetle	US Forest Service, Forest Health Technology Enterprise Team	Southern pine beetle hazard maps for South Carolina	2009
	Ips Beetle	Connor and Wilkinson (1983)	Ips beetle infestation description	1983
Vegetation Communities	Presence of Global-status ranked communities	NatureServe and Center for Remote Sensing and Mapping Science at UGA	Spatially explicit description of COWP vegetation communities	2002
	Wetlands	National Park Service, Tennessee Technological University (Roberts and Morgan, 2006)	Inventory and classification of wetlands for COWP	2003
Fish Communities	North Carolina fish IBI score	National Park Service, SCDNR survey (Scott 2006)	Final report and raw data from electrochock survey of four streams	2006
Bird Communities	O'Connell Bird Community Index (BCI) score	National Park Service, bird survey (Seriff 2006)	Final report and raw data for point counts and unconstrained surveys throughout the park	2004-2006
Mammal Communities	Percent of expected species reported	National Park Service, non-volant mammal survey (Ferris 2001)	Final report on small, non-volant mammal trapping	2000-2001
		National Park Service, non-volant mammal survey (Pivorun 2009)	Draft final report, and raw data from non-volant mammal trapping and sightings	2007-2008
		National Park Service, USFS bat survey (Loeb 2007)	Final report and raw data from mist-netting and acoustic sampling	2005-2007
Herpetofauna Communities	Percent of expected species reported	National Park Service, herpetofauna survey (Thomas 2001)	Shapefiles, voucher specimen spreadsheet, summary data	2000-2001
		National Park Service, herpetofauna survey (Reed and Gibbons 2005)	Final report, voucher specimen data with associated spreadsheets	2003-2005

Table 3. Data sources used to assess ecological condition of natural resources in Cowpens National Battlefield (continued).

Attribute	Assessment Measure	Data Sources	Data Description	Data Period
T&E Species & Communities	Dwarf-flowered heartleaf status	National Park Service, NatureServe database	Species occurrence database for COWP; Padgett (2004)	2004
		Padgett MS thesis (Appalachian State)	Abundance, populations, recovery plan	
		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. xii) for more information.

Park Resources and Introduction

Park Location and Significance

Cowpens National Battlefield (COWP) is located in Cherokee County, SC, approximately 5 km south of the North Carolina border, and 26 km NE of Spartanburg, SC (Figure 2). Overall, the park sits on a relatively small site comprising 345 ha and roughly shares its northern and western borders with Chesnee Hwy (State Hwy 11) and Cowpens Hwy (State Hwy 110), respectively. The Battle of Cowpens, for which the site is designated, was fought in January 1781, and is widely acknowledged as one of the turning points during the American Revolution that ultimately led to a Patriot victory at the Siege of Yorktown later that year. The location itself is named for its original purpose as a frontier pastureland.

Park Objectives

The park was established to restore and maintain the battlefield to its condition when the Battle of Cowpens took place in January 1781. Writings of participants in the Battle of Cowpens described the wooded area as "open and free from swamps" and having "little if any underbrush". Park staff maintain these conditions in part through adherence to the Healthy Forests Initiative of 2003 (P.L. 108-148), which translates into mechanical fuel reduction efforts and prescribed burns. In certain forest ecosystems where historical regimes of low-intensity fires play an important role in their functioning, controlled burns may assist in limiting competition from undergrowth, encouraging seed germination, and promoting habitat for wildlife species. Throughout the 1980s and 1990s, other major restoration and preservation efforts involved removing non-native plant species and planting hardwood seedlings (NPS 2009).

Climate, Geology, and Soils

Cowpens National Battlefield falls within the temperate region of the South Carolina piedmont. The mean annual temperature is 15.4 degrees Celsius (ºC), with a mean annual maximum and minimum temperature of 22.6 and 8.2 ºC, respectively. The mean annual precipitation is 133 cm (52.3 inches), while historically the wettest month is March.

This site is located on the Six Mile Thrust Sheet extending across the northwestern part of South Carolina. It is characterized by areas of muscovite-biotite paragneiss, along with interlayered biotite schist (Grapes et al. 2006). The dominant soil series at COWP belongs to the Appling series, which comprise 153 ha, or about 44.4% of the park unit. Appling soils are classified as very deep, well-drained soils occurring on ridges and side slopes (NRCS 2005). The next most common type are soils belonging to the Cecil-Madison association (Fine, kaolinitic, thermic Typic Kanhapludults), which are typically deep and well-drained soils that frequently overly gneiss, granite, and schist parent material. Cecil soils generally occupy ridges or side slopes and may contain deep saprolitic formations (NRCS 2007), while Madison soils occupy more sloping areas and often have high mica content (NRCS 2002). Together these series occupy 149 ha, or 43.1% of the park unit. Finally, Worsham soils (Fine, mixed, active, thermic Typic Endoaquults) are another series which occur mainly along drainageways that are deep and poorly drained (NRCS 2007). They comprise approximately 41 ha, or about 11.8% of the park unit (NRCS Soil Survey 2009).

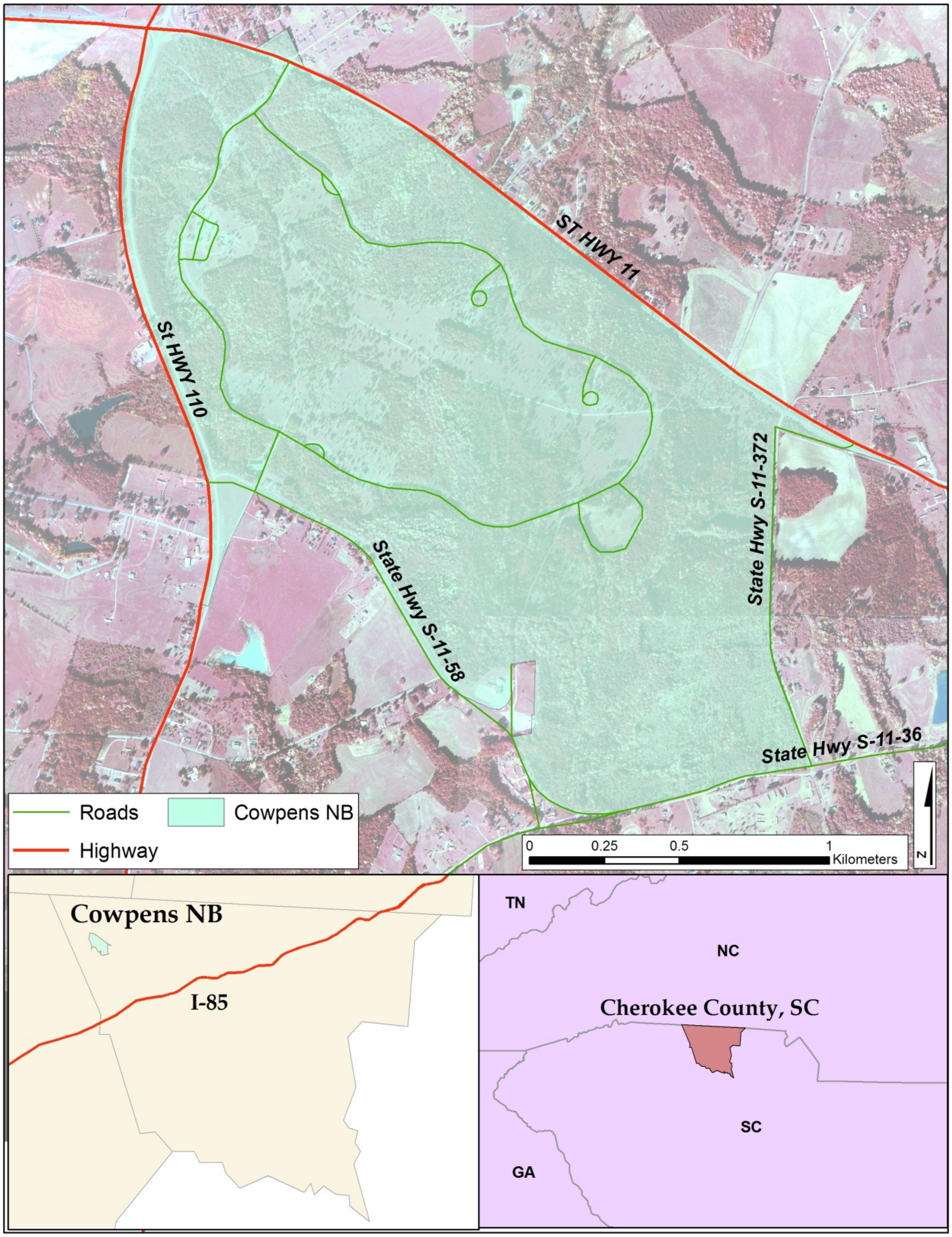


Figure 2. Cowpens National Battlefield is located in Cherokee County, SC just south of the North Carolina border.

Hydrology

Cherokee County falls entirely within the Upper Broad hydrologic cataloging unit (HUC 03050105), which in turn is within the Santee accounting unit (HUC 030501; Figure 3; USGS 2007). The largest water feature located inside the park is Long Branch Island Creek, which joins an unnamed tributary in the park and flows south into the Pacolet River about 10 km from the park. In addition, starting inside the park, Suck Creeks 1-3 flow northeast, Little Buck Creek flows northwest, and Island Creek flows southwest. All streams flowing through COWP also begin inside the park unit. Quarterly water quality and monitoring data has been collected at COWP during odd-numbered years since 2003 (Meiman 2005).

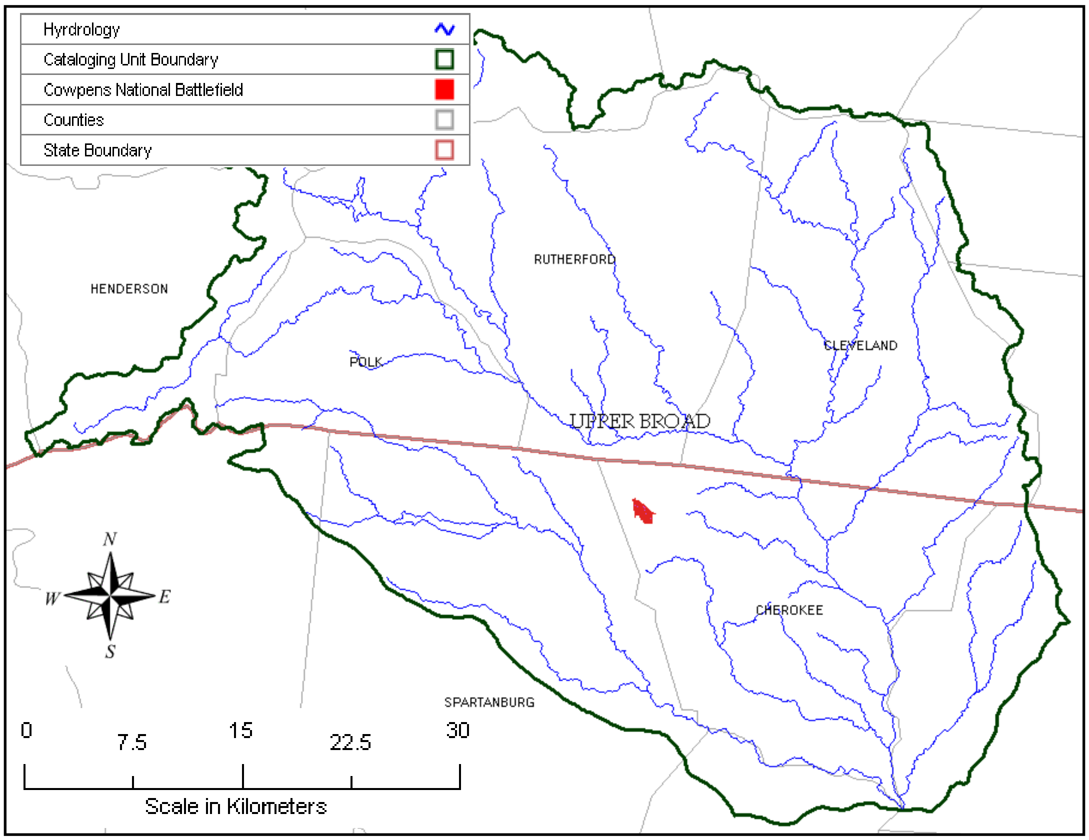


Figure 3. Cowpens National Battlefield is located in the Upper Broad hydrographic cataloging unit.

History and Park Significance

Cowpens National Battlefield is the location of a brief but significant confrontation that occurred in January 1781 between the Continental armed forces of Daniel Morgan and British regular soldiers led by Banastre Tarleton. The Battle of Cowpens is often cited as the turning point in the American Revolution at which the British army, emboldened by a series of recent victories in South Carolina, suffered a surprising and costly defeat, thus leading to their overall surrender during October 1781 in Yorktown, VA.

One of the main reference points for the site of the battle is the historic site of the Green River Road, on which portions of the Battle of Cowpens was fought. This road originally stretched from the Pacolet River south of the park, across the North Carolina border, and along the Green River towards western NC. Today, portions of the road still exist as Mills Gap Rd., but much of its original route was superseded by the creation of a more direct passage to Spartanburg.

Fire Management

Objectives and Historical Ecosystem

In 2001, COWP completed an environmental assessment to accompany proposed management actions for a fire management plan. The proposed management strategies included options of manual fuel removal and prescribed burning—all under the continued suppression of wildland fires, which is mainly due to the small size of the park (Figure 4). The overall goal of the fire management plan, in coordination with the resource management plan, is to "maintain or enhance natural ecosystems in ways which show the least evidence of manipulation by man." Of the proposed strategies, the preferred option outlines the initial manual reduction of fuel loads to prevent subsequent prescribed burns from being difficult to control. Initially, only small areas (<2 ha) would be burned at a time because of the high fuel content, though ultimately regular burns of up to 8 ha could be managed at a time. Likewise, the management plan also outlines that initial burning frequency would be 1-5 years depending on the amount of accumulated fuel. Tom Govus, who helped conduct the most recent vegetation inventory at COWP, observes that even this longer return interval is unnatural for the site, but instead is more suited to a fire-adapted ecosystem such as longleaf pine savannah (pers. comm. December 2009). The assessment suggests that this regime will also help control exotic plants – a substantial problem at COWP – in addition to improving wildlife habitat and facilitating a return to the historical vegetation conditions like those during the Battle of Cowpens in 1781 (NPS 2002).

Figure 4. Following the COWP fire management plan in 2002, prescribed burning began in the park in three management units.

Historically, the dominant vegetation type in this piedmont area of South Carolina was likely an oak-hickory-pine forest with interspersed areas of grassland where fires were more frequent (T.

Govus and R. White, pers. comm. December 2009). Frequent, low intensity fire was a natural part of the ecosystem, preventing the buildup of vegetation which can lead to infrequent, intense fires that pose a higher threat to humans and ecosystems. When the park entered NPS administration in 1972, almost two-thirds of the land (221 ha) was cleared for fields or pastures. Since much of this land returned to natural succession with suppression of wildfires along the way, large fuel loadings accumulated as well (NPS 2002).

Prescribed Burning

In the fire management plan (NPS 2002), COWP is divided into three overall fire management units which include a central battlefield unit in the area located within the Battlefield Loop Rd., a northern perimeter located above the intersections of Green River Rd. on the east and where the park boundary adjoins Battlefield Scenic Highway in the west, and the remaining southern section of the park which includes the nature trail (Figure 6). The central unit mostly consists of open field habitat in the core battlefield area, in addition to upland pine and mixed pine-hardwood forest. Two populations of dwarf-flowered heartleaf (*Hexastylis naniflora*; Figure 5), a federally-threatened wild ginger species, are present in the west and southern portions of this unit. A 2008 study determined that burning conducted before flowering time in April resulted in minimal effects on populations of this species (Walker et al. 2009).

Figure 5. Dwarf-flowered heartleaf, shown here with flowers, is the only federally-listed species at COWP. [Photo Source: R. White and T. Govus, 2002]

The fire management plan notes that ice and beetle damage has been particularly severe in the northeastern portion of the management unit, while hazardous fuels have accumulated in the forest area of the southwestern portion. Prescribed burning in these areas will help fulfill the objectives of the unit to minimize the risk of catastrophic fires and damage to the central, historical portion of the unit where significant structures are located. The northern perimeter unit contains four branches of Suck Creek in the northeastern portion, as well as Island Creek along the western boundary. This management unit is of particular interest because it also contains four known populations of the dwarf-flowered heartleaf. Compared to the central management unit, the northern unit contains a larger area of mixed pine-hardwood and less herbaceous/successional open space. The final southern unit contains large expanses of floodplain, mesic hardwood forests and an additional four populations of dwarf-flowered heartleaf, in addition to large areas of potential habitat (NPS 2002). The management plan reports that prescribed burns will not be used in this management unit, and instead mechanical fuel reductions will be undertaken every five years to maintain a medium fuel loading of 9 to 27 Mg/ha (4 to 12 tons/acre).

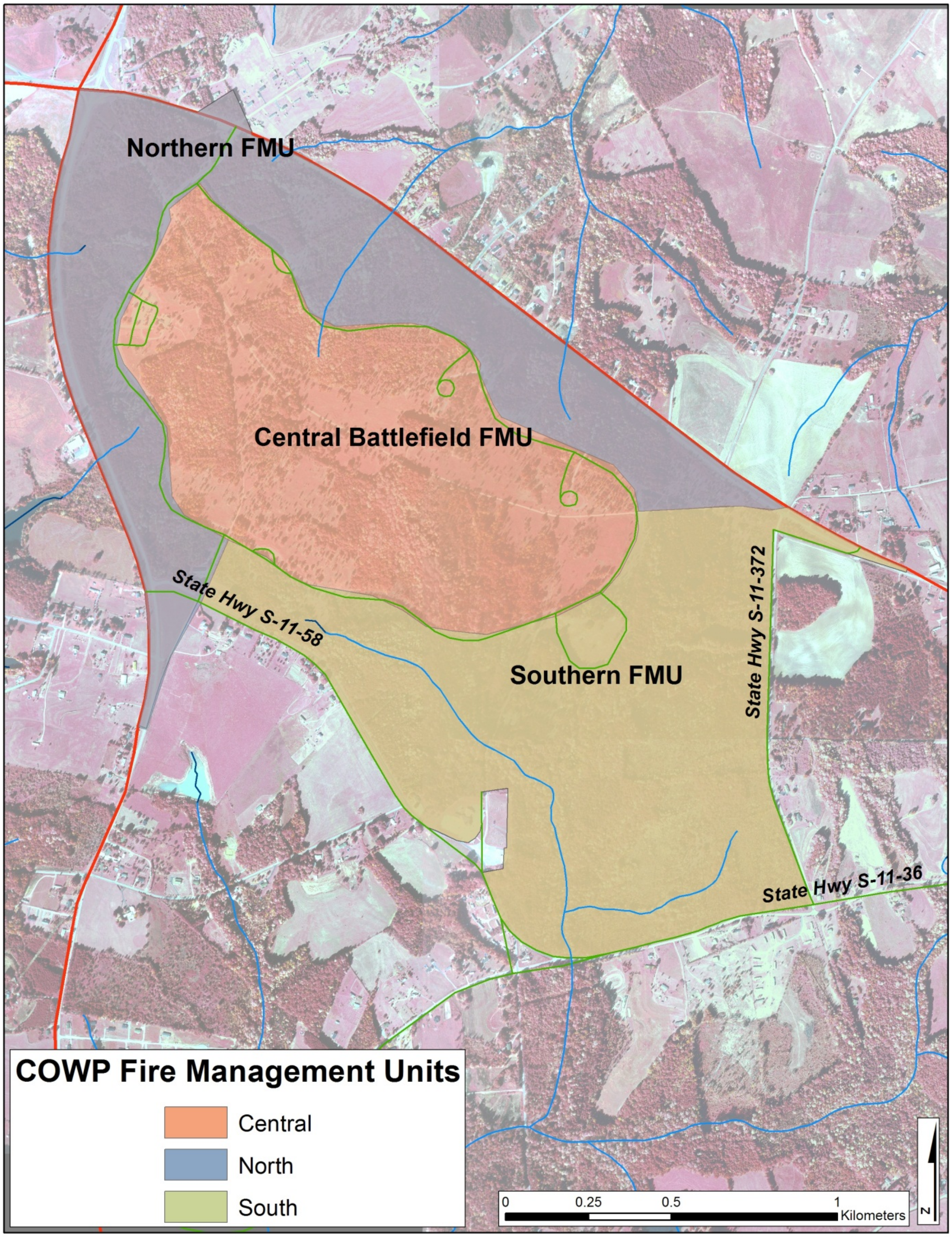


Figure 6. Three fire management units are outlined at COWP according to the Fire Management Plan (2002).

Natural Resources and NPS Vital Signs

Vegetation communities— During the time of the Battle of Cowpens, land in the South Carolina Piedmont region contained forests, grassy prairies, and savanna areas with spotted trees. The area around Cowpens was a savanna to woodland gradient maintained by cattle-grazing rather than fire after the displacement of Native Americans (NPS 2009). Settlers took advantage of the native cane, grasses, and natural springs to graze their cattle in a large region known as the Cow Pens. This open savanna-woodland played a large role in the nature of the Battle of Cowpens. After the battle, the land was converted to farmland and home sites that changed the composition of the natural community. The maintenance and restoration of the original community is one of the primary objectives at COWP, and is the basis for the fire management regime which the park currently applies (NPS 2009).

Invasive and Rare plant species—COWP has historically fought an ongoing battle with noxious and invasive species—mainly Japanese honeysuckle (*Lonicera japonica*) and kudzu (*Pueraria lobata*). Efforts have included eradication programs by the Youth Conservation Corps and Boy Scouts in the 1980s, as well as a spraying program initiated in 1994 (Binckley and Davis 2002). Currently, the park wishes to document and maintain the variety of plant species at the battlefield. As part of the I&M monitoring plan, NatureServe established 16 vegetation monitoring plots on a 0.46 km^2 grid (Leibfreid et al. 2005) and also collected new species found outside of the plots. The most recent comprehensive vegetation assessment by White (2004) documented 536 plant species, of which 30 are considered highly invasive according to the South Carolina Exotic Pest Plants Council (SCEPPC). In keeping with the park's objective to restore the battlefield, the park staff continues to remove exotic species and reintroduce native ones (NPS 2009).

Among NatureServe plots, mean species richness for all species in the inventory was 51.9 (α-diversity), with an overall diversity of 235 species among all plots (γ-diversity). The quotient of these two measures, or β-heterogeneity, is scale-dependent and addresses the heterogeneity of species types among different communities, with a minimum possible value of one representing homogeneous species assemblages among plots. Higher values reflect more diverse assemblages over a given study area. At COWP, this value was 4.5. The plots themselves covered only 11 of the 13 identified community types, with a mean sampling rate of 2.8 plots per each of the 11 community types. Despite apparent differences in species richness, an analysis of species richness differences among community types using the LSMEANS approach in SAS (SAS Institute Inc. 2002-2003) yielded no significant differences, though this result may be due in part to the small number of plots compared to the number of overall communities.

At each of the plots, evidence of disturbances was recorded during vegetation surveys. These disturbances included logging, southern pine beetle infestations, erosion, agricultural fields, invasive plants, fire suppression, and fire. Most of the plots contained 1-3 disturbance observations (*see sec.* "Invasive Species"; Figure 13). Presence of invasive species was the most common observation, recorded for one-third of the plots, most of which were located in the southeastern portion of the park. In addition, the majority of plots containing invasives also had evidence of prior agricultural activity, which most likely facilitated the incursion of the exotics. The two plots affected by southern pine beetle in the northern region of the park were generally consistent with regions of moderate risk on the risk map developed by the Forest Health Technology Enterprise Team (*see sec.* “Insect Pests”; Figure 14).

Monitoring efforts currently underway are intended to identify rare species and their habitat, as well as provide information on population status for state, federal, and global conservation concern. A recent survey of the dwarf-flowered heartleaf (*Hexastylis naniflora*), for example, found two populations at COWP out of a total of 143 populations. This species was placed on the list of federally threatened species in 1989 (Padgett 2004).

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 potentially harmful to plants, and can inhibit agricultural crops as well as natural communities (NPS 2008). 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 this pollutant. This metric, defined as 3-year averages of the 4^{th} highest daily maximum 8-hour average ozone concentration (4^{th} Hi Max 8-hr), results in nonattainment of the NAAQS when it exceeds 0.075 ppm (NPS ARD 2006a).

