National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment for Kings Mountain National Military Park

Natural Resource Report NPS/ KIMO/NRR—2012/522

ON THE COVER
U.S. Monument on Battleground Ridge in Kings Mountain National Military Park
Photograph by: L. Worsham

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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.

Acronyms and Abbreviations:

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

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

Executive Summary

This report provides a comprehensive assessment of the state of natural resources in Kings Mountain National Military Park (KIMO). 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 KIMO, this report can also play a role in directing future efforts for monitoring. This assessment focuses on vital signs outlined by the Cumberland/Piedmont Network, and on attributes for which recent I&M data collections have been conducted. Assessed attributes are roughly organized into broad groups of resources as follows: air, water, animal communities, plant communities, and landscape dynamics.

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

Kings Mountain National Military Park represents a portion of forested land amidst a larger complex of protected area that includes Kings Mountain State Park to the east and Crowders Mountain State Park to the north. The NPS unit is located on the southern part of the Kings Mountain Range, a mini-range peaking at 500m within the Piedmont of North Carolina and South Carolina. At KIMO, deciduous/mixed forest comprises about 85% of the area, while coniferous/successional land comprises 11%. There are over 29 km of streams throughout the park, most of them beginning within it, and 74 wetlands totaling almost 2 ha. Almost 600 plants have been documented at KIMO, of which about 10% are exotic. Twenty-two plant species at KIMO are considered sensitive with either a state or global listing status. Recent inventory efforts for vertebrate species have reported 27 fish, 118 seasonal birds, 20 mammals, and 42 species of reptiles and amphibians from the park. No state or federally listed threatened or endangered vertebrate species have been reported from the park.

Several broad classes of potential threats and stressors to natural resources can be identified for KIMO. 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 as good, two (14%) were ranked as fair, and five (36%) 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.

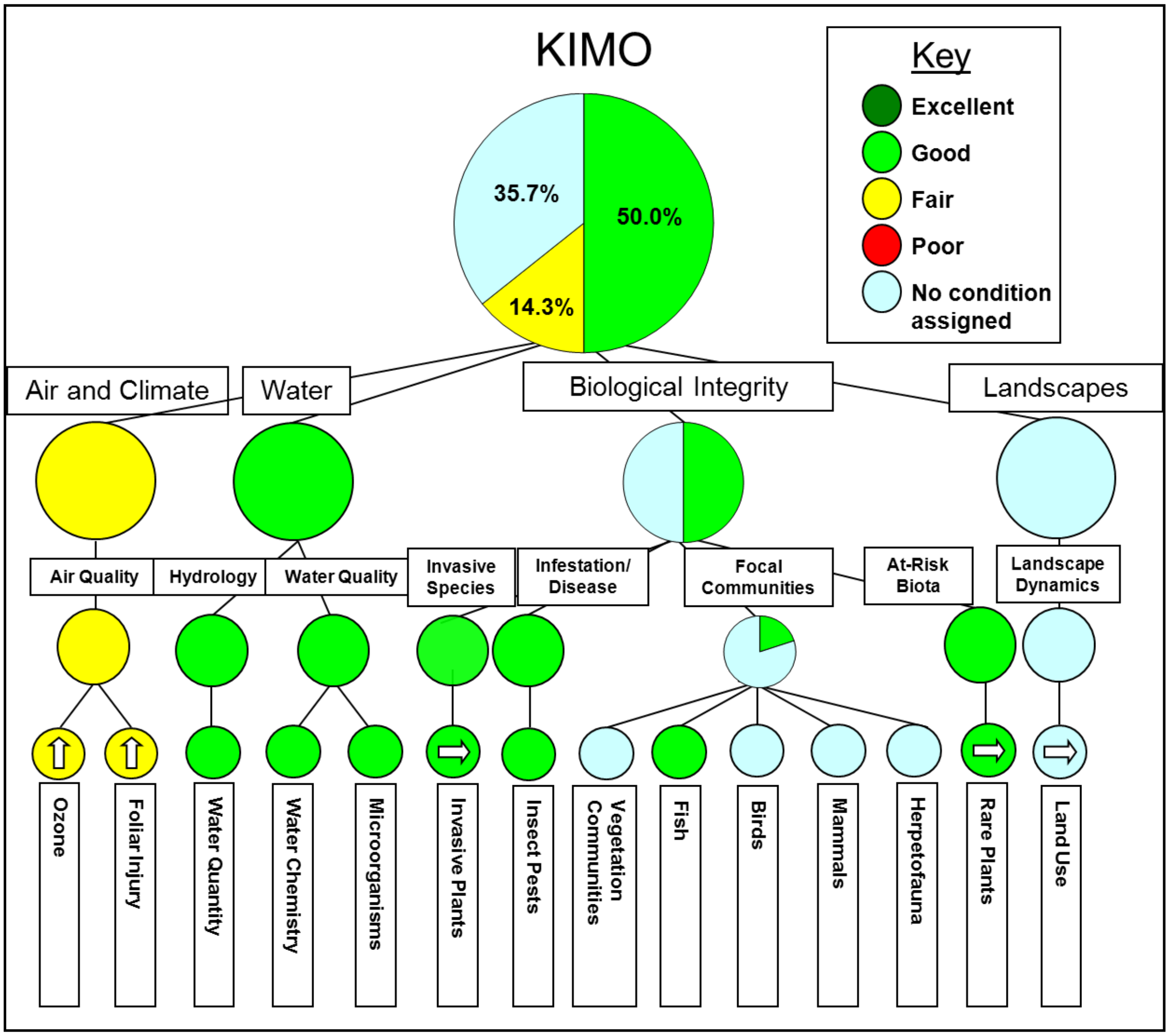


Figure 1. Summary of ecological condition status for Kings Mountain National Military Park. Fourteen attributes from four broad categories were assessed. Numbers within segments of the park-wide chart represent the percentage of attributes (out of fourteen) ranked as that status.

Purpose

The objective of this Natural Resource Condition Assessment (NRCA) is to analyze existing data to provide an assessment of the current conditions of key ecological attributes at Kings Mountain National Military Park (KIMO). 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). Kings Mountain National Military Park 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 KIMO staff. Methods used to assess the condition of each attribute are described in the appropriate sections of this report. When appropriate, we performed statistical comparisons using $a = 0.05$. The condition of each attribute was graphically represented with a colored circle where the color indicated the condition on a four-tiered scoring system of excellent (dark green), good (light green), fair (yellow), or poor (red). For several attributes, a condition was not assigned because available data were insufficient or because we lacked a defensible ranking method. These attributes are indicated with a blue circle.