Monitoring

Since 1987, COWP has maintained a state ozone monitor on site as part of the Gaseous Pollutant Monitoring Program (GPMP), and as a result has the most extensive ozone monitoring dataset of any park unit in the CUPN with the exception of Mammoth Cave, which started monitoring in 1984 (Davey et al. 2007). Overall, recent monitoring indicates COWP has remained at or near the EPA threshold level for compliance. In 1998, Cowpens had the 8^{th} highest average 8-hr and 1-hr ozone levels of the 35 nationwide NPS units conducting measurements (Binckley and Davis 2002). Figure 7 shows rolling 3-year mean ozone concentrations at COWP from 1990 (1988-1990) through 2005 (2003-2005; NPS ARD 2006a). Using the NAAQS limits set before 2008, the years 1990 and 1998-2002 exceed the limit, with no overall apparent trend. However, instead of linear regression, NPS Air Resources Division (ARD) uses a non-parametric regression technique called the Theil method in accordance with the Government Performance and Results Act (GPRA) reporting requirements to determine trends over 10-year periods (NPS ARD 2009). The Theil method is also used by the EPA to conduct time series analysis for visibility issues (EPA 2001). In the most recent NPS ARD Annual Performance and Progress Report (APPR) in 2010, COWP observed a decreasing trend of -0.022 ppm yr^{-1} over the period 1999-2008 ($p < 0.01$). The previous reporting year, analysis over the period 1998-2007 found a similar trend of -0.026 ppm yr^{-1} ($p < 0.01$; NPS ARD 2009). Figure 8 depicts number of days each year with 8-hr ozone averages that exceed the NAAQS limit. These days show no apparent trend, though this metric is not used to inform official adherence to NAAQS limits.

The EPA often performs ozone evaluations using comparisons with a reference year (1990) at 5-year intervals. When compared to the 4^{th} Hi Max 8-hr baseline of 0.088 ppm, ozone at COWP shows reductions over each of the three stated comparison time intervals (1990-1995, 1990-2000, 1990-2005) with reductions of 0.013, 0.007, and 0.017 ppm, respectively (NPS ARD 2006b). Of the 45 park units with direct monitoring data over this period, COWP is one of only four that demonstrated reductions over each of the three time intervals, along with Acadia National Park (NP), Great Smoky Mountains NP, and Pinnacles National Monument. The trend observed at COWP coincides with an overall trend of decreasing ozone concentrations for most of the eastern park units (NPS ARD 2006a; NPS ARD 2006b).

The reduction in ozone levels at eastern parks is regarded in large part to be a response to decreases in nitrogen oxide pollution resulting from the introduction of NO_x cap-and-trade programs in the mid-1990s. These programs resulted in a 25% drop in NO_x emissions from 1997 to 2004, and EPA's 2003 State Implementation Plan program (SIP Call), which was directed at reducing power plant emissions in the eastern US, resulted in a further 30% overall reduction a year after it was implemented in the northeastern US (EPA 2005). Following this first season, South Carolina joined the program along with several other states in 2004. The data at COWP are consistent with a regional trend of rural-area ozone concentration reductions in the eastern US, which is especially concentrated in the southeast (EPA 2005).

Although ozone does appear to be decreasing from the latest data period available, it still represents a monitoring priority at COWP due to its proximity to the Greenville-Spartanburg metropolitan region, as well as the I-85 corridor located six km from the park. In addition to non-point sources from traffic, several industrial facilities that contribute to ozone-producing pollution are located along this route, one of the most significant of which is the Carolina Gas Transmission Company located about 31 km from COWP, which contributed a total of 2500 Mg (2800 tons) of ozone-producing emissions (CO, NO_x, and VOCs) in 2002. Another coal-fired generation plant, operated by Duke Power, is located approximately eight kilometers north of the park in Cliffside, NC.

Nationally, the NPS strives to meet three specific air quality goals in each of the parks: maintaining or improving air quality, meeting the EPA NAAQS, and meeting visibility standards. Ozone monitoring addresses the first two goals, and as a result of the improving trend in the regression analysis on data from 1999-2008 and 1998-2007, COWP meets this first requirement (NPS ARD 2010; NPS ARD 2009). Each of those two progress reports also assigned COWP a condition status ranking of "poor" with an "improving" trend for ozone condition, based on the latest 5-yr mean of the 4^{th} highest annual 8-hr ozone concentrations.

Summary

COWP has a history of approaching the threshold for 3-yr 4^{th} Hi Max 8-hr concentration. The most recent 3-yr metric (2007-2009) of 0.067 ppm is near the attainment threshold of 0.075 ppm, and three of the last ten 3-yr averages have exceeded the EPA NAAQS threshold (0.080 ppm prior to 2008), though all of those violations were in the first three years (2000-2002).

A recent approach developed by the NPS ARD in light of the new 2008 EPA NAAQS categorizes ozone condition on 5-yr interpolated averages of the 4^{th} Hi Max 8-hr metric. Over the most recent 2003-2007 period, this interpolated metric was 0.077 ppm, which falls within the moderate or condition yellow rating category (0.068 – 0.084 ppm) assigned in the 2008 annual performance and progress report by the NPS ARD. Because of the 1) high 4^{th} Hi Max 8-hr metric in 2010 (0.068 ppm), 2) the history of EPA NAAQS violations (1998-2002), 3) the recent condition yellow rating for COWP based on 2003-2007 interpolations, and 4) the separate condition red ratings assigned to COWP in the NPS ARD 2008 and 2009 assessment, we assigned ozone concentration a fair condition rating (Table 4) and recommend continued monitoring.

Despite the history of borderline ozone concentrations, data from COWP presents a clear improving trend. This is supported by the decreasing Theil trends found by both of the recent NPS ARD reports over 10-yr intervals (2008, 2009), as well as the low annual 4^{th} Hi Max 8-hr metric of 0.059 ppm observed in 2009. In addition, although the annual NPS ARD report that includes air quality data from 2010 is not yet available, the 4^{th} Hi Max 8-hr metric for that year allows trend calculation over the period 2001-2010, which results in a significant decrease in 0.002 ppm yr^{-1} for 3-yr mean metrics over that period ($p < 0.0001$). Figure 7 also shows this most recent regression. As a result, we assigned ozone at COWP an improving trend.

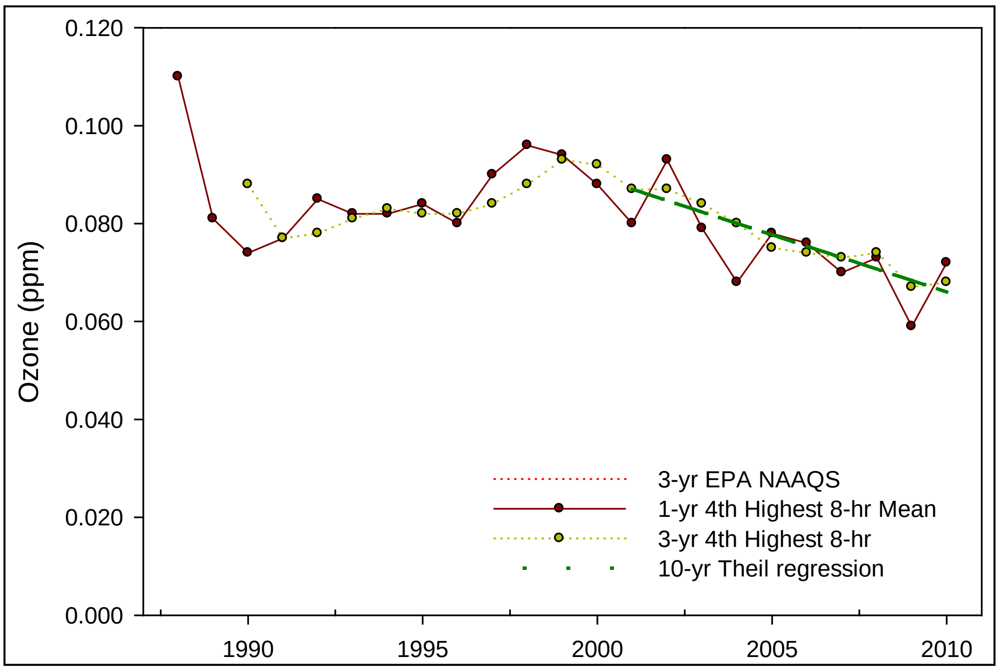


Figure 7. 3-year averages of 4th-highest 8-hr ozone averages show an improving Theil trend for the final 10 years of data (1998-2007). Each point represents the final year of a 3-year mean (e.g. 1988-1990, 1989-1991, etc.). The red-dotted line represents the NAAQS mean 3-yr annual max 8-hr ozone concentration limit, which decreased from 0.080 to 0.075 ppm in 2008.

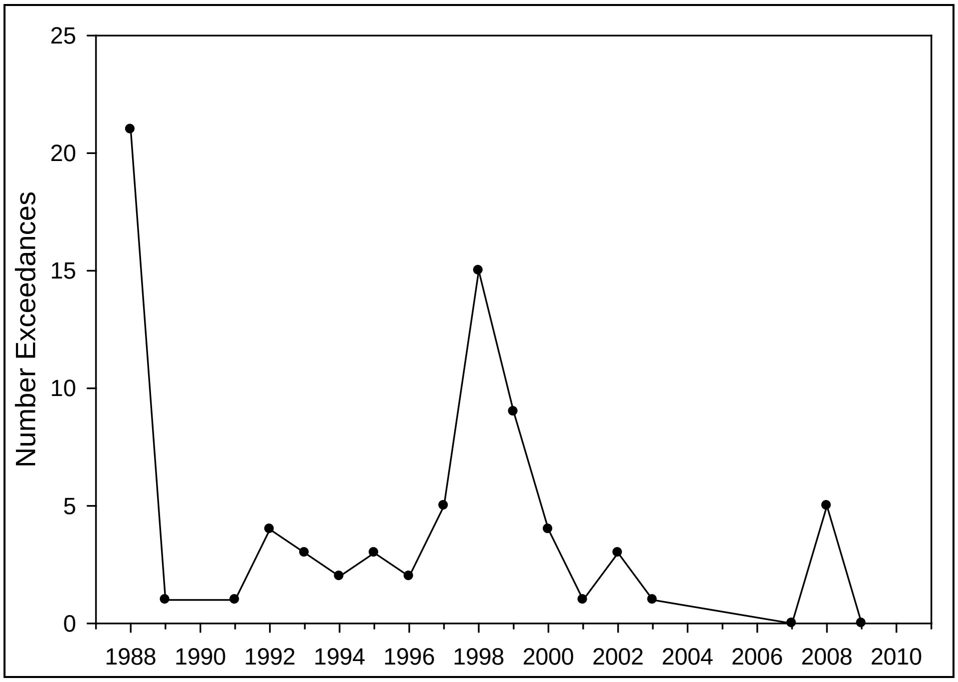


Figure 8. Number of annual days with 8-hr ozone averages exceeding NAAQS limit.

Table 4. The condition for ozone at COWP was fair. The data quality used to make this assessment was good. A trend of improving was assigned to this condition.

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

Foliar Injury

In addition to monitoring ozone concentrations from the perspective of human health, ozone has been shown to have deleterious effects on sensitive plant species (Ollinger et al. 1997; Lefohn and Runeckles 1987). The NPS Air Resources Division also developed foliar injury maps to predict potential harm to vegetation in each of the parks. In a 2004 foliar injury assessment examining all CUPN units, COWP received a high risk rating for foliar injury from the ARD (NPS ARD 2004). In this report, most of the foliar injury metrics for network parks are the result of estimates interpolated from monitoring stations within the EPA Clean Air Status and Trends Network (CASTNET), though COWP and Mammoth Cave NP were able to calculate injury metrics based on actual park measurements. These metrics are available yearly from 1995-1999 as part of this 2004 foliar injury assessment report for the CUPN. Metrics are available as a single mean over the period 1999-2003, and from annual estimates for 2004-2008.

In 2009, a new foliar injury assessment was conducted at several park units in the CUPN, including COWP (Jernigan et al. 2010). Injury metrics from this assessment are also included in Table 5. During this assessment, six plant species were observed with signs of foliar injury in the field, though in only one species—blackberry (*Rubus* sp.)—was this injury confirmed by a regional USFS expert.

In a separate assessment, Kohut (2007) outlined foliar injury risks for 244 NPS units using exposure indices, plant species (Table 6), and exposure environment (e.g. temperature and soil moisture), which resulted in an assignment of high foliar injury risk for COWP. Kohut (2007) explained this rating to be a result of "consistently high levels of ozone exposure and soil moisture conditions that favor the uptake of ozone when exposures exceed injury thresholds." He further offers that this risk rating means the park is "likely to experience foliar injury in most years." Of the 244 NPS units receiving a rating, field surveys were additionally conducted in four of the parks, including COWP, where the author observed "ozone injury on at least one bioindicator species." Kohut (2007) adds that before the time of the field survey (summer 2006), no other foliar injury assessments had been conducted at COWP.

Sum06 Metric

To assess the overall foliar injury risk, a series of three biological indices with injury thresholds based on ozone concentrations were developed for a representative group of ozone-susceptible plant species (NPS ARD 2004). The first metric, Sum06, is an index representing the maximum of the sum of ozone concentrations ≥ 0.060 ppm between 8:00 AM and 8:00 PM over a moving 90-day period. This maximum usually occurs in the summer during the September - October peak ozone period. The NPS Air Resources Division classifies 8 cumulative ppm-hours greater than 0.060 ppm as the threshold for foliar injury, with the potential for growth reduction starting at 10 cumulative ppm-hr (NPS ARD 2004). At COWP, monitored values for Sum06 averaged 34 cumulative hours > 0.060 ppm for the period from 1995-1999 and 29.7 ppm-hr for the period from 1999-2003. Both of these values exceed the threshold for foliar injury (Table 5). The most recent injury indices reported a minimal 2 ppm-hr for Sum06 in 2009, which falls well below the range for visible foliar injury and growth reduction in natural ecosystems (Jernigan et al 2010).

W126 Metric

The second index, W126, is a twofold description which includes the sum of hourly concentrations from April through October, and also considers the number of hours where the concentration was ≥ 0.010 ppm-hr for the same period (Eq. 1; 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 given disproportionately greater weight since they present more of a threat for foliar injury (LeFohn & Runeckles 1987). Ray (2010) explains this metric in further detail. For W126, highly-sensitive species are affected beginning at 5.9 cumulative ppm-hr, and moderately sensitive at 23.8 ppm-hr (NPS ARD 2004). Based on monitoring data at COWP, this metric was 46 ppm-hr for 1995-1999, and 42 ppm-hr over the period 1999-2003. Both metrics fall between the threshold affecting moderately and marginally sensitive species (Table 5). The latest annual metric of 6 ppm-hr from 2009 data, like Sum06, is much lower than previous metrics, though it still barely exceeds the threshold for foliar injury (Jernigan et al. 2010).

N100 Metric

The final foliar injury index is an N-value which corresponds to the number of hours that exceed an ozone concentration of 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, and the latter metric is the one most commonly used in reports and assessments (NPS ARD 2004). Like the other two metrics, N100 is also separated into three categories 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 level > 135 ppm-hr.

Based on monitoring data, the mean index for COWP during the period from 1995-1999 was 14 hours, while the predicted mean from 1999-2003 was 12 hours, both of which fall into the region affecting only highly sensitive species according to the 2004 foliar injury report (Table 5). The most recent foliar injury reports by Ray (2008) and Jernigan et al. (2010) do not include the N100 metric for 2007-2009.

Table 5. Set of foliar injury indices for COWP (NPS ARD 2004, Jernigan et al. 2010).

COWP Ozone Foliar Injury Indices					
Year	Sum06	W126	N60	N80	N100
	---ppm-hr---			---hr---	
1995	24	33.1	581	112	11
1996	30	33.7	647	72	2
1997	40	54.6	963	199	8
1998	39	55.4	942	236	30
1999	36	51.4	913	171	17
1999-2003*	30	42.4	-	-	12
2003	16	27.7	-	-	2
2004	9	15.7	-	-	0
2005	17	30.7	-	-	1
2006	20	31.4	-	-	2
2007	9	8.7	-	-	-
2008	22	16	-	-	-
2009	2	6	-	-	-
Mean	**24**	**34.2**	**809**	**158**	**8**

*Foliar injury indices not available for years 2000-2002, but 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)

Table 6. Twenty-five species at COWP were identified as sensitive to ozone based on crosswalking the master NPS list of ozone sensitive species (Porter 2003) with the NPSpecies list for COWP as of Nov. 2006.

Species		Family
Ailanthus alitissima	Tree-of-Heaven	Simaroubaceae
Apios americana	Groundnut	Fabaceae
Apocynum cannabinum	Indianhemp	Apocynaceae
Aster macrophyllus	Bigleaf aster	Asteraceae
Cercis canadensis	Eastern redbud	Fabaceae
Corylus americana	American hazelnut	Betulaceae
Fraxinus americana	White ash	Oleaceae
Fraxinus pennsylvanica	Green ash	Oleaceae
Gaylussacia baccata	Black huckleberry	Ericaceae
Liquidambar styraciflua	Sweetgum	Hamamelidaceae
Liriodendron tulipifera	Tulip-poplar	Magnoliaceae
Parthenocissus quinquefolia	Virginia creeper	Vitaceae
Philadelphus coronarius	Sweet mock orange	Hydrangeaceae
Pinus taeda	Loblolly pine	Pinaceae
Pinus virginiana	Virginia pine	Pinaceae
Platanus occidentalis	Sycamore	Platanaceae
Prunus serotina	Black cherry	Rosaceae
Rhus copallinum	Winged sumac	Anacardiaceae
Robinia pseudoacacia	Black locust	Fabaceae
Rudbeckia laciniata	Cutleaf coneflower	Asteraceae
Sambucus canadensis	American elder	Caprifoliaceae
Sassafras albidum	Sassafras	Lauraceae
Solidago altissima	Canadian goldenrod	Asteraceae
Verbesina occidentalis	Yellow crownbeard	Asteraceae
Vitis labrusca	Fox grape	Vitaceae

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 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 means 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 appears to be little association between foliar injury metrics and levels of soil moisture. The only year without drought conditions during the Sum06 assessment period—1997—demonstrated the highest Sum06 metric, which may have facilitated ozone damage. Most years, however, were below average moisture. The W126 metric was also minimally variable, with no clear association with this metric and levels of soil moisture.

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

Sum06	June	July	August
1995	2.99	-1.49	6.28
1996	0.27	-1.13	-1.04
1997	0.56	1.14	1.34
1998	-0.35	-2.35	-1.05
1999	0.81	-1.78	-2.36

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 COWP (NPS ARD 2004).

W126	A	M	J	J	A	S	O
1995	-2.28	-1.05	2.99	-1.49	6.28	0.42	2.61
1996	0.40	0.27	0.27	-1.13	-1.04	1.78	-0.65
1997	1.64	0.07	0.56	1.14	1.34	0.56	1.14
1998	5.34	-0.90	-0.35	-2.35	-1.05	-0.13	-0.96
1999	-0.13	-1.54	0.81	-1.78	-2.36	-0.49	1.53

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

Overall, each of the three foliar injury metrics showed a wide range of values over the history of monitoring. Furthermore, every year for which there is an ozone metric shows some degree of elevated exposure for at least one of the metrics. However, the severity of injury risk represented by each metric remains inconsistent within years. Because foliar injury indices are a function of ozone concentration, it is not surprising to observe an overall moderate risk of foliar injury at COWP that improves over time. Theil regression plotted over the monitored period from 1999 to 2008 shows the W126 metric decreasing on average 3.5 ppm-hr yr^{-1}, though the trend is not significant (p = 0.38; Figure 9). Over the entire data period, Sum06 and W126 show stronger tendencies for improvement for Theil regression— -1.56 (p = 0.10) and -2.27 ppm-hr yr^{-1} (p = 0.06), respectively. Although the most recent injury metrics for Sum06 and W126 are quite low, they are still within the range of visible foliar injury and growth reduction (Ray 2008, Jernigan et al. 2010), which was confirmed by field sampling in 2009. In addition, both metrics demonstrated high values in previous years that were easily within the range of growth reduction. The N100 metric, though not significantly decreasing, encouragingly showed levels below the minimum threshold for even highly sensitive species from 2003-2006. Because of these findings, the condition status for foliar injury at COWP received a ranking of fair with an improving trend (Table 9).

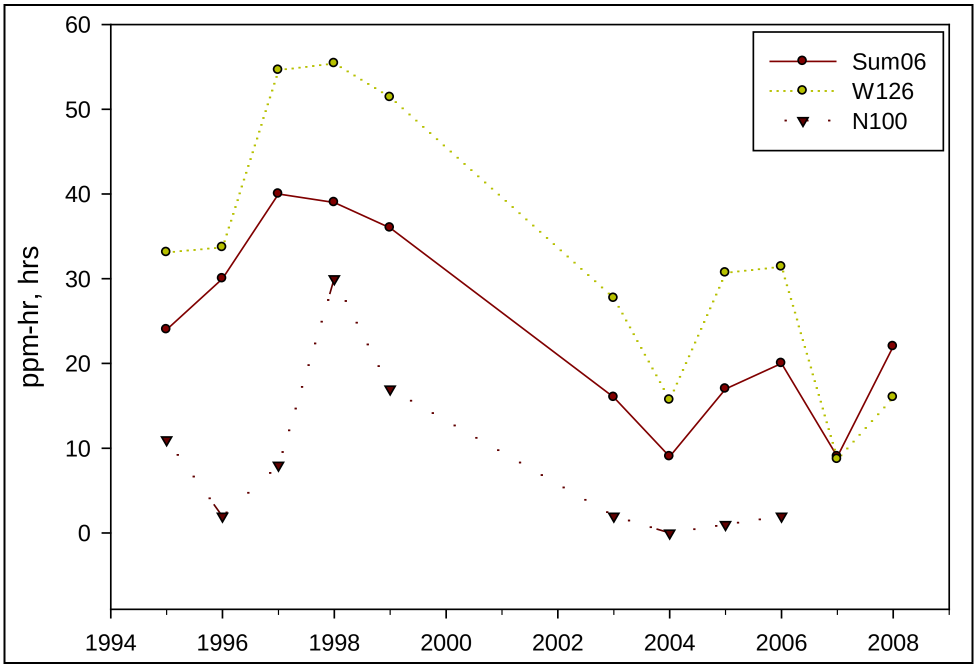
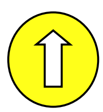


Figure 9. Foliar injury metrics from 1995-2008 appear to show a decreasing trend. Theil regression over the entire data period yielded mean reductions in Sum06 and W126 metrics of -1.56 (p = 0.10) and -2.27 ppm-hr yr^{-1} (p = 0.06), respectively.

Table 9. Foliar injury condition status for COWP was fair. The data quality used to make this assessment was good. A trend of improving was assigned to this condition.

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

Hydrology

Water Chemistry

Quarterly water quality monitoring at COWP began in fiscal year (FY) 2003 and has continued every other year, followed by comprehensive water quality reports each subsequent year. As part of the CUPN Vital Signs Monitoring Plan, the NPS Water Resources Division (WRD) requires monitoring of water temperature, pH, specific conductance, and dissolved oxygen (DO), referred to as the core parameters, in addition to any other parameters deemed necessary by the vital signs process (Meiman 2005). Select parks in CUPN, like COWP, also collect field measurements of Acid Neutralizing Capacity (ANC) and *Escherichia coli* (Meiman 2007).

Each park unit within CUPN was classified based on the significance of its water resources and how central they are to its establishment and overall management mission. COWP is classified by the CUPN as a Category-Three park unit with respect to its water resources, meaning that those resources are (1) not central to the park establishment or mission, (2) sustain limited or no recreational use, and (3) contain no federally threatened or endangered species (Leibfreid et al. 2005). This categorization further dictates the sampling regime used at COWP, such that four water quality sampling stations at COWP are sampled quarterly every other year. Sampling began in FY-2003, and each year is followed by a comprehensive annual report describing the adherence of individual stations to standards set by the South Carolina Department of Health and Environmental Control (SCDHEC). These reports also discuss explanations for non-compliant or unexpected observations.

Monitoring and Use Classification

Of the seven streams originating in COWP, water quality monitoring stations are maintained on four, each of which is located near the park boundary to maximize loading from inside the unit (Figure 10). Meiman (2009), who coordinates water quality monitoring activities at CUPN, describes the placement of the sampling locations as “integrators of the basin,” meaning they are intended to capture water quality characteristics from as much of the interior of the park as possible. The average length of flow upstream from each station is 1.21 km, and the longest upstream length, on Long Branch Island Creek, is 1.94 km.