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 data quality graphics used in this report.

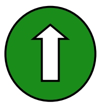
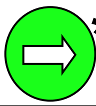
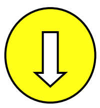
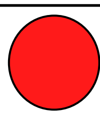
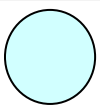
Table 1. Ecological monitoring framework of essential natural resource attributes that were assessed at Kings Mountain National Military Park for this report.

Ecological Monitoring Framework—KIMO

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	Forest/Woodland 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	Rare Plants	Georgia aster, Eastern Turkeybeard
Landscape	Landscape Dynamics	Land Cover and Land Use Change	Changes within/without KIMO

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:		✓	✓ **3 of 3: Good**	✓	Condition: Excellent Trend: Improving Data Quality: Good
Example 2:	 *		**1 of 3: Poor**	✓	Condition: Good Trend: Stable Data Quality: Poor
Example 3:		✓	✓ **2 of 3: Fair**		Condition: Fair Trend: Declining Data Quality: Fair
Example 4:			**1 of 3: Poor**	✓	Condition: Poor Trend: None assigned Data Quality: Poor
Example 5:		✓	✓ **3 of 3: Good**	✓	Condition: None assigned Trend: None assigned Data Quality: 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 KIMO (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 at Kings Mountain National Military Park.

Attribute	Assessment Measure	Data Sources	Data Description	Data Period
Ozone	4th highest maximum 8-hour average ozone concentration; 2nd highest 1-hr ozone concentration	Portable Ozone Monitoring System (POMS) in KIMO	Hourly measurements of ozone concentration within KIMO	Three week period June/July 2005
	National IDW 4th highest max 8-hr mean concentration	NPS Air Resources Division (ARD) in collaboration with the University of Denver	Model-interpolated ozone exposure maps using data from general region; 2008 APPR; 2005 – 2008 GPMP Reports	1995-1999, 1999-2003, & 2003-2007 models
	Foliar injury risk predictions (3-metric index)	NPS report for the Cumberland Piedmont Monitoring Network; Kohut (2007)	Kriged predictions extracted from US-wide ozone models; Foliar Injury Risk Assessments	1995-2003
Surface Water Dynamics	Flow (l/sec)	NPStoret data for KIMO; NPS Water Quality Monitoring Report for the CUPN (Meiman 2005/2007)	Raw water quality monitoring data from bi-monthly sampling at six stations within KIMO	2003-2007
Water Chemistry	Temperature (max, mean), pH (mean), Specific conductance (mean), DO (mean, min), ANC (mean)	NPStoret data for KIMO; NPS Water Quality Monitoring Report for the CUPN (Meiman 2005/2007)	Raw water quality monitoring data from bi-monthly sampling at six stations within KIMO; Summarized water quality data for KIMO	2003-2007
Microorganisms	*E. coli* (mean colonies/100mL); fecal coliforms (mean colonies/100mL)	NPStoret data for KIMO; NPS Water Quality Monitoring Report for the CUPN (Meiman 2005/2007)	Raw water quality monitoring data from bi-monthly sampling at six stations within KIMO; Summarized water quality data for KIMO	2002-2007
Invasive/Exotic Plants	Presence, relative predominance, and invasibility of exotics (I-rank)	White and Govus (2005)	Survey and discussion of KIMO vegetation	2004
Insect Pests	Presence or absence of gypsy moths	US Forest Service	Report on catches of gypsy moths on federal lands, including KIMO lands.	2007-2008
	Risk of infection by southern pine beetle; ips beetle	US Forest Service, Forest Health Technology Enterprise Team	Southern pine beetle hazard maps for South Carolina	2009

Table 3. Data sources used to assess ecological condition of natural resources at Kings Mountain National Military Park (continued).

Attribute	Assessment Measure	Data Sources	Data Description	Data Period
Vegetation Communities	Presence of globally- ranked communities	White and Govus (2005) Center for Remote Sensing and Mapping Science at UGA (Jordan and Madden, 2008)	Spatially explicit description of KIMO vegetation communities	2002
	Wetlands	National Park Service, Tennessee Technological University (Roberts and Morgan, 2006)	Inventory and classification of wetlands for KIMO	2005
	Vegetation Communities	White and Govus (2005)	Survey and discussion of KIMO vegetation	2004
Fish Communities	North Carolina fish IBI score	National Park Service, survey of KIMO fishes (Rogers 2003)	Final report from electroshock sampling	2001-2003
		National Park Service, SCDNR survey (Scott 2002)	Final report, summarized data from electroshock sampling,	2006
Bird Communities	O'Connell Bird Community Index (BCI) score	National Park Service, survey of KIMO birds (Rogers 2003)	Final report and summarized data for point counts	2004-2006
Mammal Communities		National Park Service, mammal survey (Fields 2005)	Final report, summarized data, for non-volant mammal trapping and sightings; includes incidental reports by NPS staff	2004-2005
		National Park Service, USFS bat survey (Loeb 2007)	Final report and raw data from mist netting and acoustic sampling	2005-2007
Herpetofaunal Communities		National Park Service, herpetofaunal survey (Thomas 2002)	Final report, raw capture data from unconstrained searches, dip nets, and coverboards	2001-2002
		National Park Service, herpetofaunal survey (Reed and Gibbons 2005)	Final report, museum specimen file from unconstrained searches and coverboards	2003-2005
Rare Plants	Presence of Georgia aster; eastern turkeybeard	National Park Service, NatureServe database; NPSpecies; USDA database	Species occurrence database for KIMO Nationwide plant database	2004; 2009
Landcover and Use	Land use change	Multi-Resolution Land Characteristics Consortium	Retrofitted landcover change maps to compare 1992 to 2001 NLCD layers	1992-2001
		National Land Cover Dataset	Nationwide landcover datasets	1992-2001
		CRMS	Land cover dataset	2002-2003

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

Park Resources and Introduction

Park Location and Significance

Kings Mountain National Military Park (KIMO) was created to preserve the location of an important battle which proved to be a turning point in the Revolutionary War. Kings Mountain NMP is located about 48 km east of Cowpens NB and straddles the boundary between Cherokee and York counties in South Carolina (Figure 2). Gastonia, NC, is located about 16 km to the northeast, whereas the town of Kings Mountain, NC is located about 8 km to the north. The park is less than 1 km from the North Carolina border and comprises 1,596 ha abutting the Kings Mountain State Park in South Carolina—together the national and state parks cover 4,383 ha. State highway 216 bisects Kings Mountain NMP, as does state highway 11-86, and I-85 is situated less than 3 km NW of the park.