The SCDHEC classifies streams throughout the state according to their use, and by definition, streams or water bodies not included in the state-level classification are categorized based on the class of stream to which they are tributary (SCDHEC 2008a). Since none of the streams at COWP are classified by SC, all of the water monitoring locations at COWP are classified indirectly as freshwater use (Meiman 2007). This classification means that the waters associated with the designation are suitable for primary and secondary contact recreation, in addition to “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).

Temperature

Samples collected at COWP are analyzed for parameters of interest and compared to SCDHEC baselines. For temperature, the SCDHEC stipulates that measurements are not to increase 2.8 ºC 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 industrial discharge of heated liquids. Meiman (2007) reported mean temperatures of ~8-23 ºC, while NPStoret data from 2002-2007 reflected the same range of temperatures, with the highest observation of any of the six monitoring sites (ºC) well below the maximum threshold of 32.2º C. Maximum summer temperatures are shown as outliers in the box and whisker plots of Figure 11. Confidence intervals ($\alpha = 0.05$) showed no significant differences among sites.

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 micro-Siemens per cm (µS/cm). 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." At COWP, the predominance of Ultisols might lend stream channels to high amounts of clay content, which in turn would result in high concentrations of cations that would increase rates of electrical conductivity (EPA 1997). However, conductance values at COWP were fairly low, ranging roughly from 25-60 µS/cm with the highest values at Little Buck Creek. Confidence intervals ($\alpha = 0.05$) showed higher specific conductance values at Little Buck Creek and Suck Creek #2 than Suck Creek #3, and higher values at Little Buck Creek than Long Branch. According to Meiman (2007), these low values may be a natural phenomenon due to the largely insoluble crystalline geology of the area.

pH

Measurements of pH are important to water quality because it affects multiple biological processes within aquatic ecosystems. Low levels of pH can potentially increase the mobility of toxic elements, and in turn, their uptake by aquatic plants and animals (EPA 1997). Even at only slightly acidic levels (6.0-6.5), species richness of phytoplankton, zooplankton, and benthic invertebrates can be inhibited, while levels between 5.0 and 6.0 can result in mortality of several fish species. In addition, algal growth increases at these acidic levels, which translates into an increased risk of mortality for macroinvertebrate species. Levels of pH below 5.0 can result in the loss of most fish species, decreased rate of nutrient cycling and organic matter decomposition, and can result in reproductive failure of certain acid-sensitive amphibians (Driscoll et al. 2003).

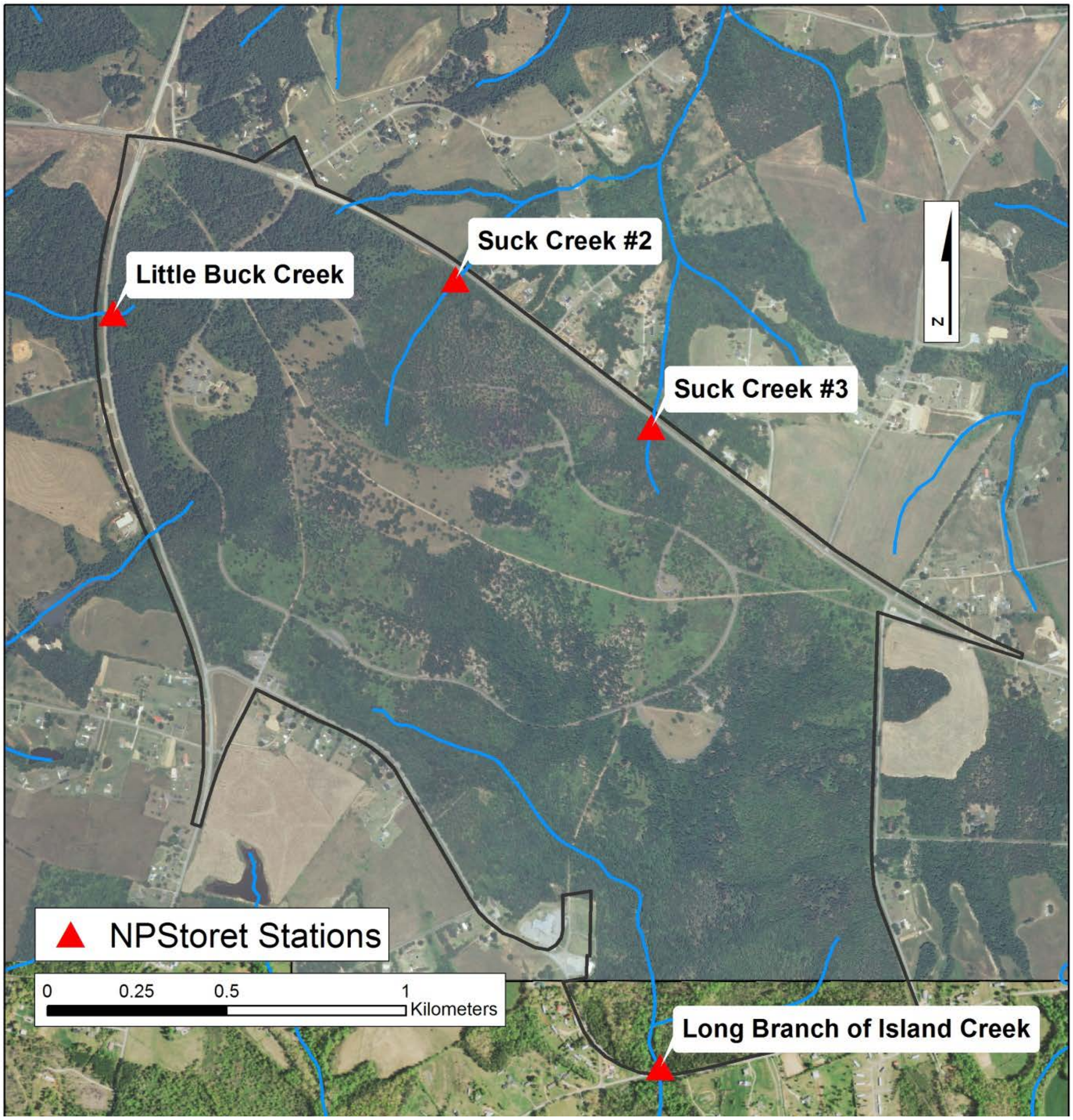


Figure 10. At COWP, 4 water quality monitoring stations are sampled quarterly during odd years.

The SCDHEC stipulates an acceptable pH range of 6.0-8.5 for freshwater, and as Meiman (2007) points out, each of the sampling locations at COWP drop below this standard at some point, though not chronically for a particular sampling year. Mean confidence intervals for pH at COWP showed a difference between the highest (Long Branch of Island Creek) and lowest (Suck Creek #3) pH means, but none of the intermediate sites which were relatively invariable. Because all of the streams at COWP originate inside the park, these elevated acidity levels are most likely caused by a combination of rainfall and parent material. Accordingly, Meiman (2007) explains that the geology of the area results in naturally acidic waters due to a lack of buffering agents. Minimum pH values were observed at all sites for one sample in February 2005, which Meiman (2007) indicates was immediately following a rain event. This acidic precipitous loading may be a result of several nearby sources of air pollution (see sec. *Air Quality—*Ozone) that contribute to acidic deposition.

Dissolved Oxygen

Dissolved oxygen (DO) is the final of the four core water quality parameters monitored at COWP, and is measured *in situ* using a sensor that adjusts for temperature and elevation. The SCDHEC standards stipulate daily DO means of at least 5.0 mg/l with absolute minimums of 4.0 mg/L. The EPA also creates national standards for DO in invertebrate habitat, stipulating levels of at least 8 mg/L for no production impairment (EPA 1986).

The significance of this parameter derives from its sensitivity to natural or anthropogenic alterations to the stream, because sensitive aquatic plants are one of the main sources of oxygen, along with aeration and mixing of atmospheric O_2. As a result, concentrations of DO are important to the survival of virtually all aquatic species (Meiman 2007). Taxa such as Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are particularly vulnerable to hypoxic waters, though these conditions may also be lethal to other benthic macroinvertebrates. Under hypoxic conditions, certain organisms may divert energy from growth and reproduction to oxygen uptake, which may in turn lower fecundity rates (Garvey et al. 2007). 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).

Because all the streams at COWP begin in the park unit, they are fortunately not subjected to any of these sources of wastewater or runoff upstream of the sampling stations. Although the data do not show daily means necessary for comparison with the SCDHEC standard, the overall mean over the 3-yr monitoring period is above 8 mg/L for all of the sites, and none of the individual measurements fell below the 4.0 mg/L threshold. It is, however, worth noting that almost one-half of the DO measurements at Suck Creek #3 fell below the EPA threshold of 8 mg/L. Confidence intervals showed no differences in mean DO concentrations among sites, which suggests that locations overall do not exhibit chronic problems with low DO.

Acid-Neutralizing Capacity

Acid-neutralizing capacity (ANC) values, measured in mg/L of calcium carbonate ($CaCO_3$), are collected to assess the relative ability of the water to buffer acidic loading resulting from precipitation or other sources. Higher values of ANC, or alkalinity, are influenced by concentrations of carbonates (CO_3^{2-}), bicarbonates (HCO_3^-), phosphates (PO_4^{3-}), and hydroxides (OH^-). Although the SCDHEC sets no standards for ANC, the EPA Goldbook (1986) recommends values greater than 20 mg/L $CaCO_3$ to benefit aquatic life. Like Ninety Six NHS, overall ANC levels at COWP were affected by the drought in 2007-2008, which actually resulted in higher levels of dissolved bicarbonates and therefore ANC. All samples collected during the first two rounds of sampling at COWP (FYs '03,'05) were below this threshold, though in the 2009 water quality assessment, Meiman (2008) only reports on ANC values collected in 2007, explaining that values from the first two sampling periods were excluded due to potential inaccuracies. During the third round of sampling (FY '07), each of the 4 monitoring locations at COWP had higher ANC values with the exception of Suck Creek #3, which was still below 20 mg/L for each of the four measurements. These low values of ANC are related to the consistently low values of pH throughout the park. Together, naturally depressed values of pH combined with minimal buffering capacity leaves the park vulnerable to acidic precipitation. Figure 11 depicts distributions of ANC values by site for all three rounds of sampling.

Summary

Overall, the observations collected for water chemistry at COWP suggest high water quality within the park unit. With the exception of pH, all measured parameters fell consistently within recommended levels or state standards. Consistently low levels of pH are presumably the result of natural conditions such as parent material and low ANC values. These acidity levels place the waters at COWP at particular risk, however, for acidic loading from rainfall, which is probable given the highly developed region and industrial output around COWP. Because of the high water quality and marginal risk of acidification, the condition status for water chemistry at COWP receives a ranking of “good” (Table 10). In addition, there is no apparent trend in the available data, though the three years of monitoring data would be insufficient to recognize long-term patterns anyway. Thus, no trend is assigned for water chemistry at COWP (Table 10).

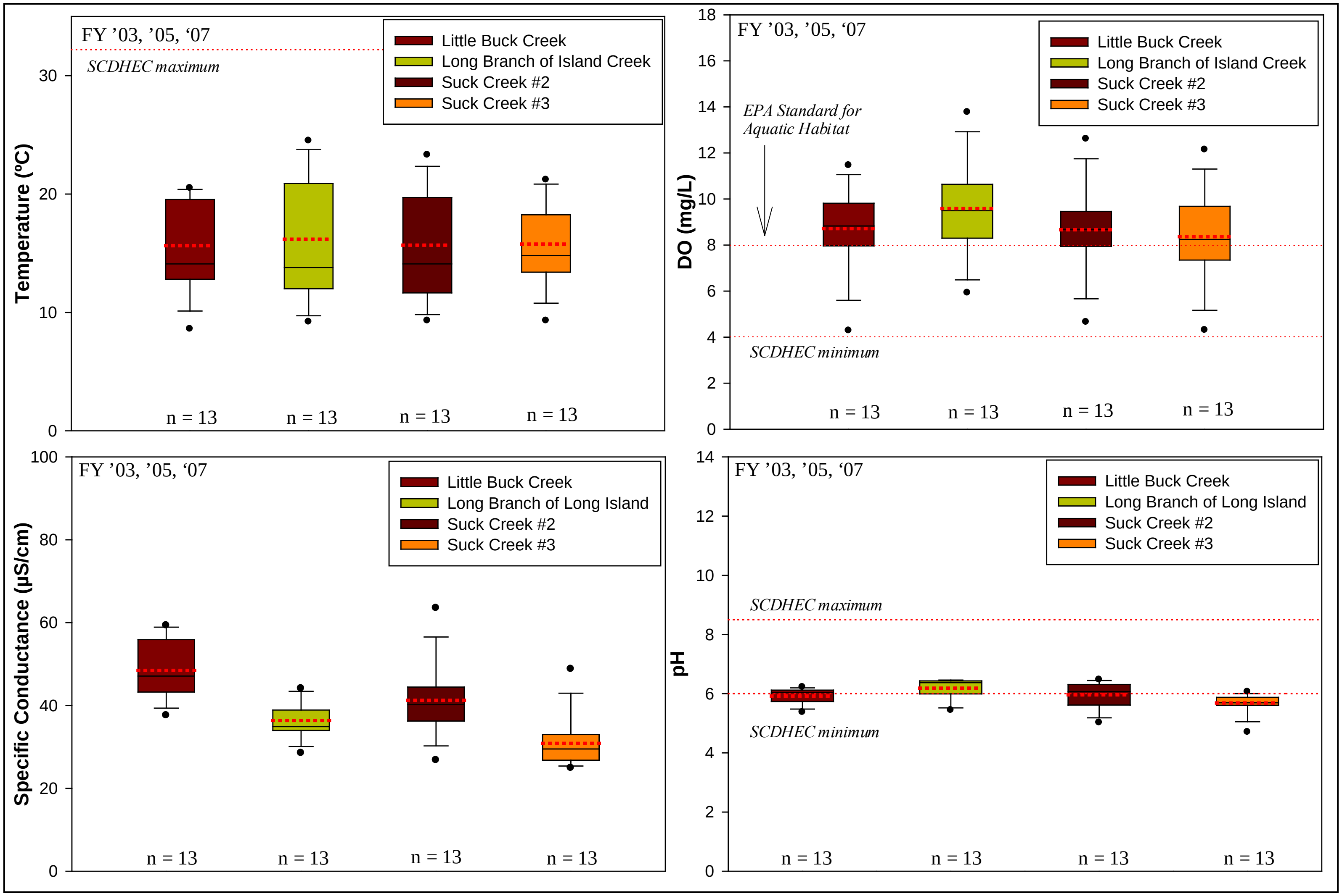


Figure 11. Data collected from 4 monitoring locations at COWP depict distributions for four core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli* and ANC as stipulated by CUPN. Box and whisker plots show 10th, 25th, 50th, 75th, and 90th percentiles, with dotted outliers and means with horizontal dotted red line. Flow is used as a reference for loading amounts and relative contents of measurements. Requirements for turbidity measurements are determined on an individual park basis, and are not required at COWP, but are also provided to show consistency among sites.

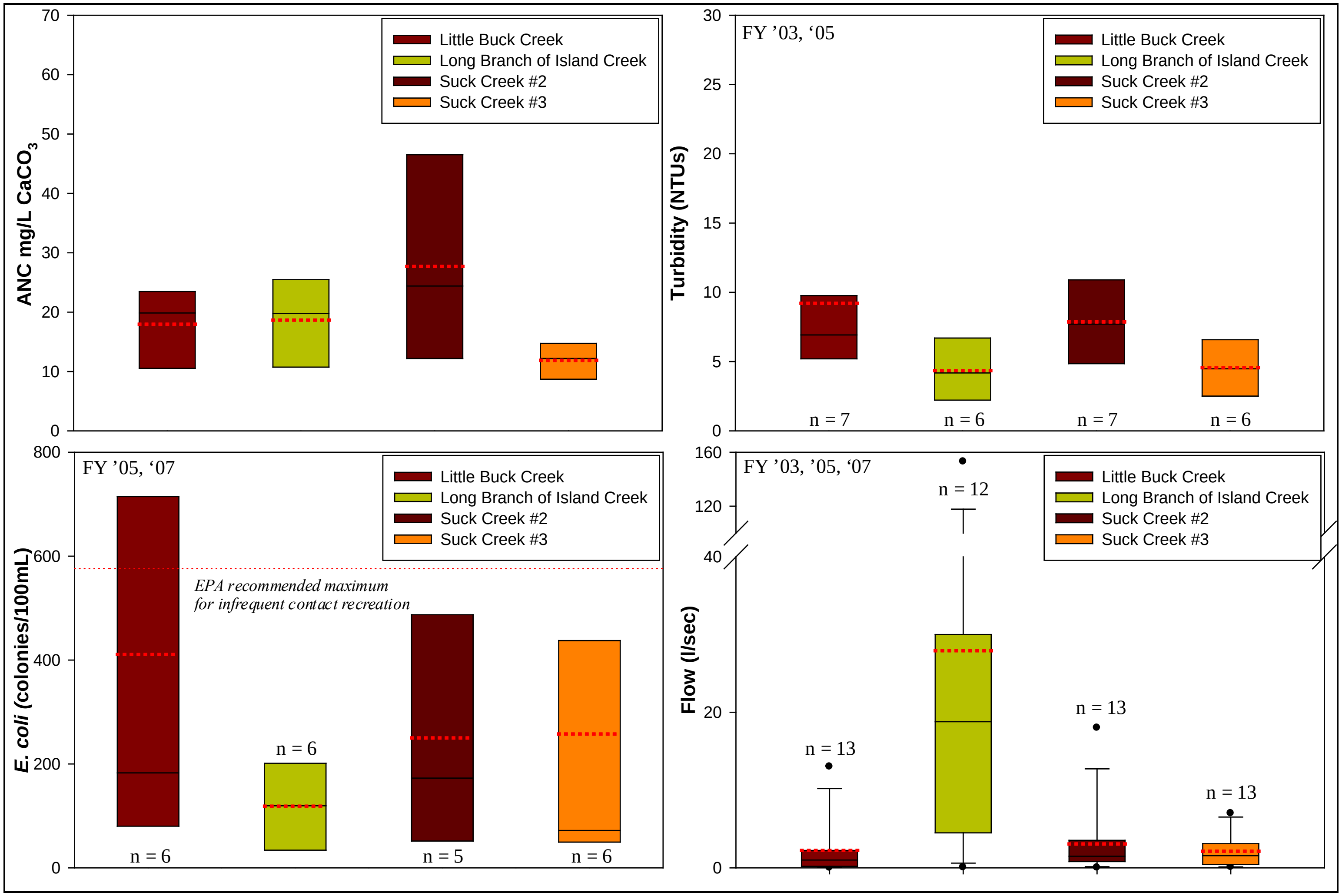


Figure 11. Data collected from 4 monitoring locations at COWP depict distributions for four core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli* and ANC as stipulated by CUPN. Box and whisker plots show 10th, 25th, 50th, 75th, and 90th percentiles, with dotted outliers and means with horizontal dotted red line. Flow is used as a reference for loading amounts and relative contents of measurements. Requirements for turbidity measurements are determined on an individual park basis, and are not required at COWP, but are also provided to show consistency among sites (continued).

Microorganisms
In addition to the core parameters discussed above, measurements of *E. coli* and total coliform bacteria were included in the network monitoring plan. The SCDHEC outlines limits for fecal coliform in its freshwater classification standards, but not *E. coli* or total coliform. Coliform are a group of bacteria that live in the intestines of both warm and cold-blooded organisms and are typically used as indicators of health risks presented by associated pathogenic bacteria and viruses. Fecal coliform are a subset of total coliform bacteria (Figure 12). They exist only in warm-blooded organisms, and sources of fecal coliform present at COWP are most likely to enter waters via wildlife feces because all of the streams originate inside the park.

E. coli is one of the most commonly monitored types of bacteria in the fecal coliform group (EPA 1997), and although there is no state standard for this measure, the EPA recommends an *E. coli* limit of 576 colonies $100mL^{-1}$ for "infrequent recreational contact" (EPA 1986), which would be the category most appropriate to COWP. The SCDHEC places a limit on fecal coliform of 200 colonies 100 mL^{-1}, based on any 5 consecutive samples during a 30-day period, and a limit of 400 colonies $100mL^{-1}$ on 10% of all samples during any 30-day period.

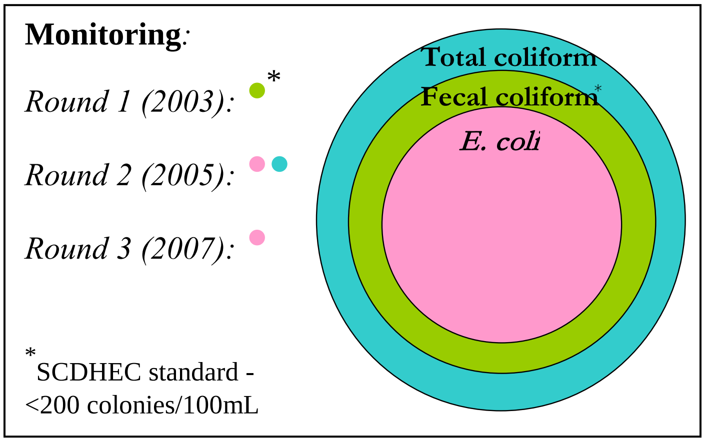


Figure 12. Bacterial monitoring history at COWP and Venn diagram showing relationship between different bacterial groups. Colored dots correspond with bacteria group from Venn diagram sampled each year.

At COWP, fecal coliform monitoring during 2003 (Figure 12) and a single date during 2005 showed mean values ranging from 76 colonies $100mL^{-1}$ at Little Buck Creek to 362 colonies $100mL^{-1}$ at Long Branch of Island Creek, though confidence intervals ($\alpha = 0.05$) showed no differences between sites, which may likely be due to the low sample size ($n = 5$). Although this sampling scheme does not meet the 30-day sampling period requirement for comparison with SCDHEC standards, the results are still useful. All means for fecal coliform fall below the 400 colonies $100mL^{-1}$ threshold, and only Little Branch of Long Island Creek—the largest stream in the park—exceeds the 200 colonies $100mL^{-1}$ limit. This is the result of two samples with elevated levels collected in September 2003.

E. coli and total coliform sampling began in 2005 (Figure 12), though only six samples were obtained over the 2-yr monitoring period for *E. coli*, and even fewer for total coliform. Mean *E. coli* concentrations ranged from 119 colonies $100mL^{-1}$ at Long Branch of Island Creek to 411 colonies $100mL^{-1}$ at Little Buck Creek, though these data did not differ significantly. These values fall below the EPA-recommended maximum threshold. The highest total coliform value was the single sample of 1986 colonies $100mL^{-1}$ at Suck Creek #2, while Suck Creek #3 had the lowest mean (of two samples) of 740 colonies $100mL^{-1}$. Unfortunately, none of these values are comparable with the SCDHEC fecal coliform standards—a related but different metric for water quality. An unpublished water quality assessment for COWP was conducted in 2000-2001 by Turner et al., who did find levels of fecal coliform above the SCDHEC standard. Because all streams originate within the park, Turner et al. proposed that this issue may be due to stream crossings by horses, though a similar explanation for elevated concentrations at stations in nearby Kings Mountain National Military Park (NMP) subsequently proved to be unsupported.

Overall, there are no signs of chronic bacterial problems at COWP. Some samples for fecal coliform during the first round and for *E. coli* during the third round exceeded state standards or EPA recommendations, but means by site did not exceed thresholds. Only *E. coli* was collected for more than one sampling round, though data was insufficient to show a trend. For these reasons, the condition status for microorganisms at COWP receives a ranking of “good” and no trend is assigned (Table 10).

Water Quantity

Flow is the final variable monitored at sampling stations to scale the flux of other parameter concentrations. Flow means of ~2-3 l sec^{-1} were consistent across each of the stations except Long Branch of Island Creek, for which the mean was 28 l sec^{-1}. 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 COWP, sampling stations are located on small streams that originate inside the park, meaning rainfall events and natural cycles are the only source of flow variability. Because flow patterns are completely unaltered within the park unit, water quantity receives a ranking of “excellent,” and no trend is assigned (Table 10).