Park Objectives

Kings Mountain National Military Park was established in March 1931 to commemorate the Battle of Kings Mountain. The main management objective of the park is the restoration and maintenance of the battlefield as it existed during the 18th century. The open woodlands during this time were often grazed by cattle, as observed by J.B. Landrum (1897): "the woodlands in the upper regions of South Carolina were carpeted with grass," and "the trees were so large and stood wide apart that a deer or buffalo could be seen at a long distance." Kings Mountain NMP employs prescribed burning to help restore and maintain this historic landscape. In addition, the park supports wildlife habitat and helps maintain high vegetation diversity by protecting a large portion of the land from development or other forms of encroachment. Park botanists predicted an increase of at least 100 vascular plant species in response to the implementation of a prescribed burning regime at Kings Mountain NMP (NPS 2008b).

As part of the Centennial Initiative (NPS 2007), Kings Mountain NMP also began rehabilitation of the 2.4 km battlefield loop trail to eliminate steep slopes that may inhibit accessibility to wheelchairs or other visitors. In addition, park staff recently completed construction of the Ridgeline Trail, which now runs 14 km between Crowder's Mountain State Park in NC and Kings Mountain State Park. Lastly, in partnership with the Overmountain Victory Trail Association and the Cowpens National Battlefield, the park staff plans to assist with the completion of the Overmountain Victory National Historic Trail, which stretches 48 km between Kings Mountain NMP and Cowpens NB.

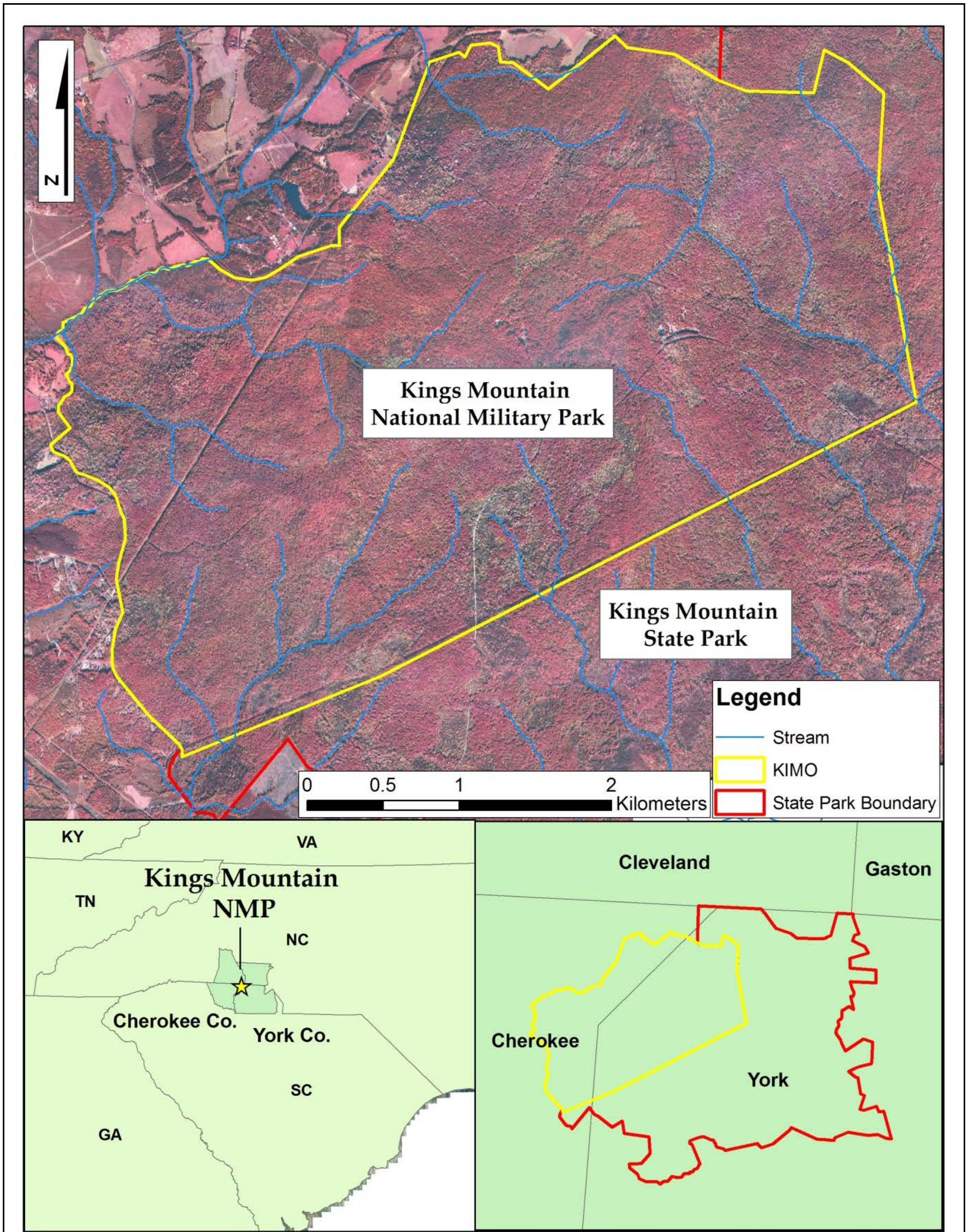


Figure 2. Kings Mountain National Military Park overlaps Cherokee and York Counties in South Carolina.

Climate, Geology, and Soils

Kings Mountain NMP is located in the temperate region of the South Carolina piedmont. The average annual temperature is 14.8 degrees Celsius (Cº), with a mean annual maximum and minimum temperature of 21.9 and 7.6 Cº, respectively. Annual precipitation averages 120 cm (47 inches), while historically the wettest month is March.

The park is in the southern extent of the Kings Mountain Range, which begins near Bessemer City, North Carolina. The range is part of the Battleground Formation (Neoproterozoic), located inside the Kings Mountain sequence of the Carolina Terrane. Much of this area is composed of metamorphosed pyroclastic rock containing lithic and plagioclase clasts. The park overlies three main striations of mottled phyllitic and plagioclase metatuff, as well as quartz phyllite and schist. These main striations are interlayered with volcanic metaconglomerate and manganiferous rocks (Horton 2006).