Table 10. The condition status for surface water at COWP was excellent. The data quality used to make this assessment was good. No trend was assigned to this condition. The condition status for water chemistry at COWP was good. The data quality used to make this assessment was good. No trend was assigned to this condition. The condition status for microorganisms at COWP was good. The data quality used to make this assessment was good. No trend was assigned to this condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Surface Water		✓	✓	✓
		3 of 3: Good		
Water Chemistry		✓	✓	✓
		3 of 3: Good		
Micro-organisms		✓	✓	✓
		3 of 3: Good		

Invasive Species

Invasive plants are one of the most significant threats to the plant and animal communities at COWP. According to NatureServe vegetation surveys conducted during 2001-2002, 151 of the 536 species (28%) identified within the park are non-native, of which 30 are ranked by the South Carolina Exotic Pest Plants Council (SCEPPC) as a significant or severe threat to other species and ecosystems within the area (Table 11). This proportion is quite high for a park the size of COWP, especially when compared to a rate of 15% non-native species statewide (NatureServe 2009). As another comparison, nearby and similarly-sized Ninety Six NHS to the south documented fewer than half that number of non-natives according to NatureServe vegetation surveys beginning in 2001 (White and Govus 2003). Kings Mountain NMP, the largest of the three CUPN parks in South Carolina and only 50 km to the east, documented 58 non-native plant species as a result of the same surveys (White and Govus 2004). These differences in species, however, are closely related to ecosystem type rather than management. Exotic species are predominant in old field and successional forests—landcover types of which KIMO and NISI contain less acreage (White, pers. comm. December 2009). During plot level assessments at COWP, White (2004) recorded disturbance history at each location based on personal observations. Presence of invasives was noted at 7 of the 22 plots (32%), while the most common disturbance was impact from agriculture, which was present at 8 plots (36%).

COWP does share many of its invasive threats with both Ninety Six NHS and Kings Mountain NMP such as Japanese stiltgrass (*Microstegium vimineum*), wisteria (*Wisteria* spp.), Johnsongrass (*Sorghum halepense*), and kudzu (*Pueraria lobata*), though it also harbors several noxious plant species that are unique to this park unit, including climbing euonymus (*Euonymus fortunei*), white poplar (*Populus alba*), Chinese silvergrass (*Miscanthus sinensis*), and wormwood (*Artemesia vulgaris*). Invasives are especially predominant in the floodplain areas, where species like Japanese stiltgrass, multiflora rose (*Rosa multiflora*), and Chinese privet (*Ligustrum sinense*) can threaten important native communities like the floodplain canebrake or

Southern Piedmont Mesic Subacid Oak-Hickory Forest. The Successional Sweetgum Floodplain Forest in many ways resembles an earlier successional version of the Piedmont Small Streamside Forest, and though not a natural community according to White (2004), it is threatened by perhaps the highest rate of non-native species invasion of any community type found at COWP.

I-rank

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 criteria consist of 20 questions which, together, cover four main subranks: ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty. We calculated the I-rank 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. Following this approach, five species resulted in an I-Rank in the highest category (>2.00) which includes Scotch broom, Japanese honeysuckle, lespedeza, and two species of *Elaeagnus*.

Scotch broom is an N-fixing species that commonly forms impenetrable thickets, thus outcompeting species in the understory layer. It generally requires a minimum time commitment of two years for elimination (NatureServe 2009). 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.

Tall fescue (*Schedonorus arundinaceus*) is mentioned briefly at the park unit website (NPS 2009) as a particular threat to native species in open prairie or savanna areas. It is the main constituent species of the cultivated meadow vegetation type (CEGL004048) which comprises 59 ha, or approximately 17% of the park (Jordan and Madden 2008). The park unit website notes that, in addition to the decreased plant diversity caused by tall fescue, it also decreases the benefit of the grassland community to wildlife.

In addition, two species of Elaeagnus (*Elaeagnus* sp.) are included in the NatureServe report (White 2004) based on inventories by Bratton and Butler (1982) and Newberry (2001), both as cited originally in White (2004). These species pose a particular threat to natives and received the highest I-Rank (Table 11) of any of the significant or severe invasives found in the park. *Elaeagnus* is known for its high rate of reproduction, as well as its ability to resprout after cutting.

White (2004) cautions that continued burning efforts intended to reduce fuel loads at COWP will do little to combat the large number of invasives unless native plants are quickly planted and sown to support recolonization in treated areas. In their 2004 landscape restoration plan, this point is reiterated by the Palmetto Conservation Foundation (PCF; 2004), which notes that exotic species control efforts should be concentrated on the area within the main loop road. Of particular importance to interpretation at the park unit are the many old field areas where non-native species such as Johnsongrass, brome (*Bromus* spp.), bull thistle (*Cirsium vulgare*), and European fescues (*Lolium* spp.) are able to quickly colonize open areas after a disturbance. Reestablishment species used in this area include Indian grass (*Sorghastrum nutans*), purple top (*Tridens flavus*), chalky bluestem (*Andropogon capillipes*), split beard (*Andropogon ternarius*), switch grass (*Panicum virgatum*), and plume grass (*Saccharum ravennae*; PCF 2004). These old field fescue and broomsedge areas cover 90 ha, or approximately one quarter of the park.

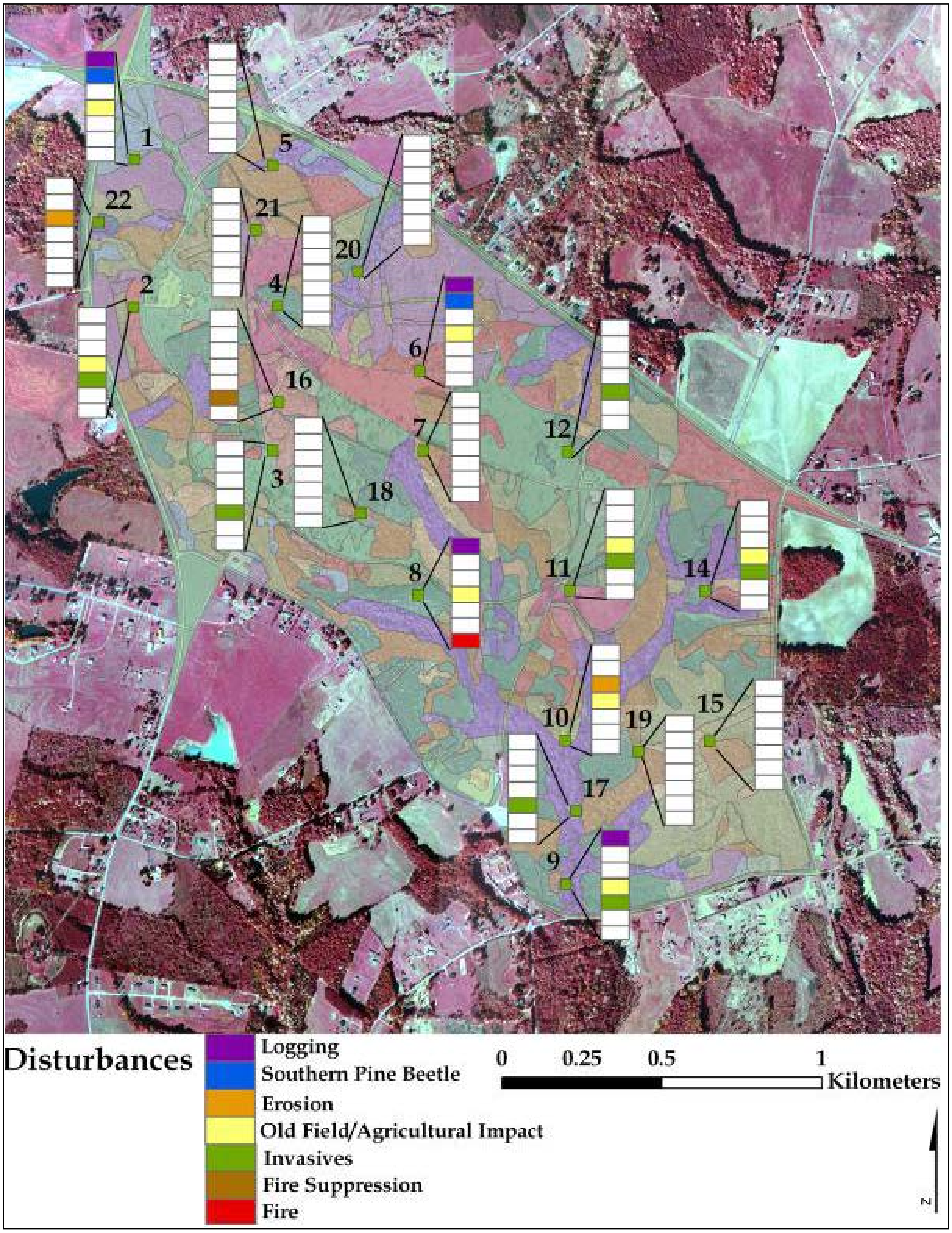


Figure 13. Disturbance history recorded at each of 22 vegetative plots established by NatureServe (disturbance data from White 2004). Stacked boxes represent presence (colored) or absence (white) of a total of seven specific disturbances according to the ordered legend.

Table 11. Of the 151 non-native plant species at COWP, 30 appear on the 2008 South Carolina Exotic Pest Plant Council Invasive Species List. '*' denotes species classified by SCEPPC as a severe threat to the composition and structure of native ecosystems in SC, while '†' denotes species classified as a significant threat.

Species	Common name	Family	I-Rank
Elaeagnus angustifola	Russian olive	Elaeagnaceae	2.67
Cytisus scoparius†	Scotch broom	Fabaceae	2.33
*Lonicera japonica**	Japanese honeysuckle	Caprifoliceae	2.33
*Elaeagnus umbellata**	Silverberry	Elaeagnaceae	2.17
*Lespedeza bicolor**	Shrubby lespedeza	Fabaceae	2.17
*Hedera helix**	English ivy	Araliaceae	2.00
Lespedeza cuneata†	Sericea	Fabaceae	2.00
*Ligustrum sinense**	Chinese privet	Oleaceae	2.00
*Microstegium vimineum**	Japanese stiltgrass	Poaceae	2.00
*Ligustrum japonicum**	Japanese privet	Oleaceae	1.83
Morus alba†	White mulberry	Moraceae	1.83
*Pueraria montana**	Kudzu	Fabaceae	1.83
*Sorghum halepense**	Johnsongrass	Poaceae	1.83
*Albizia julibrissin**	Mimosa	Fabaceae	1.67
*Miscanthus sinensis**	Chinese silvergrass	Poaceae	1.67
*Phyllostachus aurea**	Golden bamboo	Poaceae	1.67
Populus alba†	White poplar	Salicaceae	1.67
*Vinca major**	Bigleaf periwinkle	Apocynaceae	1.67
*Ailanthus altissima**	Tree-of-heaven	Simaroubaceae	1.50
Cirsium vulgare†	Bull thistle	Asteraceae	1.50
*Elaeagnus pungens**	Thorny olive	Elaeagnaceae	1.50
*Melia azedarach**	Chinaberry	Meliaceae	1.50
*Wisteria sinensis**	Chinese wisteria	Fabaceae	1.50
*Paulownia tomentosa**	Princess tree	Bignoniaceae	1.33
*Wisteria floribunda**	Japanese wisteria	Fabaceae	1.33
*Rosa multiflora**	Multiflora rose	Rosaceae	1.17
*Vinca minor**	Common periwinkle	Apocynaceae	1.00
Daucus carota†	Queen Anne's Lace	Apiaceae	0.33
*Paspalum notatum**	Bahia grass	Poaceae	0.00
Lonicera fragrantissima	Winter honeysuckle	Caprifoliaceae	Not Ranked
Paspalum dilatatum†	Dallis grass	Poaceae	Not Ranked

I-Rank is calculated as a mean 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., 2003). Each category is assigned a number based on its categorical rating and mean to give the overall I-Rank: low (0.01-1.00), medium (1.01-2.00), or high (2.01-3.00). Ranks do not reflect overall abundance within the park unit.

Summary

Overall, greater than half the total park area is represented by human-modified vegetation communities, which, as defined by White (2004), are areas that are particularly susceptible to or are already invaded by exotic species. White (2004) refers to the large list of exotics at COWP as "probably the single biggest threat to the overall ecologic health of the park." The number and proportion of non-native species documented in the park is quite large. In addition, 30 of these species are included on the 2008 South Carolina Exotic Pest Plant Council Invasive Species List as either a severe or significant threat to native ecosystems. It is highly important that exotic species removal programs be accompanied by reseeding and planting of natives. Because of the large number of entrenched invasives, White (2004) suggests concentrating on discrete occurrences that will likely benefit from management action. In addition, areas that have few or no non-natives are appropriate candidates for protection, particularly those with sensitive species or unique vegetation types, such as the Southern Piedmont Mesic Subacid Oak-Hickory Forest (CEGL006227), Interior Southern Red Oak-White Oak Forest (CEGL007244), Piedmont Granitic White Oak-Black Oak Woodland (CEGL003722), and areas resembling Floodplain Canebrake (CEGL3836) (White 2004; Govus, pers. comm. December 2009). For these reasons, the condition ranking for invasive plants at COWP receives a ranking of "poor," though there is insufficient information to qualify this with a trend (Table 12).

Table 12. The condition status for invasive plants at COWP was poor. The data quality used to make this assessment was fair. No trend was assigned to this condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Invasive Plants	(red circle)	✓	✓	
		2 of 3: Fair		

Infestations and Disease

Because such a large portion of COWP is forested, this park unit is susceptible to infestation by forest pests, which can defoliate and kill stands. One of the main forest insect pests in the southeast is the native southern pine beetle (*Dendroctonus frontalis*), which causes tree mortality at a rate higher than any other forest pest. Typical stand infestations may last 3-4 years (Fettig et al. 2007). In the mid-1990s, a large pine beetle infestation killed several trees in the park (Binckley and Davis 2002), and the COWP resource management plan (RMP; NPS 1998) reports that many trees around the buffer zone of the main battlefield have become infested in previous years.

Southern Pine Beetle

To assess the risk of southern pine beetle infestation in this region, the Forest Health Technology Enterprise Team of the US Forest Service constructed a southern pine beetle vulnerability map for the entire southeastern region using 8 separate models over 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 COWP were slope, southern pine basal area, aspect, and soil clay content. Figure 14, adapted from that model, shows that the overall risk within COWP is between none and minimal (Ellenwood & Krist 2007; Krist 2009). The highest levels of risk identified were overall moderate, according to the model, and coincide mainly with the loblolly pine stands in the north central portion of the battlefield and in the northwestern end of the park unit. 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.

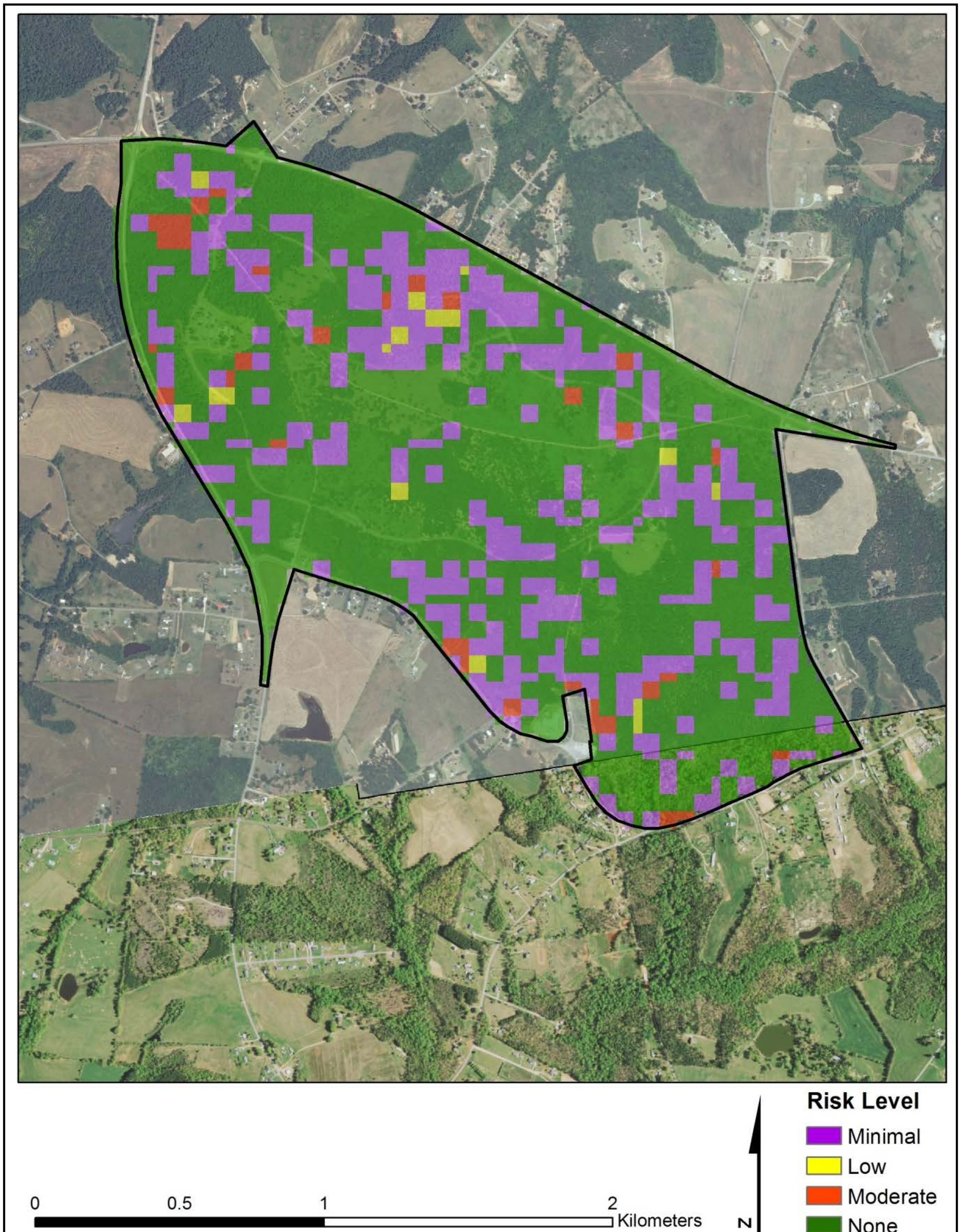


Figure 14. Southern Pine Beetle Infestation Risk at COWP (30-km resolution). [Source: Southern Pine Beetle Hazard Map. 2007. Forest Health Technology Enterprise Team. USDA Forest Service. Ft. Collins, CO.]

Gypsy Moth

Another potential forest insect pest in the southeastern US is gypsy moth (Lymantria dispar), which were introduced from Europe to the east coast of the US in the late 19th century, and has subsequently been shown to affect tree health from infestation and defoliation (Schultz and Baldwin 1982; Elkinton and Liebhold 1990).

The Forest Health and Monitoring division of the US Forest Service has annual reports for gypsy moth traps for 2007 and 2008, during which 4 traps were placed in COWP, though none 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 COWP and the surrounding region (Puckett 2008).

Ips Beetle

A third 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 COWP. However, the ips beetle is only known to infest weakened and unhealthy trees, such as ones following an extreme disturbance such as fire, storms, drought, or cutting (Connor and Wilkinson 1983). In particular, the threat of an infestation is closely tied to the management strategy adopted by the park, as an overstocking of trees in pine stands could weaken the trees and favor an infestation. Cameron and Billings (1988) recommend loblolly stands be kept below an overall basal area density of 100 ft^2/acre.

Summary

Overall, insect pests appear to present a minimal risk to the stands at COWP, and what risk there is might best be alleviated by minimizing stocking density of monospecific pine stands. For these reasons, the status of insect pests at COWP receives a condition ranking of "good," with insufficient information to assign a trend (Table 13).

Table 13. The condition status for insect pests at COWP was good. The data quality used to make this assessment was good. No trend was assigned to this condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Insect Pests	(green circle)	✓	✓	✓
		3 of 3: Good		

Vegetation Communities

Forest Communities

Classification and Accuracy
NatureServe collaborated with the Center for Remote Sensing and Mapping Science (CRMS) at the University of Georgia to map the vegetation communities at COWP, in accordance with the national standards outlined by the Federal Geographic Data Committee (FGDC 2008). Using leaf-on aerial color infrared photos taken fall in 2002 by US Forest Service Air Photographics, the CRMS classified 13 community types at COWP out of 411 delineated polygons, which included four natural vegetation types (Figure 15) and nine successional or exotic-dominated communities (Jordan and Madden 2008).

In 2005, NatureServe performed an accuracy assessment of the vegetation map created by the CRMS (O'Donoghue and Lyons 2007). 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 an overall accuracy of 65% at the finest scale. When restricted to matches based only on primary vegetation, accuracy was reduced to 61%. After the original vegetation was classified in 2002, COWP initiated several revitalization activities at the battlefield that resulted in the assimilation of areas originally classified as old field (CEGL004048), lawn, or blackberry – greenbrier successional shrubland thicket (CEGL004732) into what is now essentially the same class. As a result of the accuracy assessment, O'Donoghue and Lyons recommend grouping these vegetation types together to improve the overall accuracy of the map. In addition to these, the authors made several lumping recommendations as follows:

a. Cultivated meadows (CEGL004048), old fields (OF), and blackberry/greenbrier successional shrublands (CEGL004732)
b. Piedmont small stream sweetgum - tuliptree forest (CEGL004418) and successional sweetgum floodplain forest (CEGL007730)
c. Successional loblolly pine forest (CEGL006011) and shortleaf pine early successional forest (CEGL006327)
d. Southern piedmont mesic subacid oak-hickory forest (CEGL006227) and southern red oak – white oak mixed oak forest (CEGL007244)
e. Successional sweetgum forest (CEGL007216) and successional tuliptree - hardwood forest (CEGL 7221)

With these groupings, overall accuracy is 80%. However, the authors suggest that for users interested in fine-scale detail or determining rare vegetation types, the original full-detail of the map by CRMS (2008) should be utilized.

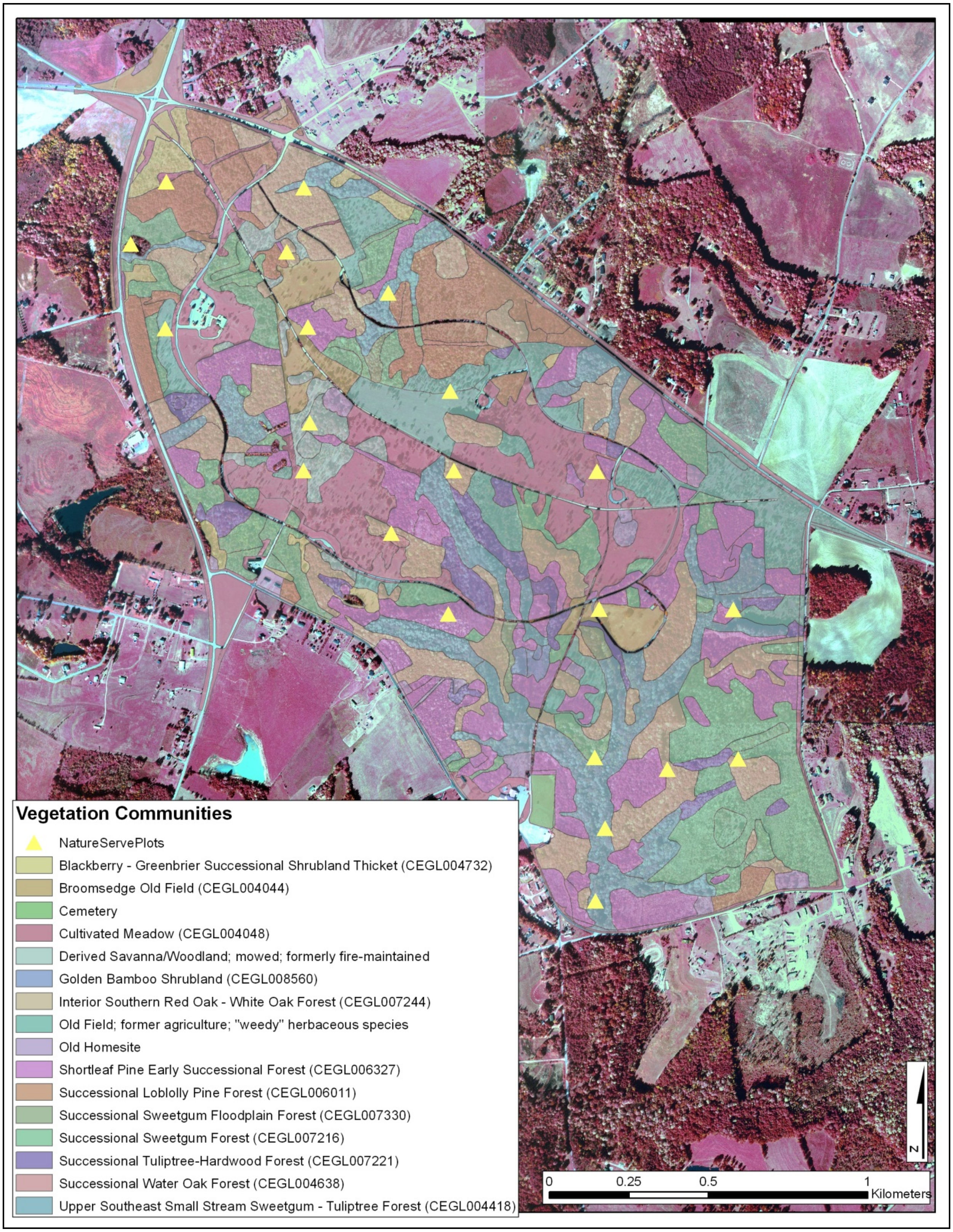


Figure 15. NatureServe sampled 21 plots at COWP spaced roughly on a 480 m square grid (White 2004). Vegetation types at COWP were classified by Center for Remote Sensing and Mapping Science (CRMS) at UGA (2008).

Significant Communities

Piedmont Granitic White Oak – Black Oak Woodland

Certain vegetation types found at COWP are considered important due to their rarity or ecological significance. Of the communities delineated by Jordan and Madden (2008), the Piedmont Granitic White Oak – Black Oak Woodland (CEGL003722) is the only one obtaining a G1? conservation ranking, partly due to the fact that it is only identified from one other area (Fort Pickens in Virginia). It comprises less than 1 ha at COWP (Figure 16). The uncertainty (G1?) refers to the likelihood that the community might occur in other locations, such as the North Carolina Piedmont, that have yet to be inventoried (NatureServe 2009). This community is thought to have formerly existed on felsic sites in North Carolina and south into Georgia when the fire return interval was shorter (NatureServe 2009). The remaining communities at COWP and Fort Pickens of this type are maintained via mowing and burning. In addition to its rarity of occurrence, this community also is thought to be one of the original vegetation types in the Piedmont area prior to settlement, which is supported by various Revolutionary War accounts that describe vegetation types approximating the ones existing today (NatureServe 2009). Though none of the associated species of this community are particularly rare, they include plants such as shaggy blazing star (*Liatris pilosa*), goat's rue (*Tephrosia virginiana*), and bluestem grass (*Schizachyrium scoparium*) that are most frequently seen on unplowed right-of-ways and rock outcrop areas, rather than previously plowed fields and open areas (NatureServe 2009). The dominant species associated with this vegetation type include white oak in the overstory and little bluestem grass and downy oatgrass (*Danthonia sericea*) in the herb layer (Miller and Miller 2005). The understory layer is relatively undeveloped. Currently, a burning regime and continued mowing are important to the persistence of this community, in addition to protection from encroaching exotics such as Japanese honeysuckle and Chinese privet in adjacent communities (NatureServe 2009).

Floodplain Canebrake

Another important ecological community within the National Vegetation Classification found at this site is the native canebrake alluvial floodplain vegetation, which (like the Piedmont Granitic White Oak – Black Oak Woodland) is reminiscent of the vegetation during the time of the war—a fact which is supported by historical accounts (Logan 1859; NPS 2009; White 2004; Figure 16). Because one of the main management objectives of the park unit is to restore and interpret the historic landscape at the time of the battle, preservation and revitalization of this community type is particularly important. Formerly an abundant community throughout the southeastern US, the canebrake refers to the thickets of river cane (*Arundinaria gigantea*) that often allow the establishment of few or no other species. In his *History of the Upper Country of South Carolina*, Logan (1859) 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. Historically, canebrake communities (CEGL003836) 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." Like the Piedmont Granitic White

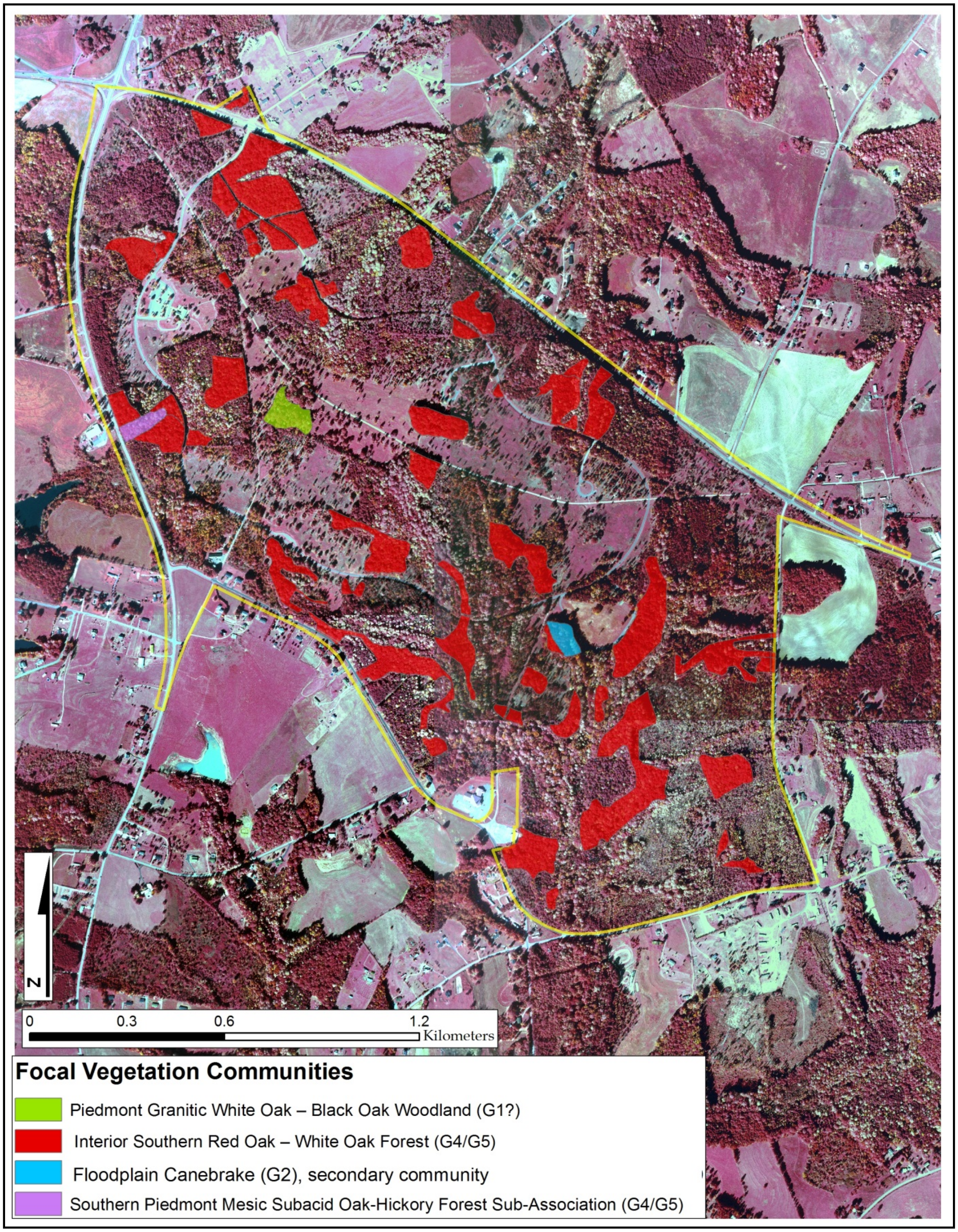


Figure 16. Natural community vegetation types mapped at COWP (Jordan and Madden 2008). Though giant cane is present in the park, it does not occur as part of a natural floodplain canebrake vegetation type. Historically this vegetation type was common in the region/park (Logan 1859; White 2004).

Oak – Black Oak Woodland, this community is largely adapted to fire, the loss of which helped lead to its decline and current listing as a G2? community (White 2004; NatureServe 2009). Although as a community, the floodplain canebrake is considered locally extinct from COWP, some patches of the native cane itself remain, and much of that area includes suitable habitat for the nationally-listed dwarf-flowered heartleaf (*Hexastylis naniflora*) as well as the critically endangered Bachman's warbler (*Vermivora bachmanii*) and other wildlife (White 2004; NatureServe 2009; IUCN 2009). At COWP, White (2004) reported a single population of giant cane in a 1-ha patch of Sweetgum Successional Floodplain Forest (Figure 16). The Palmetto Conservation Foundation's (2004) landscape restoration plan for COWP recommends planting additional river cane to bolster communities in certain areas. They identify two locations for replanting inside the loop road, which include a portion along the northern part of Suck Creek, as well as along the main battlefield trail. Both of these areas occur in the Upper Southeast Small Stream Sweetgum – Tuliptree (CEGL004418) forest type.

Other native community types in the park include Interior Southern Red Oak – White Oak Forest (G4/G5; CEGL007244), which comprises about 48 ha or 14% of the park and is one of the older, more invasive-resistant communities (White 2004; Figure 16). The other is Southern Piedmont Mesic Subacid Oak-Hickory Forest (G4/G5; CEGL006227), which comprises <1 ha as a sub-association of an Upper Southeast Small Stream Sweetgum - Tuliptree Forest. White (2004) and Govus both suggest this community is a good candidate for monitoring against an invasion of exotic species, given the large amount of invasives already in the park (personal communication December 2009).

Along with the Interior Southern Red Oak – White Oak Forest, the Shortleaf Pine Early Successional Forest (CEGL006327) and the Successional Sweetgum Forest (CEGL007216) comprise the largest communities at COWP. In the absence of disturbance, the Shortleaf Pine Early Successional Forest, which comprises 50 ha, generally grows on abandoned agricultural fields in upland and relatively dry conditions. This community is typified by low biodiversity, and is susceptible to invasion of exotic species such as Japanese honeysuckle and tree-of-heaven (*Ailanthus altissima*). The Sweetgum Successional Forest, which comprises 47 ha, resembles a late-successional version of the Shortleaf Pine Early Successional Forest and occurs on similar upland and abandoned old-field sites. Typical species include loblolly pine (*Pinus taeda*), as well as oaks and hickories. The understory is distinctively more diverse than that of the shortleaf pine forest, but is still susceptible to invasion by exotics such as Chinese lespedeza (*Lespedeza cuneata*) and Chinese silvergrass (*Miscanthus sinensis*; White 2004).

Wetland Communities

Wetlands contain a unique vegetation composition, and in turn provide habitat for a distinctive set of animal species. At COWP, Roberts and Morgan (2006) identified 37 wetland areas totaling 5 ha (Figure 17), even though the National Wetlands Inventory (NWI) did not identify any wetlands within the park boundary from aerial photographs. Roberts and Morgan (2006) attributed this omission to the small size of the wetlands (μ = 0.15 ha) and their short hydroperiod. 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,

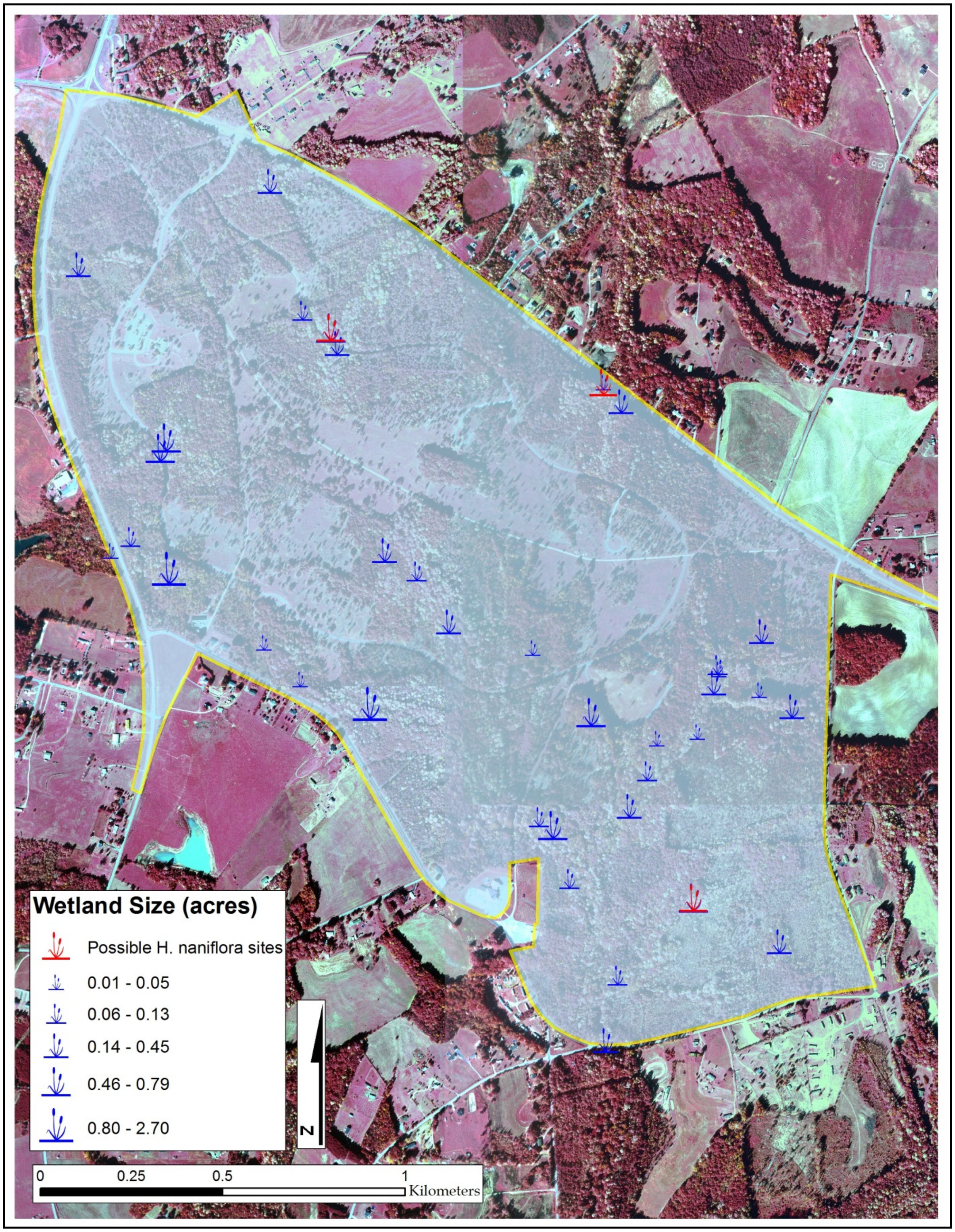


Figure 17. Roberts and Morgan (2006) identified 37 wetlands at COWP. They noted the presence of *Hexastylis* at three sites. The particular species *H. naniflora* was not in flower during the surveys, so species identification was impossible.

wetlands are classified into 1 of 5 general systems, as well as various descriptive subsystems that depend on hydrologic regime, water chemistry, or 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 (2006) classified all of the wetlands at COWP as palustrine, forested, deciduous, and temporarily flooded (PF01A). Wetland presence was identified in part by surface water presence, vegetation type, and specific indicator species such as sedge (*Carex* spp.), royal fern (*Osmunda regalis*), giant cane (*Arundinaria gigantea*), and alder (*Alnus serrulata*; Roberts and Morgan 2006).

Out of the 37 wetlands, 32 were classified as slope wetlands along stream drainages with a groundwater source, while the remaining 5 were classified as depressions charged by precipitation and overland flow. Non-depressional wetlands such as slope wetlands are dictated by the regional water table and usually cover a greater area than depressional wetlands, while depressional wetlands result from the terrestrialization of previous water bodies that become inundated 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, along with 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).

Roberts and Morgan (2006) added a classification to each of the wetlands at COWP based on the presence of invasives, amount of carbon export, flood attenuation level based on hydrogeomorphological setting, and research potential. Research potential was largely dictated by whether the wetland was large (>0.16 ha), or whether it met the habitat requirements for dwarf-flowered heartleaf.

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 (Mattsson et al. 2009). 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 (2006) point out, different forms of carbon also play an important role in the food web of detrital microorganisms and invertebrate shredders. Nine of the slope wetlands at COWP received a high rating for carbon export potential, with another 18 classified as medium.

Wetlands were also classified based on 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 these criteria, four sites were deemed valuable. In addition, an economic value classification was based on a combination of flood attenuation and potential visitor appeal, which was not further defined (Roberts and Morgan 2006). None of the wetlands were identified as having significant economic value. Wetlands were also classified as low, medium, or high quality 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). Eight of the wetlands received a medium rating for this class, whereas all others were classified as low.

Finally, Robert and Morgan (2006) assigned each wetland a rating for amphibian habitat, based on the length of hydroperiod using a two-week cutoff as a short-term ponding period. Amphibians are sensitive to the hydroperiod length, as they require saturated soils or standing water to lay eggs and complete their lifecycle (Paton & Crouch 2002). Typically, wetlands with longer vernal pools at COWP belong to the depressional hydrogeomorphological class, and of the 37 wetlands, 4 were classified as high value and 7 as medium. This wetland function is of particular importance in light of widespread 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). Vitt et al. (1990), among others, has 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 COWP continues to manage for the protection of existing wetland areas.

Because there is no recommended protocol or ranking system in place for vegetation communities, we did not assign a ranking to this vital sign as they pertain to forest and wetland areas at COWP (Table 15). Despite this, data collected by NatureServe and vegetation classifications performed by the CRMS provide a thorough baseline knowledge of vegetation resources at COWP. 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, personal communication, Nov. 2010).

Table 14. Seventeen wetland plant species at COWP fall into the category of either facultative wetland (FACW; wetland occurrence 67%-99%) or obligate wetland species (OBL; wetland occurrence >99%).

Species		**Indicator Status**
Alnus serrulata	Brook-side alder	FACW
Arisaema triphyllum	Jack-in-the-pulpit	FACW
Arundinaria gigantea	Giant cane	FACW
Betula nigra	River birch	FACW
Chasmanthium laxum	Slender spikegrass	FACW
Fraxinus pennsylvanica	Green ash	FACW
Impatiens capensis	Spotted touch-me-not	FACW
Juncus effusus	Soft rush	FACW
Lobelia cardinalis	Cardinal flower	OBL
Ludwigia alternifolia	Seedbox	OBL
Onoclea sensibilis	Sensitive fern	FACW
Osmunda cinnamomea	Cinnamon fern	FACW
Osmunda regalis	Royal fern	OBL
Quercus phellos	Willow oak	FACW
Sagittaria latifolia	Broad-leaf arrowhead	OBL
Salix nigra	Black willow	OBL
Woodwardia areolata	Netted chainfern	OBL

Table 15. The condition status for vegetation communities at COWP was unranked. The data quality used to make this assessment was good. No trend was assigned to this condition.

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

Fish Communities

Cowpens National Battlefield contains relatively little fish habitat. The unit contains seven headwater streams (Figure 18). A fish inventory was conducted at COWP in 2006 (Scott 2006). This survey used backpack electroshocking to sample four stream sites and reported seven native fish species and no introduced species (Scott 2006; Table 16). Two of the species, the highback chub (*Hybopsis hypsinotus*) and the fantail darter (*Etheostoma flabellare*), were included in the state's Comprehensive Wildlife Conservation Strategy (CWCS) as species of conservation concern (SCDNR 2005). Only a single specimen of the fantail darter was discovered, but 76 highback chubs were sampled from two sites and the species comprised about 15% of the overall park sample. The small headwater nature of COWP streams precludes assessing their condition with commonly available community indices, such as the North Carolina Index of Biotic Integrity, which are designed for flows with larger drainages (NCDENR 2006). However, the presence of an assemblage of native fish in these headwater flows, and the absence of exotic species, is consistent with observations expected at sites with quality habitat. We ranked the condition of the fish community at COWP as good (Table 17) basing this ranking upon qualitative factors. We found the quality of the data to be good.

A single baseline survey of the fishes of Cowpens National Battlefield has been conducted. The quality of that survey was good and provided high-quality data. We recommend that future monitoring efforts conform closely to the sample design used by Scott (2006). Even though fish habitat is limited and only seven fish species were reported from the park, Cowpens contains several protected headwater streams that may provide refuge for native species of concern. Headwater streams provide habitat for vertebrates and invertebrates and can play an important role in maintaining biodiversity at the drainage level (Gomi et al. 2002). Many combinations of stream size and physical landscape attributes harbor unique fish communities in the southeastern U.S. (Angermeier and Winston 1999). Therefore, the monitoring of small headwater stream fish communities within protected public land may play an important role in the conservation of regional fish communities.

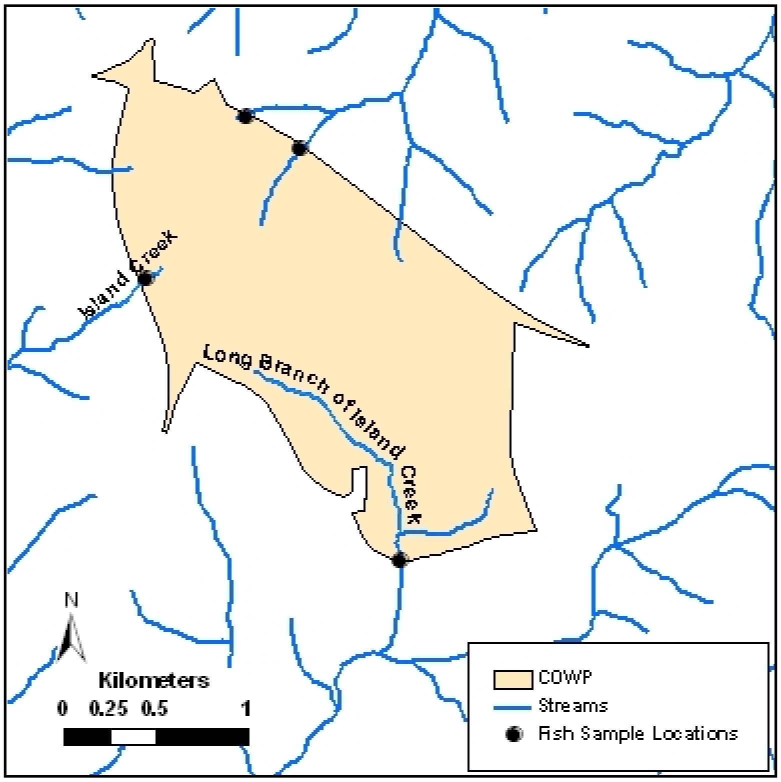


Figure 18. Streams of Cowpens of National Battlefield and fish sampling locations from the 2005 fish inventory (Scott 2006).

Table 16. Seven species of fish were reported at COWP during the 2006 survey.

Common Name	Specific Name	Family	N
Bluehead chub	*Nocomis leptocephalus*	Cyprinidae	99
Creek chub	*Semotilus atromaculatus*	Cyprinidae	94
Highback chub	*Hybopsis hypsinotus*	Cyprinidae	76
Rosyside dace	*Clinostomus funduloides*	Cyprinidae	195
Yellowfin shiner	*Notropis lutipinnis*	Cyprinidae	39
Redbreast sunfish	*Lepomis auritus*	Centrarchidae	3
Fantail darter	*Etheostoma flabellare*	Percidae	1

Table 17. Condition of fish communities at COWP was good. The quality of data available was good. No trend was assigned to fish community condition.

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

Bird Communities

Because birds are sensitive to environmental changes, are relatively long-lived, occur in diverse communities, and are relatively easy to monitor, they are valuable indicators of terrestrial ecosystem quality and function (Maurer 1993). From June, 2004 to February 2006, 84 species of birds were reported from COWP (Seriff 2006; Table 18). Breeding season data were collected using point counts at 16 pre-established plots and incidental sightings (Seriff 2006). Winter bird data were collected during unstructured field surveys and from incidental sightings (Seriff 2006). During the survey, 2837 individual birds of 84 species were reported. Sixty-five species were reported during the breeding season; representing 84% of the expected breeding diversity, and 55 species were documented during winter months (Seriff 2006).

Watson (2003) prepared a general Avian Conservation Implementation Plan (ACIP) that proposed broad management guidelines for COWP. The COWP ACIP draft, following the management recommendations of Partners in Flight for the southern Piedmont physiographic region, suggested managing for several species (Watson 2003). These recommended species were: Wood Thrush (*Hylocichla mustelina*) and Summer Tanager (*Piranga rubra*) for forest interior species, Northern Bobwhite (*Colinus virginianus*) and Prairie Warbler (*Dendroica discolor*) for early successional species, and Swainson's Warbler (*Limnothlypis swainsonii*), Louisiana Waterthrush (*Seiurus motacilla*), and Acadian Flycatcher (*Empidonax virescens*) for riparian species. Five of these seven species were reported during the baseline bird inventory at COWP (Seriff 2006). Summer Tanager was reported 10 times, and Wood Thrush was reported 14 times. Northern Bobwhite was reported six times and Prairie Warbler was reported twice. Acadian Flycatcher was reported four times and Louisiana Waterthrush and Swainson's Warbler were not reported. The relative dearth of riparian species is expected due to the small amount of riparian habitat in the park.