Kings Mountain is dominated by the Tatum-Nason-Manteo soil association. The predominant soil series within the park is Manteo channery soils (Fine, mixed, semiactive, thermic Typic Hapludults) (53%), which contain flat fragments of sericitic schist with thin and firm clayey subsoils. This series is found mostly on steep slopes on mountains and on moderately steep slopes adjacent to streams. The Tatum series (Fine, mixed, semiactive, thermic Typic Hapludults) are deep/well-drained soils that cover 567 ha or 35% of the park. These soils typically occupy ridges, contain red silty clay subsoils, and are characterized by moderate permeability and strong acidity, usually with a high proportion of rock fragments. Nason soils (Fine, mixed, semiactive, thermic Typic Hapludults) are deep/well-drained soils with silty clay subsoils occupying 12% of the park, and are usually found in upland areas on shallow to very steep slopes.

Hydrology

Kings Mountain NMP falls entirely within the Upper Broad drainage hydrologic cataloging unit (HUC 03050105), generally considered the watershed-level, which in turn is within the Santee accounting unit (HUC 030501; Figure 3; USGS 2009). The accounting unit is a geographic sub-region or portion thereof. The CUPN Monitoring Plan classifies Kings Mountain NMP as a Category Two park with respect to its water resources, explaining that while they are important as a park feature, these resources were not significant to the enabling legislation of the park, and have not identified any threatened or endangered species (Meiman 2005). Several streams are located within the boundary of the park, overall covering a distance of 29 km. These include the Long Branch tributary of the Broad River on the east side of the park, as well as several other tributaries to Kings Creek on the west side.

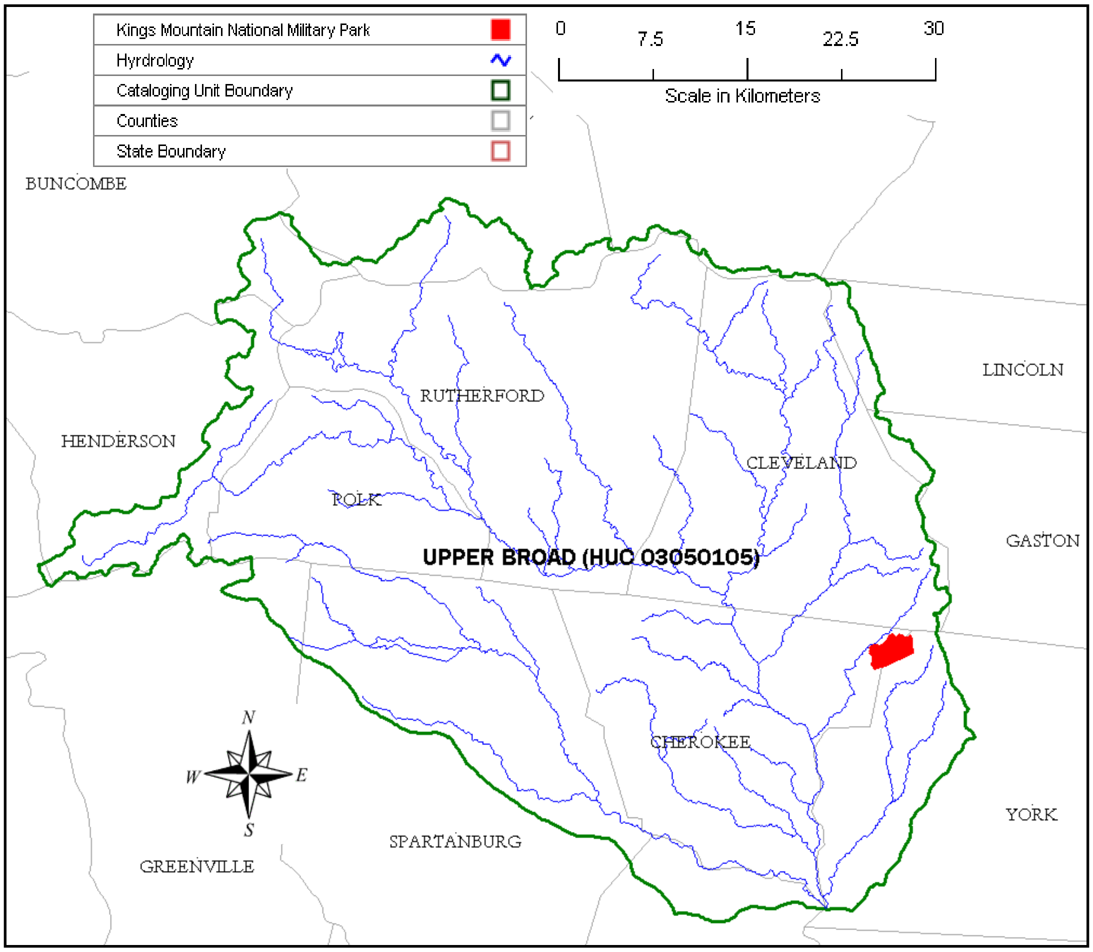


Figure 3. Kings Mountain National Military Park is located in the Upper Broad hydrographic cataloging unit (HUC 03050105).

History and Park Significance

Established in 1931, Kings Mountain NMP is the largest Revolutionary War Military Park administered by the National Park Service   The Battle of Kings Mountain took place in October 1780 and represented an important turning point during the Revolutionary War, as it was the first major Patriot victory after the May 1780 British invasion of Charleston, SC. Other than Major Patrick Ferguson, a British officer who led the colonial Loyalists, the battle was fought entirely between the American Patriot militia and the American Loyalist militia allied with Great Britain. The Patriot militiamen, also known as the Overmountain men, were mainly from west of the Blue Ridge Mountains and mounted a response of approximately 1,000 men to confront Ferguson and his militia. Ferguson had previously threatened to “march his army over the mountains, hang their leaders, and lay their country waste with fire and sword” if the rebels continued their refusal to take an oath of loyalty to the Crown (NPS 2008b).

Today, KIMO contains some of the most well-preserved roads and trails from the Colonial Era and also has maintained the route followed by soldiers leading up to the Battle of Kings Mountain. These trails are part of the Overmountain Victory Trail, which extends south from Virginia, through Cowpens NB to the west, and finally to its terminus at KIMO. The trail retraces the route the American Patriots took as they followed and battled the British throughTN, NC, SC, and VA (NPS 2008b).