We used an index of biotic integrity (Karr 1981; O'Connell et al. 2003) to explore the quality of the COWP 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 piedmont region of the eastern U.S. containing COWP. To use this 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. Possible scores range from 0 for fully "humanistic" habitats that have received a high level of anthropogenic disturbance, to 100 for fully "naturalistic" habitats existing in a pristine state (O'Connell et al. 2003). Greater values are awarded to sensitive species and species with specialist life history traits.

We applied the regional BCI to COWP 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). Cowpens 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. A single plot out of 16 scored in the highest "naturalistic" category, six scored in the "largely intact" category, eight scored in the "moderately disturbed" category, and a single plot scored in the "humanistic" category (Figure 19a). The grand mean score for all individually calculated point counts was 0.585 (SD±0.12), corresponding to a

Table 18. Bird species reported from Cowpens National Battlefield during a 2004-2006 survey (Seriff 2006).

Common Name	Scientific Name	Common Name	Scientific Name
Acadian Flycatcher	*Empidonax virescens*	House Finch	*Carpodacus mexicanus*
American Crow	*Corvus brachyrhynchos*	House Sparrow	*Passer domesticus*
American Goldfinch	*Carduelis tristis*	House Wren	*Troglodytes aedon*
American Robin	*Turdus migratorius*	Indigo Bunting	*Passerina cyanea*
Barn Swallow	*Hirundo rustica*	Killdeer	*Charadrius vociferus*
Barred Owl	*Strix varia*	Loggerhead Shrike	*Lanius ludovicianus*
Black Vulture	*Coragyps atratus*	Mourning Dove	*Zenaida macroura*
Blue Grosbeak	*Guiraca caerulea*	Northern Bobwhite	*Colinus virginianus*
Blue Jay	*Cyanocitta cristata*	Northern Cardinal	*Cardinalis cardinalis*
Blue-gray Gnatcatcher	*Polioptila caerulea*	Northern Flicker	*Colaptes spp.*
Blue-headed Vireo	*Vireo solitarius*	Northern Mockingbird	*Mimus polyglottos*
Broad-winged Hawk	*Buteo platypterus*	Northern Parula	*Parula americana*
Brown Creeper	*Certhia americana*	Ovenbird	*Seiurus aurocapillus*
Brown Thrasher	*Toxostoma rufum*	Pileated Woodpecker	*Dryocopus pileatus*
Brown-headed Cowbird	*Molothrus ater*	Pine Warbler	*Dendroica pinus*
Brown-headed Nuthatch	*Sitta pusilla*	Prairie Warbler	*Dendroica discolor*
Canada Goose	*Branta canadensis*	Purple Martin	*Progne subis*
Carolina Chickadee	*Poecile carolinensis*	Red-bellied Woodpecker	*Melanerpes carolinus*
Carolina Wren	*Thryothorus ludovicianus*	Red-eyed Vireo	*Vireo olivaceus*
Cedar Waxwing	*Bombycilla cedrorum*	Red-shouldered Hawk	*Buteo lineatus*
Chimney Swift	*Chaetura pelagica*	Red-tailed Hawk	*Buteo jamaicensis*
Chipping Sparrow	*Spizella passerina*	Red-winged Blackbird	*Agelaius phoeniceus*
Chuck-will's-widow	*Caprimulgus carolinensis*	Ruby-crowned Kinglet	*Regulus calendula*
Common Grackle	*Quiscalus quiscula*	Ruby-throated Hummingbird	*Archilochus colubris*
Common Yellowthroat	*Geothlypis trichas*	Scarlet Tanager	*Piranga olivacea*
Cooper's Hawk	*Accipiter cooperii*	Sharp-shinned Hawk	*Accipiter striatus*
Dark-eyed Junco	*Junco hyemalis*	Song Sparrow	*Melospiza melodia*
Downy Woodpecker	*Picoides pubescens*	Summer Tanager	*Piranga rubra*
Eastern Bluebird	*Sialia sialis*	Swamp Sparrow	*Melospiza georgiana*
Eastern Meadowlark	*Sturnella magna*	Tufted Titmouse	*Baeolophus bicolor*
Eastern Phoebe	*Sayornis phoebe*	Turkey Vulture	*Cathartes aura*
Eastern Towhee	*Pipilo erythrophthalmus*	White-breasted Nuthatch	*Sitta carolinensis*
Eastern Wood-Pewee	*Contopus virens*	White-eyed Vireo	*Vireo griseus*
European Starling	*Sturnus vulgaris*	White-throated Sparrow	*Zonotrichia albicollis*
Field Sparrow	*Spizella pusilla*	Wild Turkey	*Meleagris gallopavo*
Fish Crow	*Corvus ossifragus*	Winter Wren	*Troglodytes troglodytes*
Fox Sparrow	*Passerella iliaca*	Wood Duck	*Aix sponsa*
Golden-crowned Kinglet	*Regulus satrapa*	Wood Thrush	*Hylocichla mustelina*
Great Blue Heron	*Ardea herodias*	Yellow-bellied Sapsucker	*Sphyrapicus varius*
Great Crested Flycatcher	*Myiarchus crinitus*	Yellow-billed Cuckoo	*Coccyzus americanus*
Hairy Woodpecker	*Picoides villosus*	Yellow-breasted Chat	*Icteria virens*
Hermit Thrush	*Catharus guttatus*	Yellow-rumped Warbler	*Dendroica coronata*

"moderately disturbed" interpretation (O'Connell et al. 2003). Because these scores were calculated using bird lists from individual point counts, they were most useful for suggesting relative habitat quality differences among the plots. 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 19b). The grand mean of the resulting BCI scores was 0.640 (SD±0.07) corresponding to a "largely intact" interpretation (O'Connell et al. 2003).

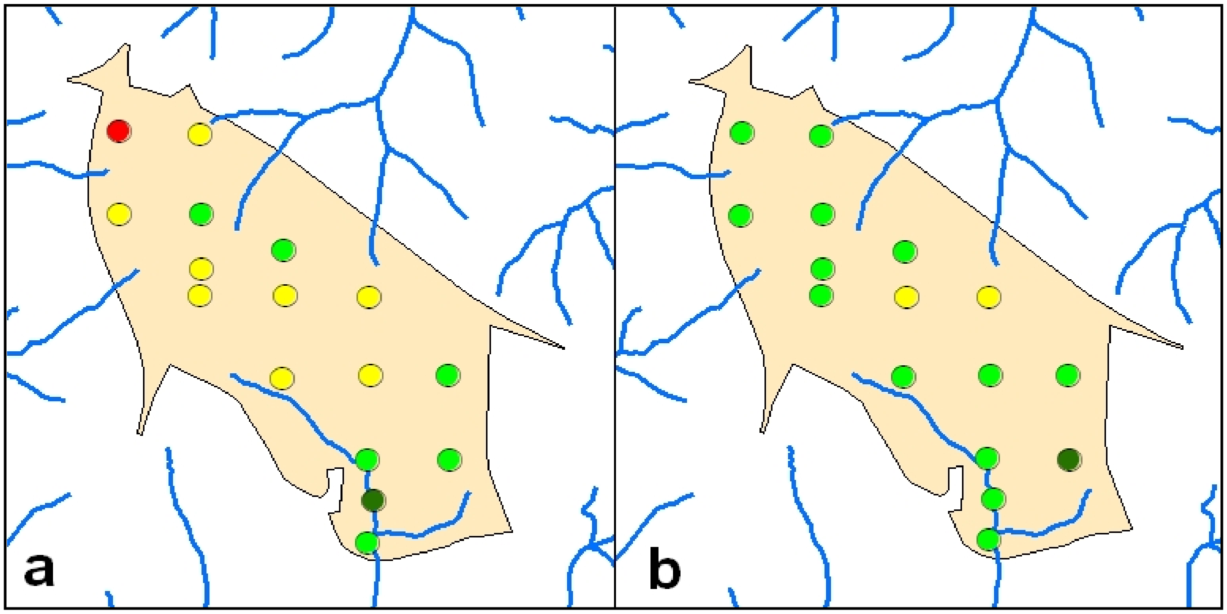


Figure 19. BCI score interpretations for bird point count data from COWP calculated using both individual plot count bird lists (a) and 5-plot count bird lists (b). Dark green=naturalistic, light green=largely intact, yellow=moderately disturbed, red=humanistic.

We ranked the COWP bird community as good (Table 19). The grand park mean of scores calculated using 5-plot bird lists corresponded to an interpretation of "largely intact" (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 COWP bird habitat has moderate anthropogenic disturbance, relative to the most pristine test sites used to develop the BCI (O'Connell et al. 2003).

The baseline bird survey conducted at COWP provided data useful for assessing and monitoring park birds. If future bird monitoring is conducted at NISI, we recommend that these efforts be conducted with methods similar to the methods used for this 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 COWP was good. The quality of available data was good. No trend was assigned to bird community condition.

Attribute	Condition & Trend	Data Quality: Thematic	Spatial	Temporal
Bird Community	Good (green circle)	✓	✓	✓
		3 of 3: Good		

Mammal Communities

Mammals are an important component of southeastern forested ecosystems. Because of great variation in size, behavior, and life history, they are inherently difficult to sample. Surveys of non-volant mammals were conducted at Cowpens National Battlefield in 2000-2001 (Ferris 2001), and in 2007-2008 (Pivorun 2009). A 2005-2007 bat survey at several piedmont National Park units included COWP (Loeb 2007). These surveys reported 16 mammal species in the park, including four bats, four rodents, four carnivores, one insectivore, one lagomorph, one marsupial, and one ungulate (Table 20).

During the 2000-2001 survey Ferris (2001) sampled for small mammals in the four most prevalent park habitat types, using two trapping stations in each type. Each station contained a mix of Sherman and Havahart live traps. Approximately 2,592 trap nights produced 72 captures, of which 63 (88%) were white-footed mice (*Peromyscus leucopus*). Ferris (2001) compiled a list of small mammals from the orders Insectivora and Rodentia likely to occur in the park. From his efforts he reported four (25%) of the 16 species on this list, and two additional larger mammals (Table 20). A seventh species, the striped skunk (*Mephistes mephistis*) was reported by NPS staff during the time period of the survey (Ferris 2001). Ferris (2001) stated that the abundance and diversity of small mammals was lower than expected, and speculated that this may have resulted, in part, from the ongoing drought, the prevalence of mowed fields in the park, and the amount of habitat fragmentation in the surrounding landscape. He also commented that trap success may have been higher if pitfall trapping methods had been used (Ferris 2001).

During the 2007-2008 survey effort Pivorun (2009) sampled for mammals year-round using Sherman live traps (300 trap nights), Tomahawk live traps (15 trap nights), unfenced pitfall bucket traps (30 trap nights), two remote, automatically-triggered digital cameras, and visual encounters. Traps were set at ten sites believed to contain good small mammal habitat with 275 trap nights in woodlands and 70 trap nights in old fields (Pivorun 2009). Pivorun (2009) prepared a list of 26 expected mammals for the park, and his effort reported nine (35%), of these species (Table 20). The most commonly reported mammal, and the only species captured in live traps, was the white-footed mouse (Pivorun 2009). Pivorum (2009) reported the eastern chipmunk (*Tamias striatus*) from COWP, but NPS staff have suggested that further evidence is needed to document this species because COWP is outside of its typically reported range (Steve Thomas, pers. comm). Pivorun (2009) suggested that the drought and the unusually high temperatures occurring during the period when this survey was conducted may have reduced the reproductive success of rodents and shrews in the park resulting in low densities during the sample period. Although he did not report any feral or domestic animals from his sampling efforts, Pivorun (2009) commented that COWP is surrounded by home sites and farms and suggested that predation by domestic pets may represent a significant negative impact on small mammals in the park. He also suggested that periodic mowing of park fields may partially account for the absence of small mammals specializing in old field habitats (Pivorun 2009).

Loeb (2007) used literature search results and expert knowledge to prepare an expected list of bat species for COWP including four species expected in summer and two expected winter migrants. The 2005-2007 survey reported three of the four (75%) expected summer species and one of the two (50%) expected winter migrants (Loeb 2007). Sample efforts included both mist netting and acoustic sampling with AnabatII detectors (Loeb 2007). No bats were captured in mist nets during nine nights of effort across six sites in the summer months, although bats were acoustically sampled at 13 of 16 locations during the summer, and at 7 of 14 locations during the winter (Loeb 2007). Among the five parks sampled in the survey, three had greater richness than COWP (Loeb 2007). In further analyses of bat diversity at 10 National Park units across the southeastern U.S., Loeb et al. (2009) found that eight of the parks had greater species richness than COWP. Loeb (2007) stated that the lack of mist-net captures might have been due to the lack of flyways at COWP that naturally concentrate bats, and further stated that the park probably contained good foraging habitat for all four observed species and good roosting habitat for three of the four observed species.

The species richness of mammal samples at COWP was low, relative to expected lists, and the capture success of trapping efforts was low (Ferris 2001; Pivorun 2009). The combined list of expected mammals, including bats, compiled from the studies discussed above, included 36 species, of which 16 (44%) were reported from these efforts (Table 20). Compiling accurate lists of expected mammals for the region is somewhat subjective. Each of the expected lists used by Ferris (2001) and Pivorun (2009) included species not included on the other's list. Reported small mammal capture rates from the southeastern U.S. vary considerably by region, by habitat, by disturbance regime, and by trap method (Bellows et al. 2001; Kilpatrick et al. 2004; Osbourne et al. 2005; Kaminski et al. 2007; Linehan et al. 2008). Therefore, capture success alone may not be a reliable indicator of mammal assemblage quality. Nevertheless, the absence of shrews and the low diversity of small rodents reported from COWP sampling efforts is consistent with the hypothesis that the park does not support a rich mammal assemblage. Shrews and small rodents are often well-represented in terrestrial mammal samples from southeastern forests (Mengak and Guynn 1987; Osbourne et al. 2005; Kaminski et al. 2007; Linehan et al. 2008). Regionally common species not reported from the park include the short-tailed shrew (*Blarina* spp.), hispid cotton rat (*Sigmadon hispidus*), pine vole (*Microtus pinetorum*), southern flying squirrel (*Glaucomys volans*), and red fox (*Vulpes vulpes*), as well as several other shrews, rodents, and carnivores. Much of the sampling at COWP thus far has occurred during periods of drought (Ferris 2001; Pivorun 2009). Both Ferris (2001) and Pivorun (2009) commented upon the isolated nature of this small park in a landscape generally characterized by home sites, farms, and roads, suggesting that COWP is a habitat island with few sources of immigration.

Table 20. Mammal species expected to occur in Cowpens National Battlefield and species actually reported from two non-volant mammal surveys (2000-2001 and 2007-2008), and a bat survey (2005-2007). F=reported by Ferris (2001); L=reported by Loeb (2007); P=reported by Pivorun (2009); * = reported by park staff.

Scientific Name	Common Name	Reported
Order Artiodactyla		
Odocoileus virginianus	White-tailed deer	P
Order Carnivora		
Canis latrans	Coyote	P
Lynx rufus	Bobcat	
Mephitis mephitis	Striped skunk	*
Mustela frenata	Long-tailed weasel	
Procyon lotor	Raccoon	F, 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
Nycticeius humeralis	Evening bat	
Pipistrellus subflavus	Eastern pipistrelles	L
Order Didelphidae		
Didelphis virginiana	Virginia opossum	F, P
Order Insectivora		
Blarina spp.	Short-tailed shrew	
Cryptotis parva	Least shrew	
Scalopus aquaticus	Eastern mole	F
Sorex longirostris	Southeastern shrew	
Order Lagamorpha		
Sylvilagus floridanus	Eastern cottontail	P
Order Rodentia		
Glaucomys volans	Southern flying squirrel	
Microtus pennsylvanicus	Meadow vole	
Microtus pinetorium	Pine vole	
Mus musculus	House mouse	F
Neotoma floridana	Eastern woodrat	
Ochrotomys nuttalli	Golden mouse	
Peromyscus leucopus	White-footed mouse	F, P
Peromyscus maniculatus	Deer mouse	
Rattus norvegius	Norway rat	
Rattus rattus	Black rat	
Reithrodontomys humilis	Eastern harvest mouse	
Sciuris carolinensis	Gray squirrel	F, P
Sciuris niger	Fox squirrel	
Sigmodon hispidus	Hispid cotton rat	
Tamius striatus	Eastern chipmunk	P
Zapus hudsonius	Meadow jumping mouse	

The effort directed toward mammal surveys at COWP had been relatively low at the time of our analysis, and had relied heavily on box-style live traps. Non-bat mammal sampling from the two

COWP studies reported here included less than 3,000 trap nights with total pitfall effort of 30 trap nights (Ferris 2001; 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 insectivores (Briese and Smith 1974; Bury and Corn 1987), a group with at least three potential species in the region that have not been reported from COWP. 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. Sherman live traps set in trees have proven effective for sampling southern flying squirrels (Loeb et al. 2001). 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).

If further sampling is conducted at COWP, and particularly if efforts have the goal of documenting most of the non-volant mammals present, we recommend the use of greater overall 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 COWP 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 Cowpens National Battlefield (Table 21). The quality of the data was fair. We did not check the thematic component of data quality (Table 21) because we believe the effort of non-volant mammal sampling was not sufficient to adequately document a representative sample of the COWP mammal assemblage.

Table 21. No condition was assigned to mammal communities at Cowpens National Battlefield. The quality of mammal data was fair. No trend was assigned to mammal community condition.

Attribute	Condition & Trend	Data Quality		
		Thematic	**Spatial**	**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 have been two herpetofaunal surveys at Cowpens National Battlefield. Thomas (2001) used coverboards, road cruising, and unconstrained visual searches to document 16 species in the park. Reed and Gibbons (2005) used coverboards, road cruising, and unconstrained visual searches to document 30 species in COWP. The total effort for the Reed and Gibbons (2005) survey was 34 person days. Thirty-three species were documented by these combined efforts including 16 species of reptile and 17 species of amphibian (Thomas 2001; Reed and Gibbons 2005; Table 22). No state or federally listed threatened or endangered species were reported from the park. Three species of frogs, northern cricket frog (*Acris crepitans*), pickerel frog (*Rana palustris*), and upland chorus frog (*Pseudacris feriarum*) were included in the South Carolina Comprehensive Wildlife Conservation Strategy as species of conservation priority (SCDNR 2005). Reed and Gibbons (2005) commented that the upland areas of COWP, including open mowed and burned areas, exhibited low herpetofaunal diversity relative to the bottomland forest habitats in the southeastern quadrant of the park.

The herpetofaunal species richness reported from the combined COWP survey results included around 60% 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 55 species reasonably expected to occur in COWP (Table 22). The richness reported from COWP was within the broad range observed from other studies in protected forests in the piedmont region of South Carolina (Metts et al. 2001; Floyd et al. 2002). Floyd et al. (2002) reported 29 species from efforts with drift fence pitfall arrays in north-western South Carolina. Metts et al. (2001) reported 49 species from the same experimental forest following sampling with drift fences, minnow and hoop traps, and coverboards. Amphibians were relatively better-represented than reptiles in the COWP inventories, with 64% of salamanders and 83% of expected anurans observed (Reed and Gibbons 2005; Table 23). The relatively rich assemblage of observed amphibians emphasizes the importance of temporary wetlands in the park (Figure 17). There was relatively little permanent aquatic habitat in the park so the lack of aquatic turtles in the samples is not surprising. However, the observed diversity of snakes was quite low and Reed and Gibbons (2005) suggested that several unreported species are probably present.

Table 22. Herpetofauna species expected to occur in Cowpens National Battlefield by Reed and Gibbons (2005), and species actually reported by Thomas (2001) and Reed and Gibbons (2005). T=reported by Thomas (2001); R=reported by Reed and Gibbons (2005).

Scientific Name	Common Name	Obs	Scientific Name	Common Name	Obs
Anurans			**Lizards**		
Acris crepitans	Northern cricket frog	R	*Anolis carolinensis*	Green anole	R
Bufo americanus	American toad	T,R	*Cnemidophorus sexlineatus*	Six-lined racerunner	R
Bufo fowleri	Fowler's toad	T,R	*Eumeces fasciatus*	Five-lined skink	R
Gastrophryne carolinensis	Eastern narrowmouth toad		*Eumeces inexpectatus*	Southeastern five-lined skink	
Hyla chrysoscelis/versicolor	Gray/Cope's gray treefrog	R	*Eumeces laticeps*	Broadhead skink	
Pseudacris crucifer	Spring peeper	R	*Ophisaurus attenuatus*	Slender glass lizard	
Pseudacris feriarum	Upland chorus frog	T,R	*Sceloporus undulatus*	Fence lizard	T,R
Rana catesbeiana	Bullfrog	R	*Scincella lateralis*	Ground skink	T,R
Rana clamitans	Green frog	R	**Snakes**		
Rana palustris	Pickerel frog	R	*Agkistrodon contortrix*	Copperhead	T
Rana utricularia	Southern leopard frog	R	*Carphophis amoenus*	Worm snake	T,R
Scaphiopus holbrookii	Eastern spadefoot toad		*Cemophora coccinea*	Scarlet snake	
Salamanders			*Coluber constrictor*	Black racer	
Ambystoma maculatum	Spotted salamander	R	*Crotalus horridus*	Canebrake rattlesnake	
Ambystoma opacum	Marbled salamander		*Diadophis punctatus*	Ringneck snake	T,R
Desmognathus fuscus	Northern dusky salamander	T,R	*Elaphe guttata*	Corn snake	
Eurycea cirrigera	Southern two-lined salamander	R	*Elaphe obsoleta*	Rat snake	R
Eurycea guttolineata	Three-lined salamander	R	*Heterodon platirhinos*	Eastern hognose snake	
Gyrinophilus porphyriticus	Spring salamander	T,R	*Lampropeltis calligaster*	Mole kingsnake	R
Hemidactylium scutatum	Four-toed salamander		*Lampropeltis getula*	Eastern kingsnake	T,R
Notophthalmus viridescens	Red spotted newt		*Nerodia sipedon*	Northern banded water snake	R
Plethodon glutinosus complex	Slimy salamander	T,R	*Opheodrys aestivus*	Rough green snake	T,R
Pseudotriton montanus	Mud salamander		*Regina septemvittata*	Queen snake	
Pseudotriton ruber	Red salamander	R	*Storeria dekayi*	Brown snake	T
Turtles			*Storeria occipitomaculata*	Redbelly snake	T
Chelydra serpentina	Common snapping turtle		*Tantilla coronata*	Southeastern crowned snake	
Kinosternon subrubrum	Eastern mud turtle		*Thamnophis sauritus*	Ribbon snake	
Sternotherus odoratus	Common musk turtle		*Thamnophis sirtalis*	Garter snake	
Terrapene carolina	Eastern box turtle	T,R	*Virginia valeriae*	Smooth earth snake	

Efforts at documenting herpetofaunal diversity in COWP have relied significantly upon active searching, and, to a lesser degree, upon coverboards (Thomas 2001; 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 (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 COWP, 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 (2006).

Table 23. Number of species of herpetofauna expected at Cowpens National Battlefield, and numbers and percentages of species actually observed during two inventories (Thomas 2001; Reed and Gibbons 2005).

	# Expected	# Observed	% Expected Observed
All species	55	33	60
Amphibians	23	17	74
Reptiles	32	16	50
Salamanders	11	7	64
Anurans	12	10	83
Snakes	20	10	50
Lizards	8	5	63
Turtles	4	1	25

We did not assign a condition to the herpetofaunal community of Cowpens National Battlefield (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 COWP herpetofauna. The park demonstrably contains an assemblage of regionally typical reptiles and amphibians. At the time of this analysis, approximately 60% of the expected species had been documented in the park. The quality of the available 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 COWP reptiles and amphibians.

Table 24. No condition was assigned to reptile and amphibian communities at COWP. The quality of herpetofaunal data was fair. No trend was assigned to reptile and amphibian community condition.

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

Rare Plants

According to White (2004), Newberry (2001) and King (1997) both conducted recent comprehensive vegetation surveys at COWP before the one conducted by NatureServe. In total, the three surveys resulted in a total documentation of 536 species. In 2001-2002, NatureServe established fourteen 50 x 20 m permanent monitoring plots on a roughly 480m grid, with eight additional plots in specific locations to capture unique vegetation types.