Natural Resources and NPS Vital Signs

Despite its primary importance as a historical park, KIMO contains significant natural resources that deserve protection and management attention. The natural landscape of Kings Mountain played a crucial role in shaping the nature of the battle, and management in the park is focused on maintaining and restoring the 18th century battle – period landscape. J. Logan offers the following description of the region: "as late as 1775, the woodlands, carpeted with grass, and the wild pea-vine, growing as high as a horse's back, and wild flowers of every hue…" (1859). Currently, about 1,275 ha, or approximately 80% of the park, consists of deciduous and mixed upland forest, whereas the remainder is mainly planted pine (SCDNR 2002). In 2001-2002, NatureServe established a sampling design for inventory and monitoring (I&M) activities within the CUPN, that included 21 sampling points spaced on a 0.87 km^2 grid for KIMO (Figure 4). In addition to outlining vegetation in need of restoration and re-establishment, these surveys also identified portions of globally significant (G2/G3) xeric hardwood forest at KIMO that represent important conservation goals (White and Govus 2004). Along with the adjacent Kings Mountain State Park and Crowders Mountain State Park in North Carolina, a total of about 6,070 ha are protected to maintain these important areas.

Restoration and conservation efforts are also important to specific plant species. Concomitant with the preservation of these unique hardwood communities are plans to identify invasive exotic plants in the park unit with the objective of controlling these species and reintroducing native ones (NPS 2007). Preservation efforts are also essential for several species of concern found at KIMO, including the Georgia aster (*Symphyotrichum georgianum*), which is listed as threatened in North Carolina, and is found only in three counties in South Carolina (USDA 2009). Eastern turkeybeard (*Xerophyllum asphodeloides*), a native wildflower listed as threatened in Tennessee and rare in Georgia, is also present within the park. Sunfacing coneflower (*Rudbeckia heliopsidis*), identified in only three counties in South Carolina and at KIMO, is an S1 species that generally is dependent on fire or disturbed areas (NatureServe 2009). Ashleaf goldbanner (*Thermopsis fraxinifolia*), a G3? species and S2-ranked in both Georgia and North Carolina (not ranked in South Carolina), is generally regarded as a rare plant (NatureServe 2009; Govus, pers. comm.).

Other inventory and monitoring activities at KIMO have shown its importance as a protected habitat for vertebrate species. The numerous small streams in the park, of which most are headwaters, support a diverse ichthyofauna and represent an example of protected headwater fish assemblages that is unusual for the region. The mature mixed hardwood forest community at KIMO protects a number of bird species requiring undisturbed interior forest habitat. Recent inventories have reported 20 species of mammals and, 42 species of reptiles and amphibians in KIMO.

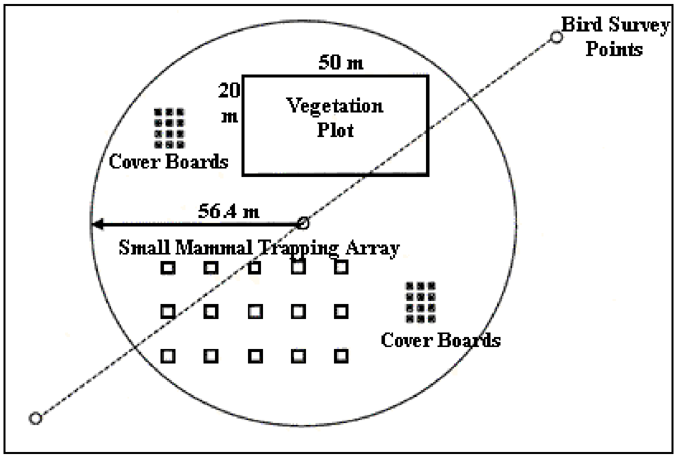


Figure 4. Idealized plot schematic for each of 21 NatureServe sampling points established at Kings Mountain NMP in 2001 (Nichols et al. 2000).

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 2006a).

Monitoring

According to the CUPN monitoring plan, ozone monitoring stations will alternate among parks on six year rotations, with each park collecting half an ozone season at a time, which is roughly April through October (Jernigan et al. 2009). Formerly, there were two weather and climate monitoring stations located within the boundary of KIMO—one from the Portable Ozone Monitoring System network (POMS), and one from the Remote Automated Weather Station (RAWS) network. The POMS has since been removed for monitoring use at other network locations. There are multiple weather monitoring stations located near the park including: ten NWS Cooperative Observer Program Stations (COOP), two Citizen Weather Observer Program Stations (CWOP), two NWS/FAA Surface Airways Observation Network Stations (SAO), and one Weather For Your Network Station (WX4U), though none of these stations collect ozone measurements.

At KIMO, the POMS station on Reservoir Hill recorded hourly ozone concentrations from 5/26/2005 to 6/22/2005. Consequently, the POMS station does not meet the EPA standard for regulatory monitoring of a 3-year average, though the results from this station are still useful as a comparison to the EPA baseline. During this period the 4^{th} highest daily maximum 8-hour average ozone concentration was 0.064 ppm, and no day exceeded the 0.075 ppm reference during an 8-hr average (Figure 5). The overall daily average ozone concentration was 0.037 ppm.

Another measure of ozone concentration used to give an idea of its variability is the 2^{nd} highest 1-hr concentration. The EPA stipulated a limit of 0.120 ppm for 1-hr ozone concentrations in

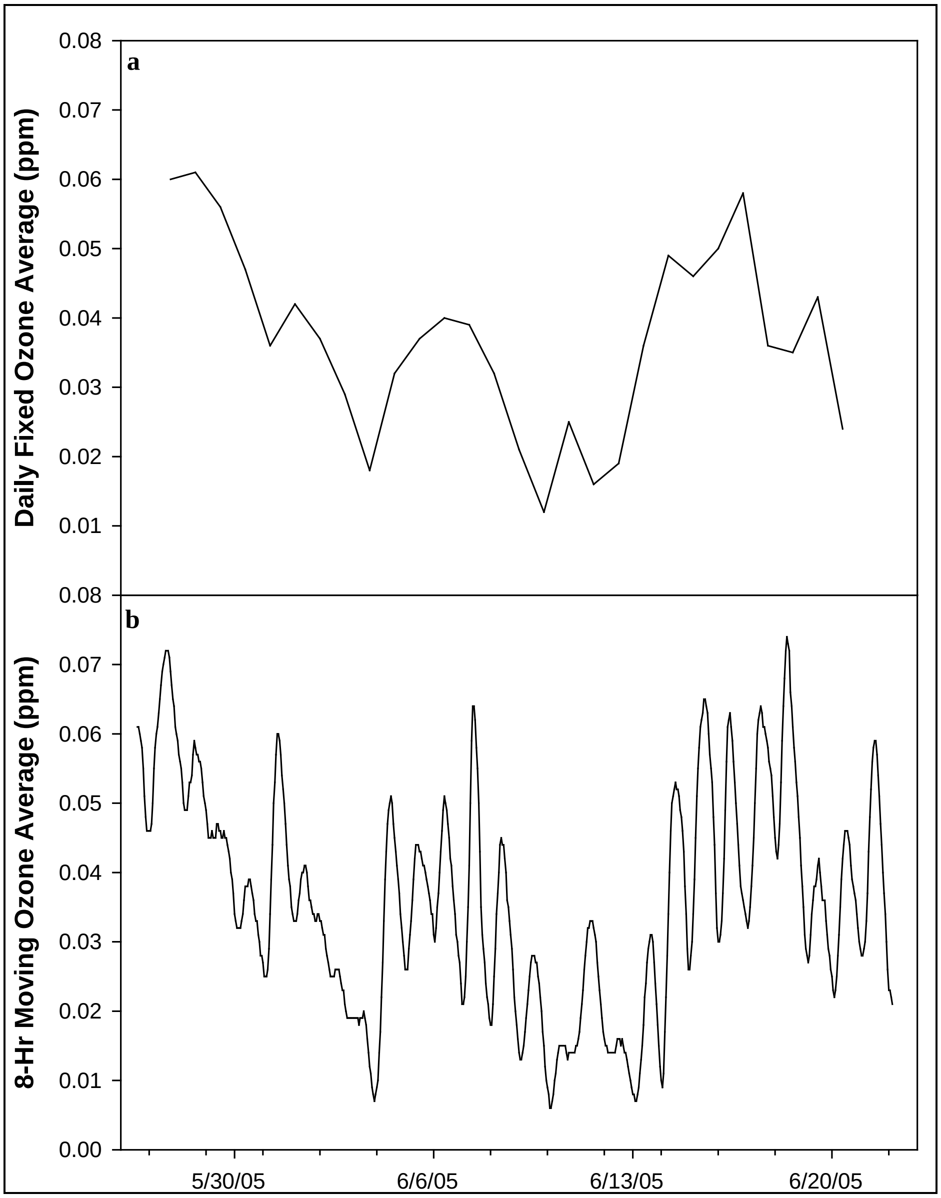


Figure 5. Daily (a) and 8-hr (b) mean ozone concentrations collected Spring 2005 from the POMS at Reservoir Hill in KIMO.

2005, but this standard was revoked in 2005. At KIMO, the highest 1-hr concentration during the monitoring period was 0.089 ppm. Although below the old threshold, the difference between this metric and the 4th Hi Max 8-hr metric suggests concentrations are somewhat variable and may therefore benefit from continued monitoring.

One of the most consistent sources of data for ozone concentrations at KIMO are maps produced by the NPS Air Resources Division (ARD) for several air quality variables. These maps interpolate data from surrounding stations in the EPA Clean Air Status and Trends Network (CASTNET) and report them over 5-yr averages for individual park units. At KIMO, interpolated maps predicted 0.090 ppm at KIMO as the 4th Hi Max 8-hr ozone concentration for the period from 1995-1999 (Figure 6), with an overall predicted average of 0.033-0.036 ppm.

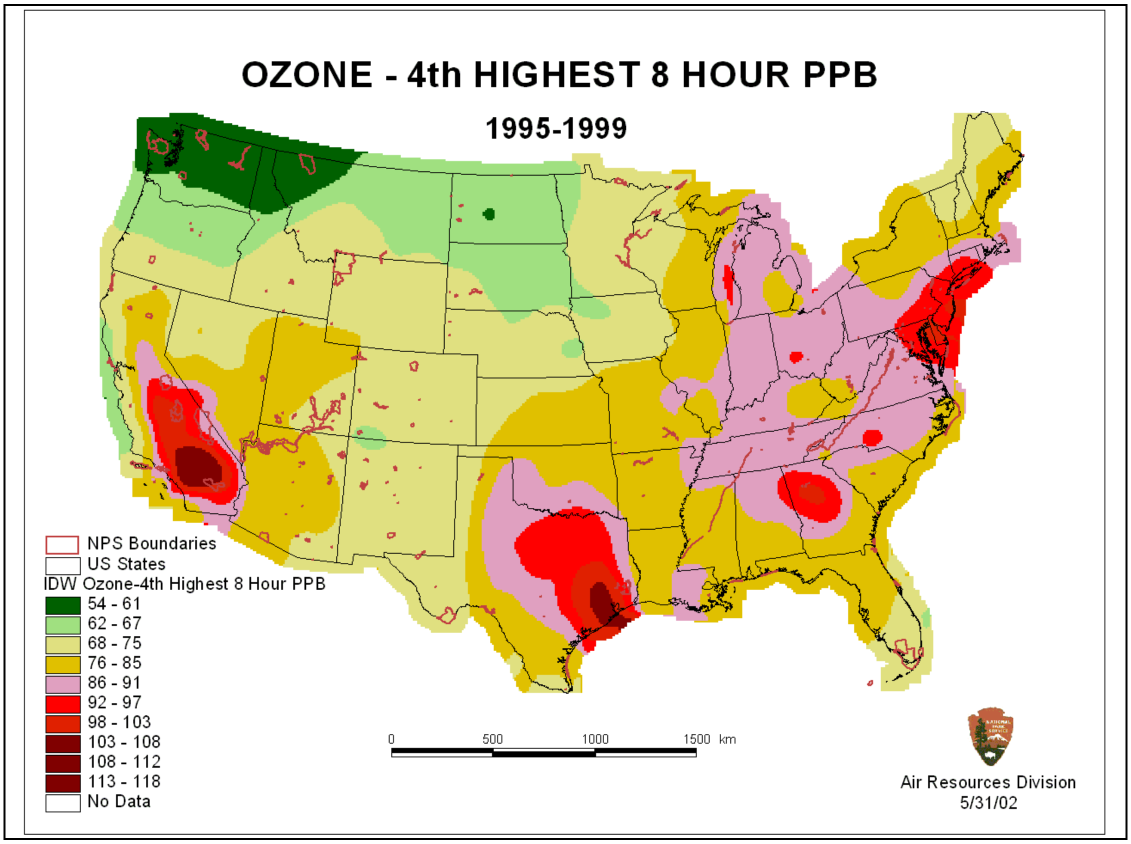


Figure 6. 4th Highest 8-Hour Ozone Concentration IDW predictions depicting KIMO in the region of 0.086-0.091 ppm. [Source: National Park Service Air Resources Division. 2002.]