Dwarf-flowered Heartleaf

As a result of the survey, White (2004) identified 7 focal species in the park unit that were significant due to federal or state rankings (Table 25). Among these species, the dwarf-flowered heartleaf (*Hexastylis naniflora*) is perhaps the most important one known to occur in the park, and is included by the US Fish and Wildlife (USFWS) on the list of threatened species (Table 25). In 1997, there were only 60 remaining populations of this species—a perennial herb notable for having the smallest flowers of any evergreen wild ginger species. A 2002 description of the COWP fire management plan reported populations of heartleaf along the three branches of Suck Creek, Island Creek, and along both Long Branches of Island Creek in the southern portion, in addition to much more potential habitat in that area (NPS 2002). In general, dwarf-flowered heartleaf occurs on acidic north-facing slopes and on bluffs and hillsides in boggy stream areas, typically in Piedmont oak-hickory-pine forests. At COWP, this species is likely to occur in the successional Tuliptree-Hardwood Forest vegetation type, which totals 11 ha in 19 patches (White 2004; Table 25).

There are, however, several positive aspects to the current status of dwarf-flowered heartleaf. In a study of *Hexastylis* spp. complexes, Padgett (2004) documented 143 populations of dwarf-flowered heartleaf in 11 counties in North Carolina and South Carolina, with number of individuals ranging from 20 to 2000 in each population. Three of the sites were located at COWP. He noted that dwarf-flowered heartleaf is associated with forest complexes that include chestnut oak (*Quercus prinus*), scarlet oak (*Q. coccinea*), and black oak (*Q. velutina*), and that the species prefers moist and acidic sandy-loam soils such as Pacolet, Madison, or Museulla series. Data available from the Soil Survey Geographic Database (SSURGO) for COWP indicate that the Madison – Cecil association comprises about one-quarter of the soil types present (see sec. *Climate, Geology, and Soils*). NatureServe (2009) outlines several population threats for this species that include continued habitat fragmentation, land-use conversion, and forest management interference; while Padgett (2004) explains that much of the past habitat destruction involved conversion to pastures, ponds, and peach orchards. Overall, these activities are unlikely to affect existing populations within COWP, and with persistent protection they will likely continue to do well.

However, the condition of dwarf-flowered heartleaf over its entire range may not be as encouraging as at this park-level perspective. Although the USFWS does not have a recovery plan for this particular species, Padgett (2004) adopts one designed by the USFWS for Heller's blazing star (*Liatris helleri*). In it, he suggests several objectives as a precursor to delisting dwarf-flowered heartleaf, which notably include the protection of at least 20 populations, as well as surveying additional habitat areas for transplant potential. Currently, only five sites at most are protected at different administrative levels, of which COWP is the only federally protected site.   As current metropolitan areas continue to expand throughout the range of this species, it will undoubtedly become more difficult to protect it against the pressure of habitat destruction.

In 2008, a study was conducted by the USFS Southern Research Station at Clemson University to determine the effects, if any, of prescribed burning on dwarf-flowered heartleaf habitat (Walker et al. 2009). Results of the study suggest that prescribed burns conducted in late winter/early spring before plants are in flower will unlikely affect flowering or plant and population size (Walker et al. 2009). The authors are careful to point out, however, that the results of the study do not address the effect of recurring fires on *H. naniflora* populations, nor do they exclude the possibility of residual effects of burning on *H. naniflora* populations without continued monitoring.

Summary

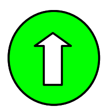
Overall, because of the positive outlook of these reports, as well as the protection from habitat destruction within COWP, condition status of rare plants with special consideration for *H. naniflora* is assigned a ranking of "good". Protection afforded by the park unit will likely allow continued recovery over time. Past inventories of *H. naniflora* by White (2004), Padgett (2004), and Walker et al., 2009 are encouraging. Walker et al. (2009) identified over 100 occurrences of *H. naniflora* throughout the park. As a result of such close monitoring, protection, and encouraging population status across surveys, the condition status of rare plants with consideration for *H. naniflora* at COWP is assigned an "improving" trend (Table 26).

Table 25. List of focal and conservation-listed vascular plant species at COWP (White, 2004).

Species		Conservation Status	Associated Community
Dwarf-flowered heartleaf*	*Hexastylis naniflora*	G3, S3 (SC)	Success. Tuliptree – Hdwd Forest
Joe-Pyeweed	*Eupatorium fistulosum*	G5?	--
Indian lovegrass	*Eragrostis pilosa*	G4	--
Hairy lettuce	*Lactuca hirsuta*	G5	--
Trailing Phlox	*Phlox nivalis*	G4	--
Black huckleberry	*Gaylussacia baccata*	G5, S1 (SC)	Multiple
Virginia sweetspire	*Itea virginica*	G4	Success. Sweetgum Fldpln. Forest

*Federally-threatened

Table 26. The condition status for rare plants at COWP was good. The data quality used to make this assessment was good. A trend of improved was assigned to this condition.

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

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 COWP is located in a developed region, it is prone to the influence of alteration and continued expansion of the surrounding Greenville and Charlotte metropolitan areas. These infringements on the park can serve as threats in several ways, including: 1) vectors for invasive species, 2) producers of air and depositional pollution, or (3) sources of water quality degradation, in addition to a variety of other effects.

Landcover Class Comparisons

CRMS

In addition to delineating detailed vegetation classes inside the park unit, the CRMS also prepared a more general set of classes inside a 400m buffer. Comparison of the land cover types inside COWP with those found in the buffer (Table 27) show a much higher proportion of "other/impervious" area – 66% outside the park unit vs. 6% inside the unit. The park unit maintains a much higher proportion of deciduous, successional, and graminoid landcover, which, when juxtaposed with an intensely developed surrounding area, may be especially vulnerable to invasive exotic species (Vitousek et al. 1997; Fraver 1994).

Table 27. Class comparison of COWP CRMS vegetation classification with CRMS 400m buffer.

Landcover	**400m buffer**	**COWP (CRMS)**
	---------ha (% cover)--------	
Coniferous	3 (1%)	1 (<1%)
Deciduous	27 (6%)	85 (24%)
Mixed	103 (23%)	36 (10%)
Successional	9 (2%)	151 (42%)
Graminoid	9 (2%)	63 (18%)
Other/Impervious	288 (66%)	20 (6%)
Total	**439**	**356**

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 Landcover Database (NLCD) data layers. This data product, specifically created for comparisons, corrected for differences in mapping methodologies and classification types between the individual landcover products in 1992 and 2001 (MRLC 2009). The retrofitted layer shows which areas have transitioned to new landcover types, and which have not changed at a 30m resolution. Surprisingly, the only change within the park boundary over the 9 year period is a transition of 1 ha from grassland to forest. Such small changes observed at this scale of analysis are extremely error-prone and may generally be disregarded.

A more recent comparison was produced by reclassifying the 2002-2003 CRMS vegetation types to match the 2001 NLCD Landsat 7 Anderson Level II classifications. This yielded several transitions, primarily showing a loss of forested area (45 ha coniferous and deciduous), an addition of mixed forest (34 ha), and an overall transition towards grassland (52 ha). These changes might in part reflect the fuel reduction and burning programs that began at COWP in 2002 and 2003, respectively, though in 2003 only 21 ha were burned (NPS 2009; Table 28). It is likely though, that these transitions represent a considerable portion of classification error, based on the minimal changes observed in the much longer period of comparison by the 1992 and 2001 NLCD classifications (~1ha).

Table 28. Class comparison of 2001 NLCD with 2002-2003 CRMS data.

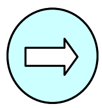
Landcover	**2001 NLCD**	**CRMS**	**Difference**
	---ha (% cover)---		
Coniferous	58 (17%)	51 (15%)	-2%
Deciduous	189 (56%)	151 (44%)	-11%
Mixed	2 (1%)	36 (10%)	+9%
Graminoid	45 (13%)	97 (28%)	+15%
Other/Impervious	46 (13%)	11 (3%)	-10%
Total	**340**	**345**	**--**

Summary

Despite the available data from the CRMS and NLCD landcover classifications, we did not assign a condition ranking to landscape dynamics at COWP (Table 29). The stability of landcover classes between time periods in the NLCD change product led to an assignment of a "stable" trend.

As of this writing, a landscape dynamics monitoring protocol (NPScape) is still in review for each of the parks in the CUPN (S. McAninch, personal communication Jan. 2010). Landscape data from the NLCD, and especially the vegetation classification performed for COWP 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 29. The condition status for landscape dynamics at COWP was not ranked. The data quality for this condition was 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 COWP, we addressed the current condition of fourteen natural resource attributes in the park. We provided qualitative condition ranks for 10 of the 14 attributes. Four attributes were discussed and not ranked. One attribute (7.1%) was ranked as excellent, six (42.9%) were ranked as good, two (14.3%) were ranked as fair, and one (7.1%) was ranked as poor. The remaining four attributes (28.6%) were not ranked. The single excellent ranking was given to water quantity, and 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)—67% Good, 33% Excellent
3) Biological Integrity (eight attributes)—12.5% Poor, 50% Good, 37.5% Not Ranked
4) Landscapes (one attribute)—100% Not Ranked.

We also characterized the quality of information used to make each assessment. We considered the temporal, thematic, and spatial quality of available data for each attribute. Data for all attributes, including attributes not ranked, were classified as fair or good. Attribute data was ranked as fair for the following attributes: vegetation communities, invasive plants, herpetofaunal communities, mammal communities, and land use.

Natural Resource Conditions

Natural resources at COWP were chosen based on data availability, park-level importance, and 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

Recent monitoring of ozone concentrations have shown elevated measurements at COWP. Over the past decade, monitoring has resulted in frequent violations of EPA ambient ozone concentrations, and the most recent monitoring period showed a borderline result. COWP received a “fair” condition status ranking, though continued growth from the surrounding Greenville metropolitan area could worsen air quality at the park, including ozone.

Data quality

COWP has one of the most extensive ozone monitoring histories of any CUPN park unit and serves as a valuable reference point for other park units in the region. With continued unbroken monitoring, data from the park will continue to be useful for annual comparisons with EPA metrics and for monitoring air quality trends.

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 three foliar injury metrics was inconsistent at COWP, though they overall averaged 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 are derived from ozone monitoring, data for this attribute are also extensive. Continued monitoring by the on-site ozone station, along with soil moisture measurements, will ensure that data quality remains high for this attribute and its derived metrics. In addition, periodic vegetation inventories will ensure that sensitive species lists remain up-to-date.

Hydrology
Comprised of three condition rankings, overall water quality at COWP is in good condition. Surface water, or water quantity, is mainly influenced by flow alterations and is largely irrelevant because of the scale of the park, the short flow lengths, and because all streams at COWP are first-order. Because of the effective absence of any type of flow alteration to streams within COWP, this attribute received an "excellent" ranking.

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". Measurements for pH were consistently low, however, likely due to natural geologic conditions and low ANC values. These low values and lack of buffering could leave streams in COWP and the surrounding watershed sensitive to acidic atmospheric deposition (e.g. acid rain), especially given the highly-industrialized surrounding region.

The third hydrology condition ranking was for microorganisms, for which the monitored parameter changed from fecal coliform to *E. coli* in the most recent monitoring period. Although concentrations were elevated in the most recent round, no chronic contamination is apparent, and the condition status for microorganisms was assigned a ranking of "good".

Data quality
Data for these three attributes is collected at four stations quarterly every other year. Although the current dataset is sparse due to monitoring originating in 2003, this monitoring regime represents an important beginning for COWP to develop water quality baselines.

Invasive Plants
Exotic species are one of the most severe current threats to the ecological health of COWP. The park unit contains a high proportion of non-native species, as well as a high number of significantly or severely invasive plants identified as posing a significant ecological threat. Because of these factors and the potential for crossover effects to other natural resources, invasive plants received a condition ranking of "poor".

Data quality

The most recent vegetation inventory on which this assessment is based was conducted in 2004. Since that time, management from prescribed burning and direct exotic treatment has likely altered the species composition at the park. 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 COWP could help in developing treatment priorities.

Insect Pests

Based on records of previous infestations, southern pine beetle likely presents the greatest risk to vegetation communities at COWP. There appear to be no particular predisposing factors for infestation within the park unit, though generally drought, fires, and lightning strikes should alert attention to vulnerable areas. Overall, other possible insect pests such as gypsy moth and ips beetle appear to present little risk at COWP. 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, in addition to vegetation plot observations from the 2004 inventory. Frequent vegetation monitoring at these plots, or devoted monitoring for beetle infestation, would help construct a history of infested areas, as well as help identify sensitive stands.

Vegetation Communities

Detailed vegetation maps have been completed for the park and incorporated into the most recent vegetation inventory. A recent wetlands inventory is also extensive. Together, these data sources outline several vegetation communities threatened by invasive species, as well as focal communities that provide unique habitat for plant diversity. This attribute did not receive a ranking in the current report, but with the completion of the vegetation monitoring protocol—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

The park contains limited fish habitat. A fish inventory conducted in 2006 reported seven native species and no exotic species from four sample locations. The condition of COWP fish communities was ranked "good". 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 limited habitat.

Bird Communities

Eighty four species of birds were reported from a recent park inventory, suggesting COWP contains a relatively rich bird assemblage. A bird community index applied to breeding bird count data indicated that habitat ranged from "naturalistic" to "humanistic" with most habitat being "largely intact" or "moderately disturbed". The forested habitat in the park is demonstrably able to support breeding by a number of interior forest bird specialists. The condition of the bird community was ranked "good".

Data quality

The available bird data were good. 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 mammal community that has been reported from the park to date is less diverse than expected. Regionally common species of carnivores, insectivores, and small rodents have not been documented in COWP. Because the sampling effort has been relatively low, this observed lack of diversity may not represent an accurate understanding of the park mammal assemblage. 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. Some non-bat samples were collected recently and in representative park habitats. However, the effort applied to non-volant mammals was lower than the amount of effort 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 COWP includes about 60% of the expected species of reptiles and amphibians, with amphibians being relatively better-represented than reptiles. The observed assemblages of salamanders and anurans were relatively rich. Several expected species of snakes were not reported. 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 COWP. 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

Although there are several sensitive species present at COWP, the dwarf-flowered heartleaf is perhaps the most important because of its federal status and resulting protection and monitoring efforts. Recent surveys have shown encouraging recovery of their populations within COWP, and continued protection of their habitat in the park will likely ensure improvement of populations of this species. As a result, the condition is assigned a ranking of “good” for this attribute.

Data quality

Four recent surveys have been devoted either wholly or partially to the assessment of dwarf-flowered heartleaf populations, including a survey conducted on the effects of prescribed fire. As a result, the data available for monitoring its recovery are fairly satisfactory. However, specific data on the distribution and viability of other sensitive species, such as black huckleberry and Virginia sweetspire, is relatively sparse with the exception of their plot-level presence observations in the most recent vegetation inventories. Additional monitoring efforts focused on these species would aid in their protection and recovery.

Landscape Dynamics

Numerous factors are involved in an explanation of landscape dynamics and their effects on the park unit. Comparing landcover from within and without the park shows higher proportions of developed and impervious land in the surrounding buffer area, while landcover inside the park contains more forest and grassland. No condition rank was assigned to the status of this attribute, and currently, the CUPN is also reviewing a protocol to standardize the assessment of this natural resource vital sign.

Data quality

Several sources of data are readily available and are important for this condition assessment, including recent vegetation maps of COWP produced by CRMS and NLCD layers.

Natural Resource Synthesis

The natural resource attributes selected for this condition ranking are intended as a comprehensive summary of the ecological status of COWP. Although each condition is assigned a rank separately, a large part of their importance relies on their potential to interact and influence other attributes. 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 COWP, 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. This, in turn, can depress diversity of other guilds such as birds, mammals, and herpetofauna that may rely on a specific habitat type. Besides reducing overall diversity in these stands, sensitive species such as dwarf-flowered heartleaf lack resistance to competition and can easily be extirpated from their habitat. As noted in the invasive plants section, the pervasiveness of exotic 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 alter vegetation communities through foliar injury. Encroachment may have effects on water quality of streams at COWP via atmospheric deposition, which are already susceptible to acidic loading due to naturally low buffering capacities.

This project represents the first iteration in the development of a comprehensive natural resource monitoring program at COWP. 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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Appendix A. NPS Ecological Monitoring Framework table, with highlighted categories representing vital signs relevant to Cowpens National Battlefield. '*' denotes an official vital sign as identified by the CUPN for COWP (Leibfreid et al., 2005). '†' represents significant natural resources mentioned elsewhere, or vital signs mentioned in the original list of considerations by the CUPN. Column four measures are intended as possible aspects for consideration of the specific resource area.

Ecological Monitoring Framework—Cowpens National Battlefield			
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 ozone impact" ; Measures: Ozone levels and impact on native plants
		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
		Marine Hydrology	
	Water Quality	Water Chemistry*	Official Vital Sign: "Water Quality and Quantity" ; Measures: Temp, pH, specific conductivity, DO, ANC;
		Nutrient Dynamics	
		Toxics	

Appendix A. Continued.

		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"; (151 non-native species; 34 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 Communities"; Measures: Vegetation structure, composition, extent, focal communities
		Riparian Communities*	Official Vital Sign: "Vegetation Communities"; Measures: Vegetation structure, composition, extent, focal communities
		Freshwater Communities	
		Sparsely Vegetated Communities	
		Cave Communities	
		Desert Communities	
		Grassland/Herbaceous Communities	
		Shrubland Communities	
		Forest/Woodland Communities*	Official Vital Sign: "Vegetation Communities"; (Piedmont Granitic White/Black Oak; Floodplain Canebrake) Measures: Vegetation structure, composition, extent, focal communities

Appendix A. Continued

		Marine Invertebrates	
		Freshwater Invertebrates	
		Terrestrial Invertebrates	
		Fishes†	Not an official Vital Sign: Measures: North Carolina fish IBI, Species Richness, Composition, Abundance, Water Temp./Chemistry
		Amphibians and Reptiles	
		Birds†	Not an official Vital Sign: Measures: Population changes in birds of priority concern
		Mammals†	Unofficial Vital Sign in Monitoring Plan Appendix Q: Measures: Deer Impact on forest/plant community
		Vegetation Complex (use sparingly)	
		Terrestrial Complex (use sparingly)	
	At-risk Biota	T&E Species and Communities*	Official Vital Sign "Plant Species of Concern" Measures: Species abundance and change (Dwarf-flowered heartleaf)
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: "Adjacent Land Use" 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 plant species in COWP identified collectively by Bratton and Butler (1982), King (1997), Radford (1968), Newberry (2001), Patton (1996), and Rogers (2000) as referenced in White (2004). '*' indicates species presence in park unconfirmed, but probable.

Scientific Name	Common Name	Scientific Name	Common Name
Abelia chinensis	Chinese abelia	*Linum virginianum*	Woodland flax
Abelia X grandiflora	Glossy abelia	*Liquidambar styraciflua*	Sweetgum
Abutilon theophrasti	Velvetleaf Indian mallow	*Liriodendron tulipifera*	Tuliptree
Acalypha gracilens	Slender threeseed mercury	*Lobelia puberula*	Downy lobelia
Acalypha rhomboidea	Threeseed mercury	*Lolium perenne* ssp. *multiflorum*	Annual ryegrass
Acer negundo	Box elder	*Lolium pratense*	Meadow fescue
Acer nigrum	Black maple	*Lonicera fragrantissima*	Sweet breath of spring
Acer rubrum	Red maple	*Lonicera japonica*	Japanese honeysuckle
Achillea millefolium	Common yarrow	*Ludwigia alternifolia*	Seedbox
Agalinis tenuifolia	Slenderleaf false foxglove	*Ludwigia decurrens*	Wingleaf primrose-willow
Agrostis perennans	Autumm bentgrass	*Ludwigia palustris*	Marsh primrose-willow
Ailanthus altissima	Tree of heaven	*Luzula multiflora*	Common woodrush
Aira sp.	Hairgrass	*Lycopodium digitatum*	Fan clubmoss
Ajuga reptans	Common bugle weed	*Lycopodium obscurum*	Ground pine
Albizia julibrissin	Mimosa	*Lycopus virginicus*	Virginia bugleweed
Allium sp.	Wild onion	*Magnolia grandiflora*	Southern magnolia
Alnus serrulata	Tag alder	*Maianthemum racemosum* ssp. *racemosum*	False Solomon's seal
Ambrosia artemisiifolia	Common ragweed	*Malus platycarpa**	Georgia crabapple
Amelanchier arborea	Downy serviceberry	*Malus pumila*	Paradise apple
Amianthium muscitoxicum	Flypoison	*Malus sylvestris**	European crabapple
Amphicarpaea bracteata	Hog-peanut	*Medeola virginiana*	Indian cucumber-root
Andropogon gerardii	Big bluestem	*Medicago* sp.	Medic clover
Andropogon ternarius	Splitbeard bluestem	*Melia azedarach*	Chinaberry
Andropogon virginicus	Broomsedge	*Melilotus alba*	White sweetclover
Anemone lancifolia	Mountain thimbleweed	*Microstegium vimineum*	Japanese stiltgrass
Anemone virginiana	Tall thimbleweed	*Mikania scandens*	Climbing hempvine
Anthoxanthum odoratum	Sweet vernal grass	*Mimosa microphylla*	Littleleaf sensitive-briar
Apios americana	Groundnut	*Miscanthus sinensis*	Chinese silvergrass
Arabidopsis thaliana	Mouse-ear cress	*Mitchella repens*	Partridgeberry
Arisaema triphyllum	Jack in the pulpit	*Mollugo verticillata*	Green carpetweed
Aristida dichotoma	Churchmouse threeawn	*Monotropa hypopithys*	Pinesap
Aristida oligantha	Oldfield threeawn	*Monotropa uniflora*	Indianpipe
Aristida purpurascens	Arrowfeather threeawn	*Morus alba*	White mulberry
Arnoglossum atriplicifolium	Pale Indian plaintain	*Morus rubra*	Red mulberry
Artemisia vulgaris	Wormwood	*Muhlenbergia*	Muhly
Arundinaria gigantea	Giant cane	*Muhlenbergia schreberi*	Nimblewill muhly
Asclepias amplexicaulis	Clasping milkweed	*Mollugo verticillata**	Green carpetweed
Asclepias tuberosa	Butterflyweed	*Muscari* sp.	Grape hyacinth
Asclepias verticillata	Eastern whorled milkweed	*Muscari neglectum*	Starch grapehyacinth
Asimina parviflora	Smallflower pawpaw	*Narcissus* spp.	Daffodil

Appendix B. Continued.

Scientific Name	Common Name	Scientific Name	Common Name
Asimina triloba	Pawpaw	*Nuttallanthus canadensis**	Canada toadflax
Asparagus officinalis	Asparagus	*Nyssa sylvatica*	Blackgum
Asplenium platyneuron	Ebony spleenwort	*Oenothera fruticosa*	Narrowleaf evening-primrose
Athyrium filix-femina ssp. *Asplenioides*	Southern ladyfern	*Oenothera laciniata*	Cut-leaved evening primrose
Aureolaria flava	Smooth yellow false foxglove	*Onoclea sensibilis*	Sensitive fern
Baccharis halimifolia	Eastern baccharis	*Ophioglossum vulgatum*	Southern adder's tongue
Betula pendula	European white birch	*Osmunda cinnamomea*	Cinnamon fern
Bidens bipinnata	Spanish needles	*Osmunda regalis*	Royal fern
Bidens frondosa	Sticktights	*Osmunda regalis var. spectabilis*	Royal fern
Bignonia capreolata	Crossvine	*Oxalis* sp.	Woodsorrel
Boehmeria cylindrica	Smallspike false nettle	*Oxalis stricta*	Dillen's oxalis
Botrychium biternatum	Southern grapefern	*Oxydendrum arboreum*	Sourwood
Botrychium virginianum	Rattlesnake fern	*Packera anonyma*	Small's ragwort
Brickellia eupatorioides var. eupatorioides	False boneset	*Panicum anceps*	Beaked panicgrass
Bromus commutatus	Hairy brome	*Panicum dichotomiflorum*	Fall panicgrass
Bromus japonicus	Japanese brome	*Parthenium integrifolium*	Wild quinine
Broussonetia papyrifera	Paper mulberry	*Parthenocissus quinquefolia*	Virginia creeper
Bulbostylis capillaris	Densetuft hairsedge	*Paspalum dilatatum*	Dallisgrass
Buxus sp.	Boxwood	*Paspalum floridanum*	Florida paspalum
Callicarpa americana	American beautyberry	*Paspalum laeve*	Field paspalum
*Calycanthus floridus**	Sweet shrub	*Paspalum notatum*	Bahiagrass
Calystegia sepium	Hedge bindweed	*Passiflora incarnata*	Purple passionflower
Campsis radicans	Trumpet creeper	*Paulownia tomentosa*	Princess tree
Capsella bursa-pastoris	Shepherd's purse	*Pennisetum glaucum*	Yellow bristlegrass
Cardamine hirsuta	Hairy bittercress	*Penstemon laevigatus*	Eastern smooth beardtongue
Carex sp.	Sedge	*Philadelphus coronarius*	Sweet mock orange
Carex complanata	Blue sedge	*Phlox carolina*	Thickleaf phlox
Carex debilis	White edge sedge	*Phlox nivalis*	Trailing phlox
Carex lurida	Shallow sedge	*Phoradendron leucarpum*	Oak mistletoe
Carex muehlenbergii	Muhlenberg's sedge	*Photinia pyrifolia*	Red chokeberry
Carex nigromarginata	Black edge sedge	*Phryma leptostachya*	Lopseed
Carex rosea	Rosy sedge	*Phyllostachys* sp.	Bamboo
Carpinus caroliniana	American hornbeam	*Phyllostachys aurea*	Golden bamboo
Carya alba	Mockernut hickory	*Physostegia virginiana* ssp. *Virginiana*	Obedient plant
Carya glabra	Pignut hickory	*Phytolacca americana*	Pokeweed
Carya illinoinensis	Pecan	*Pinus echinata*	Shortleaf pine
Carya pallida	Sand hickory	*Pinus elliottii*	Slash pine

Appendix B. Continued.