Predictions over the period 1999-2003 yielded a 4th Hi Max 8-hr concentration 0.088 ppm with a mean of 0.033 ppm. For the period 2001-2005, this prediction dropped to 0.083 ppm with a mean concentration of 0.314 ppm. The latest prediction for the period 2003-2007 was 0.079 ppm, though no overall mean was available. When compared with the 2005 onsite monitoring, it appears that these concentrations might be slightly decreasing but overestimated (NPS 2009). However, it is difficult to compare these two values, because while the interpolations are intended for the entire ozone season (April – October), the monitoring data only represent a brief three-week period, and may not include elevated values expected from a longer dataset.

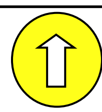
Of the four interpolation periods provided by the NPS ARD, all of them would represent NAAQS violations as 3-yr means under the new 2008 attainment standard. In other words, assuming the accuracy of interpolations at KIMO made by the ARD, KIMO would be in violation of the NAAQS guidelines after 2007 without reductions in ozone concentrations. However, actual measurements, and not estimates, would be required to make this determination.

Summary

Ozone concentrations at nearby Cowpens NB (COWP) have significantly decreased during the period 1998-2007. Because nitrogen oxides (NO_x) are an essential ingredient for the production of ground-level ozone, the introduction of nationwide cap-and-trade programs during the mid-1990s to reduce these pollutants likely played a role in the ozone reduction observed throughout the region and at COWP (EPA 2005). Although data are insufficient to test for genuine ozone reductions at KIMO, because the parks are so close together (~50 km), this mechanism for reductions at COWP might also help explain the lower maximum and average concentrations at KIMO in 2005 compared to ARD estimates for the prior 10 years. As a result, the overall condition for ozone appears to be improving, though the quality of data supporting this assessment at the park unit itself is lacking, because it is based mainly on the interpolated predictions by the ARD. Consequently, the spatial data criterion was not met. Data collected directly from the POMS on Reservoir Hill, even if only during the high-ozone summer months, would greatly improve the ability to detect changes in this network vital sign for KIMO.

Due to the elevated ARD predictions at KIMO that would exceed current NAAQS levels (though no data is available after 2007) and occasional short-term exceedances, the ozone condition status at KIMO is assigned a condition of "fair" (Table 4). Due to consistent decreases in the 4th Hi Max 8-hr metric estimated by the ARD from 1995-2007, as well as an even lower 4th Hi Max 8-hr from the three week monitoring dataset in 2005, the condition is assigned a trend of "improving." Ideally, continued data collection from the POMS on Reservoir Hill, even if only during the high-ozone summer months, would greatly improve the monitoring accuracy of this network vital sign.

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

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

Foliar Injury
In addition to monitoring ozone concentrations from the perspective of human health, ozone has been linked to deleterious growth and physiological effects in multiple plant species (Ollinger et al. 1997; Lefohn and Runeckles 1987). The NPS ARD also developed interpolated foliar injury maps to predict potential harm to vegetation in each of the NPS units. In a 2004 assessment of foliar injury for all the CUPN park units, KIMO received an overall risk rating of high (NPS 2004). Like the interpolated values for ozone concentration, foliar injury metrics for KIMO are not direct measurements, but are instead kriged predictions extracted from ozone models for the entire US based on EPA CASTNET data. These metrics are available as yearly predictions from 1995-1999 as part of a 2004 foliar injury assessment report for the CUPN, though predictions are only available as an average over the periods 1999-2003 and 2001-2005 (Table 5).

Injury Metrics
To assess the overall foliar injury risk, the ARD uses three biological indices with injury thresholds based on ozone concentrations for a representative group of ozone-susceptible plant species (NPS 2004). The first metric Sum06, measured in ppm-hrs, which quantifies the

cumulative hourly sum of ozone concentrations ≥ 0.060 ppm between 8 AM and 8 PM over a moving 90-day period. This maximum usually occurs during the summer months. The NPS ARD classifies 8 cumulative ppm-hours as the threshold for foliar injury, with the potential for growth reduction starting at 10 cumulative ppm-hr (NPS 2004). At KIMO, Sum06 prediction values averaged 30 ppm-hrs for both 1995-1999 and 1999-2003, and 24 ppm-hrs for 2001-2005, all of which are well above the threshold for growth reduction and therefore represent a high foliar injury risk.

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 for the same period (LeFohn et al. 1997). For the hourly sum, this index weights the values using a sigmoidal function according to the equation

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

where W_i is the weighting factor for concentration C_i in ppm, and M and A are constants (M = 4403 ppm and A = 126 ppm). The constant A represents the ozone concentration of maximum weighting, and lends itself to the naming of the index. By using this index, higher ozone concentrations are weighted disproportionately greater since they present more of a threat for foliar injury (LeFohn & Runeckles 1987). For W126, highly-sensitive species are affected beginning at 5.9 cumulative ppm-hr, and moderately sensitive at 23.8 ppm-hr. At KIMO, this predicted metric falls between the threshold affecting moderately and marginally sensitive species for all of the predicted time periods (Table 5), and therefore implies a moderate risk for foliar injury.

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

KIMO Ozone Foliar Injury Indices					
	Sum06	W126	N60	N80	N100
	-----ppm-hrs-----		-------hrs-------		
1995	24	35.6	646	118	16
1996	27	33.8	607	98	10
1997	30	40.4	728	122	12
1998	37	51.6	891	220	32
1999	34	47.8	829	189	28
1995-1999 Mean	**30**	**41.8**	**740**	**149**	**20**
1999-2003 Mean	**30**	**40.8**	**--**	**--**	**16**
1995-2003 Mean	**30**	**41.3**	**--**	**--**	**18**
2001-2005 Mean	**24**	**33.6**	**--**	**--**	**10**

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

Sum06 (ppm-hr): 8-10 (low), 10-15 (mid), 1+ (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)

Finally, a series of three N-value indices have been developed that correspond to the number of exposure hours that exceed each 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 (NPS 2004). The N100 metric is the most commonly used, especially for later air quality summaries by the ARD, and like the W126 metric, it is separated into three categories according to plant sensitivity: highly sensitive plants are those affected by ozone levels exceeding six cumulative ppm-hr, moderately sensitive plants are affected at levels > 51 ppm-hr, and marginally sensitive plants are affected at level > 135 ppm-hr. Overall, the N100 metric showed minimal risk for foliar injury, whereby average predicted indices during both monitoring periods fell into the region affecting only highly sensitive species (Table 5).