Scientific Name	Common Name	Scientific Name	Common Name
Castanea dentata	American chestnut	*Pinus strobus*	White pine
Catharanthus roseus	Madagascar periwinkle	*Pinus taeda*	Loblolly pine
Ceanothus americanus	New Jersey tea	*Pinus virginiana*	Virginia pine
Celtis laevigata	Hackberry	*Piptochaetium avenaceum*	Blackseed needlegrass
Centaurea cyanus	Bachelor's button	*Pityopsis adenolepis*	Carolina silkgrass
Centrosema virginianum	Butterflypea	*Pityopsis aspera*	Pineland silkgrass
Cerastium fontanum ssp. *vulgare*	Big chickweed	*Pityopsis graminifolia var. graminifolia*	Narrowleaf silkgrass
Cerastium glomeratum	Sticky chickweed	*Plantago aristata*	Largebracted plantain
Cercis canadensis	Redbud	*Plantago lanceolata*	English plantain
Chaenomeles speciosa	Flowering quince	*Plantago virginica*	Virginia plantain
Chaerophyllum tainturieri	Hairyfruit chervil	*Platanthera clavellata*	Small green wood orchid
Chamaecrista fasciculata	Partridge pea	*Platanus occidentalis*	Sycamore
Chamaecrista fasciculata var. fasciculata	Partridge pea	*Pleopeltis polypodioides* ssp. *polypodioides*	Resurrection fern
Chamaecrista nictitans	Partridge pea	*Pluchea camphorata*	Camphor weed
Chamaecrista nictitans var. nictitans	Partridge pea	*Poa annua*	Annual bluegrass
Chamaesyce maculata	Spotted sandmat	*Poa pratensis*	Kentucky bluegrass
Chamaesyce nutans	Eyebane	*Podophyllum peltatum*	Mayapple
Chasmanthium laxum	Slender woodoats	*Polygala lutea*	Orange milkwort
Chasmanthium sessiliflorum	Longleaf woodoats	*Polygonatum biflorum*	King Solomon's-seal
Chelone sp.	Turtlehead	*Polygonum*	Smartweed
Chenopodium album	Lambsquarters	*Polygonum aviculare*	Prostrate knotweed
Chenopodium ambrosioides	Mexican tea	*Polygonum caespitosum var. longisetum*	Oriental ladysthumb
Chimaphila maculata	Striped prince's pine	*Polygonum punctatum*	Dotted smartweed
Chionanthus virginicus	Fringetree	*Polypremum procumbens*	Juniper leaf
Chrysopsis mariana	Maryland goldenaster	*Polystichum acrostichoides*	Christmas fern
Cinna arundinacea	Stout wood-reed	*Populus alba*	White poplar
Cirsium altissimum	Tall thistle	*Populus nigra*	Lombardy poplar
Cirsium horridulum	Yellow thistle	*Potentilla canadensis*	Dwarf cinquefoil
Cirsium vulgare	Bull thistle	*Potentilla recta*	Roughfruit cinquefoil
Clitoria mariana	Atlantic pigeonwings	*Prenanthes altissima*	Tall rattlesnakeroot
Commelina communis	Asiatic dayflower	*Prenanthes autumnalis*	Slender rattlesnakeroot
Consolida ajacis	Rocket larkspur	*Prunella vulgaris*	Heal all
Convolvulus arvensis	Field bindweed	*Prunus americana*	American plum
Conyza canadensis var. canadensis	Canadian horseweed	*Prunus angustifolia*	Chickasaw plum
Coreopsis major	Greater tickseed	*Prunus persica*	Peach
Cornus amomum	Silky dogwood	*Prunus serotina*	Black cherry
Cornus florida	Flowering dogwood	*Pseudognaphalium obtusifolium* ssp. *obtusifolium*	Rabbit tobacco
Cornus foemina	Stiff dogwood	*Pseudognaphalium*	

Appendix B. Continued.

Scientific Name	Common Name	Scientific Name	Common Name
		obtusifolium ssp. *praecox*	Rabbit tobacco
Crataegus spp.	Hawthorn spp.	*Pteridium aquilinum*	Bracken fern
Crataegus flava	Yellowleaf hawthorn	*Pueraria montana var. lobata*	Kudzu
Crotalaria sagittalis	Arrowhead rattlebox	*Pycnanthemum incanum*	Hoary mountainmint
Croton glandulosus var. septentrionalis	Vente conmigo	*Pycnanthemum tenuifolium*	Narrowleaf mountainmint
Cuscuta pentagona var. pentagona	Field dodder	*Pyracantha* sp.	Pyracantha
Cynodon dactylon	Bermuda grass	*Pyrrhopappus carolinianus*	Carolina false dandelion
Cyperus aggregatus	Inflated-scale flatsedge	*Pyrus communis*	Pear
Cyperus echinatus	Globe flatsedge	*Quercus alba*	White oak
Cyperus esculentus	Chufa flatsedge	*Quercus coccinea*	Scarlet oak
*Cyperus flavescens**	Yellow flatsedge	*Quercus falcata*	Southern red oak
Cyperus iria	Ricefield flatsedge	*Quercus marilandica*	Blackjack oak
Cyperus lupulinus ssp. *lupulinus*	Great Plains flatsedge	*Quercus michauxii*	Swamp chestnut oak
Cyperus pseudovegetus	Marsh flatsedge	*Quercus nigra*	Water oak
Cyperus retrorsus	Pine barren flatsedge	*Quercus phellos*	Willow oak
Cyperus strigosus	Stawcolored flatsedge	*Quercus prinus**	Chestnut oak
Cypripedium acaule	Pink lady's slipper	*Quercus rubra*	Northern red oak
Cytiscus scoparius	Scotch broom	*Quercus shumardii*	Shumard's oak
Dactylis glomerata	Orchard grass	*Quercus stellata*	Post oak
Datura stramonium	Jimsonweed	*Quercus velutina*	Black oak
Daucus carota	Queen Anne's lace	*Ranunculus abortivus*	Littleleaf buttercup
Decumaria barbara	Woodvamp	*Ranunculus arvensis*	Corn buttercup
Desmodium canescens	Hoary ticktrefoil	*Ranunculus bulbosus*	Bulbous buttercup
Desmodium ciliare	Littleleaf tickclover	*Ranunculus hispidus*	Bristly buttercup
Desmodium glabellum	Dillenius' ticktrefoil	*Ranunculus parviflorus*	Smallflower buttercup
Desmodium laevigatum	Smooth tickclover	*Ranunculus recurvatus*	Blisterwort
Desmodium lineatum	Sand ticktrefoil	*Rhododendron calendulaceum*	Flame azalea
Desmodium marilandicum	Smooth ticktrefoil	*Rhododendron canescens*	Piedmont azalea
Desmodium nudiflorum	Nakedflower ticktrefoil	*Rhododendron periclymenoides*	Pink azalea
Desmodium paniculatum	Panicled tickclover	*Rhododendron viscosum*	Swamp azalea
Desmodium rotundifolium	Prostrate ticktrefoil	*Rhus copallina*	Dwarf sumac
Desmodium viridiflorum	Velvetleaf ticktrefoil	*Rhus glabra*	Smooth sumac
Dianthus armeria	Deptford pink	*Rhynchospora glomerata*	Clustered beaksedge
Dichanthelium acuminatum var. acuminatum	Tapered rosette grass	*Rosa* sp.	Rose
Dichanthelium commutatum	Variable panicgrass	*Rosa carolina*	Carolina rose
Dichanthelium dichotomum var. dichotomum	Cypress panicgrass	*Rosa multiflora*	Multiflora rose
Dichanthelium laxiflorum	Openflower rosette grass	*Rosa wichuraiana*	Memorial rose
Dichanthelium scoparium	Velvet panicum	*Rubus argutus*	Sawtooth blackberry

Appendix B. Continued.

Scientific Name	Common Name	Scientific Name	Common Name
Dichanthelium sphaerocarpon	Roundseed panicgrass	*Rubus bifrons*	Himalayan berry
Dichanthelium sphaerocarpon var. isophyllum	Roundseed panicgrass	*Rubus flagellaris*	Northern dewberry
Digitaria cognata var. cognata	Fall witchgrass	*Rubus trivialis*	Southern dewberry
Digitaria ischaemum	Smooth crabgrass	*Rudbeckia hirta*	Black-eyed Susan
Digitaria sanguinalis	Hairy crabgrass	*Rumex acetosella*	Sheep sorrel
Dioscorea	Wild yam	*Rumex crispus*	Curly dock
Dioscorea quaternata	Fourleaf yam	*Rumex hastatulus*	Heartwing sorrel
Dioscorea villosa	Wild yam	*Saccharum alopecuroidum*	Silver plumegrass
Diospyros virginiana	Persimmon	*Saccharum brevibarbe var. contortum*	Bentawn plumegrass
Draba verna	Spring Whitlowgrass	*Sagina decumbens*	Trailing pearlwort
Duchesnea indica	Indian strawberry	*Salix nigra*	Black willow
Elaeagnus angustifolia	Russian-olive	*Salix X pendulina*	Weeping willow
Elaeagnus umbellata	Silverberry	*Salvia lyrata*	Lyreleaf sage
Eleocharis obtusa	Blunt spikerush	*Sambucus nigra* ssp. *canadensis*	Elderberry
Elephantopus carolinianus	Carolina elephantsfoot	*Sanicula canadensis*	Canadian blacksnakeroot
Elephantopus tomentosus	Hairy elephantfoot	*Saponaria officinalis*	Bouncing bet
Eleusine indica	Indian goosegrass	*Sassafras albidum*	Sassafras
Epigaea repens	Trailing arbutus	*Schizachyrium scoparium*	Little bluestem
Eragrostis capillaris	Lace grass	*Scirpus cyperinus*	Bulrush
Eragrostis hirsuta	Bigtop lovegrass	*Scleranthus annuus*	German knotgrass
Eragrostis pilosa	Indian lovegrass	*Scleria oligantha*	Littlehead nutrush
Eragrostis spectabilis	Purple lovegrass	*Scutellaria elliptica*	Hairy skullcap
Erechtites hieraciifolia	Fireweed	*Scutellaria integrifolia*	Helmet flower
Eremochloa ophiuroides	Centipede grass	*Senna obtusifolia*	Sicklepod
Erigeron strigosus	Daisy fleabane	*Setaria parviflora*	Marsh bristlegrass
Erodium cicutarium	Filaree	*Setaria viridis*	Bottle grass
Erythronium americanum	Dogtooth violet	*Sherardia arvensis*	Blue fieldmadder
Euonymus americana	Strawberry bush	*Sida* sp.	Sida
Euonymus fortunei	Climbing euonymus	*Sida spinosa*	Prickly fanpetals
Eupatorium album	White thoroughwort	*Silphium compositum*	Kidneyleaf rosinweed
Eupatorium capillifolium	Dogfennel	*Silphium perfoliatum*	Cup plant
Eupatorium fistulosum	Joe Pye weed	*Sisyrinchium albidum*	White blue-eyed grass
Eupatorium hyssopifolium	Hyssopleaf thoroughwort	*Smilax bona-nox*	Saw greenbrier
Euphorbia corollata	Flowering spurge	*Smilax glauca*	Cat greenbrier
Euphorbia pubentissima	False flowering spurge	*Smilax laurifolia*	Laurel greenbrier
Eurybia macrophylla	Bigleaf aster	*Smilax rotundifolia*	Roundleaf greenbriar
Facelis retusa	Annual trampweed	*Solanum carolinense*	Carolina horsenettle
Fagus grandifolia	American beech	*Solanum ptycanthum**	Eastern black nightshade

Appendix B. Continued.

Scientific Name	Common Name	Scientific Name	Common Name
Ficus carica	Common fig	*Solidago arguta**	Atlantic goldenrod
Fimbristylis autumnalis	Slender fimbry	*Solidago arguta var. caroliniana*	Atlantic goldenrod
Fragaria virginiana	Virginia strawberry	*Solidago canadensis var. scabra*	Canadian goldenrod
Frangula caroliniana	Carolina buckthorn	*Solidago gigantea*	Late goldenrod
Fraxinus sp.	Ash	*Solidago nemoralis*	Gray goldenrod
Fraxinus americana	White ash	*Solidago odora*	Licorice goldenrod
Galium aparine	Bedstraw	*Solidago rugosa*	Wrinkleleaf goldenrod
Galium circaezans	Licorice bedstraw	*Sonchus asper*	Spiny sowthistle
Cruciata pedemontana	Piedmont bedstraw	*Sonchus oleraceus*	Common sow-thistle
Galium pilosum var. puncticulosum	Hairy bedstraw	*Sorghum halepense*	Johnsongrass
Gaylussacia baccata	Black huckleberry	*Spiraea cantoniensis*	Reeves' meadowsweet
Gelsemium sempervirens	Carolina jessamine	*Spiraea X vanhouttei*	Van Houtt's spirea
Gentiana saponaria	Moss gentian	*Stachys latidens*	Broadtooth hedgenettle
Geranium carolinianum	Carolina crane's-bill	*Steinchisma hians*	Gaping grass
Geranium maculatum	Spotted geranium	*Stellaria media*	Common chickweed
Geum canadense	White avens	*Stenanthium gramineum*	Eastern featherbells
Gleditsia triacanthos	Honey locust	*Streptopus lanceolatus var. roseus*	Twisted stalk
Goodyera pubescens	Downy rattlesnake plantain	*Strophostyles* sp.	Fuzzy bean
Halesia carolina	Carolina silverbell	*Stylosanthes biflora*	Endbeak pencilflower
Hedera helix	English ivy	*Styrax americanus*	American snowbell
Helenium amarum	Bitter sneezeweed	*Styrax grandifolius*	Bigleaf snowbell
Helianthus atrorubens	Purpledisk sunflower	*Symphoricarpos orbiculatus*	Indiancurrant coralberry
Helianthus divaricatus	Woodland sunflower	*Symphyotrichum dumosum*	Rice button aster
Helianthus microcephalus	Small woodland sunflower	*Symphyotrichum lateriflorum*	Calico aster
Hemerocallis fulva	Orange daylily	*Symphyotrichum pratense*	Barrens silky aster
Heterotheca subaxillaris	Camphorweed	*Taraxacum officinale*	Dandelion
Hexastylis arifolia	Little brown jug	*Tephrosia spicata*	Spiked hoarypea
Hexastylis heterophylla	Variableleaf heartleaf	*Tephrosia virginiana*	Goat's rue
Hexastylis naniflora	Dwarf-flowered heartleaf	*Thelypteris noveboracensis*	New York fern
Hibiscus syriacus	Rose-of-Sharon	*Thuja* sp.	Arborvitae
Hieracium gronovii	Gronovi's hawkweed	*Tilia americana var. heterophylla*	American basswood
Hieracium venosum	Rattlesnakeweed	*Tipularia discolor*	Crippled cranefly
Houstonia caerulea	Azure bluet	*Toxicodendron pubescens*	Poison oak
Houstonia purpurea	Venus' pride	*Toxicodendron radicans* ssp. *radicans*	Poison ivy
Houstonia pusilla	Tiny bluet	*Toxicodendron vernix*	Poison sumac
Huperzia lucidula	Shining clubmoss	*Trichostema dichotomum*	Forked bluecurls

Appendix B. Continued

Scientific Name	Common Name	Scientific Name	Common Name
Hypericum perforatum	St. John's wort	*Tridens flavus*	Purpletop
Hypericum calycinum	Aaron's beard	*Trifolium* sp.	Clover
Hypericum gentianoides	Orangegrass	*Trifolium arvense*	Rabbitfoot clover
Hypericum hypericoides	St. Andrew's cross	*Trifolium campestre*	Field clover
Hypericum setosum	Hairy St. Johnswort	*Trifolium pratense*	Red clover
Hypochaeris radicata	Openflower rosette grass	*Trifolium repens*	White clover
Hypoxis hirsuta	Eastern yellow star-grass	*Trillium* sp.	Trillium
Ilex glabra	Inkberry	*Triodanis perfoliata*	Clasping Venus'
Ilex opaca	American holly	*Ulmus alata*	Winged elm
Ilex verticillata	Common winterberry	*Ulmus rubra*	Slippery elm
Ipomoea coccinea	Scarlet morningglory	*Uvularia puberula*	Mountain bellwort
Ipomoea hederacea	Ivyleaf morningglory	*Vaccinium arboreum*	Farkleberry
Ipomoea lacunosa	White morninglory	*Vaccinium elliottii*	Elliott's blueberry
Ipomoea pandurata	Man of the earth	*Vaccinium fuscatum*	Black highbush blueberry
Ipomoea purpurea	Common morningglory	*Vaccinium pallidum*	Hillside blueberry
Ipomoea sagittata	Saltmarsh morning-glory	*Vaccinium stamineum*	Deerberry
Iris verna	Dwarf violet iris	*Valerianella locusta*	Lewiston cornsalad
Iris verna var. smalliana	Dwarf violet iris	*Valerianella radiata*	Beaked cornsalad
Itea virginica	Virginia sweetspire	*Verbascum blattaria*	Moth mullein
Juglans nigra	Black walnut	*Verbascum thapsus*	Woolly mullein
Juncus acuminatus	Tapertip rush	*Verbena urticifolia*	White vervain
Juncus effusus	Common rush	*Verbesina occidentalis*	Yellow crownbeard
Juncus tenuis	Path rush	*Veronica arvensis*	Corn speedwell
Juniperus virginiana	Eastern red-cedar	*Veronica hederifolia*	Ivyleaf speedwell
Kalmia latifolia	Mountain laurel	*Veronica peregrina*	Neckweed
Krigia virginica	Virginia dwarfdandelion	*Viburnum dentatum var. lucidum*	Arrowwood
Kummerowia stipulacea	Korean clover	*Viburnum nudum*	Possumhaw
Kummerowia striata	Japanese clover	*Vicia* sp.	Vetch
Lactuca canadensis	Florida blue lettuce	*Vicia sativa* ssp. *nigra*	Common vetch
Lactuca floridana	Florida lettuce	*Vicia tetrasperma*	Sparrow vetch
Lactuca hirsuta	Hairy lettuce	*Vicia villosa* ssp. *varia*	Winter vetch
Lagerstroemia indica	Crape myrtle	*Vinca major*	Greater periwinkle
Lamium amplexicaule	Henbit	*Vinca minor*	Common periwinkle
Lamium purpureum	Purple deadnettle	*Viola affinis*	Sand violet
Laportea canadensis	Canada wood nettle	*Viola arvensis*	European field pansy
Lathyrus hirsutus	Singletary pea	*Viola bicolor*	Johnny-jump-up
Lathyrus latifolius	Everlasting pea	*Viola hastata*	Halberdleaf yellow violet
Leersia virginica	Cut grass	*Viola palmata*	Early blue violet
Lepidium virginicum	Virginia pepperweed	*Viola pedata*	Birdfoot violet
Lespedeza bicolor	Shrubby lespedeza	*Viola x primulifolia*	Primrose violet
Lespedeza cuneata	Chinese lespedeza	*Viola sagittata var. sagittata*	Arrowleaf violet
Lespedeza procumbens	Trailing lespedeza	*Viola sororia*	Common blue violet
Lespedeza repens	Creeping lespedeza	*Viola tricolor*	Jonny-jump-up

Appendix B. Continued

Scientific Name	Common Name	Scientific Name	Common Name
Kummerowia stipulacea	Korean clover	*Viola X primulifolia*	Primrose violet
Lespedeza violacea	Violet lespedeza	*Vitis aestivalis*	Summer grape
Lespedeza virginica	Slender bush clover	*Vitis labrusca*	Fox grape
Leucanthemum vulgare	Oxeye daisy	*Vitis rotundifolia*	Muscadine
Liatris pilosa var. pilosa	Shaggy blazing star	*Vitis vulpina*	Fox grape
Ligustrum spp.	Privet spp.	*Wisteria floribunda*	Japanese wisteria
Ligustrum japonicum	Japanese privet	*Wisteria sinensis*	Chinese wisteria
Ligustrum sinense	Chinese privet	*Woodwardia areolata*	Netted chainfern
Ligustrum vulgare	European privet	*Xanthorhiza simplicissima*	Yellowroot
Lilium superbum	Turk's-cap lily	*Yucca filamentosa*	Adam's needle

Appendix C. Community types in COWP outlined from US National Vegetation Classification by Jordan and Madden (2008) according to Grossman et al. (1998).

Vegetation Type	**CEGL**	**Ecological Group**	**Total Area**	**Mean Patch Size**	**Number Patches**	**Mean *S* (total plots)**
			----ha-----			
Shortleaf Pine Early Successional Forest	6327	Semi-natural Wooded Uplands	50 (14%)	1	75	53 (3)
Successional Loblolly Pine Forest	6011	Semi-natural Wooded Uplands	25 (7%)	1	30	71 (2)
Successional Tuliptree – Hardwood Forest	7221	Semi-natural Wooded Uplands	11 (3%)	<1	19	73 (1)
Southern Piedmont Mesic Subacid Oak – Hickory Forest[1]	6227	Appalachian Highlands Mesic Acid Hardwood Forest	1 (<1%)	1	1	63 (1)
Interior Southern Red Oak – White Oak Forest	7244	Appalachian Highlands Dry-mesic Oak Forests and Woodlands	48 (14%)	1	57	40 (5)
Successional Water Oak Forest	4638	Semi-natural Wooded Uplands	<1 (<1%)	<1	1	6 (1)
Successional Sweetgum Floodplain Forest	7330	Semi-natural Riparian and Willow Forests	2 (<1%)	<1	3	76 (1)
Successional Sweetgum Forest	7216	Semi-natural Wooded Uplands	47 (13%)	1	48	--
Piedmont Granitic White Oak – Black Oak Woodland	3722	Appalachian Highlands Dry-mesic Oak Forests and Woodlands	1 (<1%)	1	1	72 (1)
Golden Bamboo Shrubland	8560	Exotic Species-Dominated Southeastern Wooded Uplands	1 (<1%)	<1	3	--
Floodplain Canebrake[2]	3836	Interior Highlands Riverfront and Levee Forests and Shrublands / Southeastern Coastal Plain Floodplain Shrublands	1 (<1%)	1	1	--
Blackberry – Greenbrier Successional Shrubland Thicket	4732	Semi-natural Wooded Uplands	6 (2%)	<1	13	57 (3)
Broomsedge Old Field	4044	Semi-natural Upland Herbaceous Vegetation	38 (11%)	1	34	42 (1)
Cultivated Meadow	4048	Exotic Species-Dominated Herbaceous Upland Vegetation	59 (17%)	1	75	--
Other/Human Influence	--	--	21 (6%)	<1	36	--
Upper Southeast Small Stream Sweetgum – Tuliptree Forest	4418	Semi-natural Floodplain Forest	37 (11%)	2	18	35 (2)
Planted Pine	--	--	1 (<1%)	<1	5	--
Total/Mean	--	--	349	1	420	--

[1] - The single patch of Southern Piedmont Mesic Subacid Oak – Hickory Forest at COWP 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 dominant modifier within a Sweetgum Successional Floodplain Forest.

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