Sensitive Species

The NPS ARD has also developed a list of ozone sensitive plant species, defined as species that "exhibit foliar injury at or near ambient ozone concentrations in fumigation chambers and/or are species for which ozone foliar symptoms…have been documented." From this list, a subset of bioindicator species was developed, defined as sensitive species that best serve as indicators of ozone injury, due to easy identification of both the species and injury symptoms (NPS 2003). This list was cross-referenced with the current plant list on NPSpecies to identify ozone-sensitive species at each park unit (Table 6).

Table 6. Twenty-five species present at KIMO were identified as sensitive to ozone exposure (NPS 2003).

Species		Family
Tree-of-heaven	*Ailanthus altissima*	Simaroubaceae
Groundnut	*Apios americana*	Fabaceae
Indianhemp	*Apocynum cannabinum*	Apocynaceae
Eastern redbud	*Cercis canadensis*	Fabaceae
American hazelnut	*Corylus americana*	Betulaceae
White ash	*Fraxinus americana*	Oleaceae
Green ash	*Fraxinus pennsylvanica*	Oleaceae
Black huckleberry	*Gaylussacia baccata*	Ericaceae
Sweetgum	*Liquidambar styraciflua*	Hamamelidaceae
Tulip-poplar	*Liriodendron tulipifera*	Magnoliaceae
Maleberry	*Lyonis ligustrina*	Ericaceae
Virginia creeper	*Parthenocissus quinquefolia*	Vitaceae
Loblolly pine	*Pinus taeda*	Pinaceae
Virginia pine	*Pinus virginiana*	Pinaceae
Sycamore	*Platanus occidentalis*	Platanaceae
Black cherry	*Prunus serotina*	Rosaceae
Winged sumac	*Rhus copallinum*	Anacardiaceae
Black locust	*Robinia pseudoacacia*	Fabaceae
Sand blackberry	*Rubus cuneifolius*	Rosaceae
Cutleaf coneflower	*Rudbeckia laciniata*	Asteraceae
American elder	*Sambucus canadensis*	Caprifoliaceae
Sassafras	*Sassafras albidum*	Lauraceae
Canada goldenrod	*Solidago altissima*	Asteraceae
Yellow crownbeard	*Verbesina occidentalis*	Asteraceae
Fox grape	*Vitis labrusca*	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 averages for a given month and location by assigning a number in the range ±4.0 based on temperature, precipitation, and available soil water content, with ±0.9 representing the typical range for soil moisture (NPS ARD 2004; Wager 2003). This method was used to calculate separate drought indices for the same time periods used to calculate both the Sum06 and W126 metrics (Table 7 and Table 8) from 1995-1999.

As the 2004 foliar injury report for the CUPN points out, there is little association when comparing foliar injury metrics to levels of soil moisture at KIMO. The Sum06 was lowest in 1995, which was also the wettest year during the estimation period. Sum06 was highest in 1998 and 1999, each of which had one month of mild and moderate drought each. The W126 metric was also minimally variable and showed no clear association with soil moisture. The wettest year for the W126 monitoring period was 1997, for which the W126 metric did not demonstrate an exceptionally high value.

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

Sum06	Month 1	Month 2	Month 3
1995	2.99	-1.49	6.28
1996	-1.13	-1.04	0.64
1997	1.12	-2.38	0.56
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 KIMO (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	-1.13	-1.04	0.64	1.78	-0.65
1997	1.64	0.07	1.43	1.12	-2.38	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
Because the three prediction metrics (Sum06, W126, N100) fell mostly in the middle range of the threshold for foliar injury, this attribute received a “fair” condition ranking (Table 9). In addition, Kohut (2007) outlined foliar injury risks for 244 NPS units using exposure indices, plant species, and exposure environment (e.g. temperature and soil moisture), which resulted in a “high” risk assignment at KIMO. The foliar injury metric is closely correlated to the official 4th highest 8-hr ozone concentration metric used for air quality assessment, so it is likely that foliar injury risk will lessen with decreasing concentrations of ozone. Because each of the foliar injury metrics demonstrated decreasing means over the three interpolation periods, an improving trend is assigned to the condition ranking (Table 9).

Data collected directly from the POMS at Reservoir Hill, as opposed to the interpolations used for this report, would provide the most accurate assessment for foliar injury at KIMO. A data quality check was not assigned for the spatial aspect of the data quality ranking because metrics were interpolated for the park instead of collected onsite. A new ozone and foliar injury protocol has outlined, however, on-the-ground foliar injury assessments for parks on a rotating schedule. Assessments at KIMO would be conducted every six years and would coincide with POMS monitoring (Jernigan et al. 2009). This additional data would improve the data quality ranking for this attribute.

Table 9. The condition status for foliar injury at KIMO was fair. The data quality used to make this assessment was fair. A trend of improving was assigned to this condition.

		Data Quality		
Attribute	**Condition & Trend**	**Thematic**	**Spatial**	**Temporal**
Foliar injury	⇧	✓		✓
		2 of 3: Fair		

Hydrology

Water Chemistry

Monitoring

Water quality monitoring as part of CUPN I&M began at KIMO in 2003 and includes the regular measurement of specific parameters. These parameters—water temperature, pH, specific conductance, and DO— are considered core parameters by the CUPN Inventory and Monitoring process (Meiman 2007). Some parks in the CUPN, including KIMO, also collect field measurements of Acid Neutralizing Capacity (ANC) and *E. coli* concentration (Meiman 2007). Each park within the I&M network was classified based on the significance of its water resources and how central they are to the establishment of the park or its overall management mission. KIMO is classified by the CUPN as a Category Two park unit with respect to its water resources, meaning that although they are important as a park feature, they are not significant to the enabling legislation of the park, and do not contain any identified threatened or endangered species (Meiman 2005). This categorization further dictates the sampling regime used at KIMO, such that six water quality sampling stations at KIMO were sampled bi-monthly during FY-'03, '05, '07, and '09, though at the time of writing, only three years of data is available (Figure 7). In addition to sampling conducted by personnel at KIMO in accordance with the I&M program, the South Carolina Department of Health and Environmental Control (SCDHEC) collects monthly data at locations throughout the state, which includes a station at Long Branch ~400m downstream from the station in KIMO inside Kings Mountain State Park. Data for this location is available from 1975 to 2004 and includes measurements for water temperature, pH, DO, fecal coliform, and turbidity.

Initially, there were only five water quality sampling stations at KIMO, though an additional site on the Upper Dellingham was added in April 2003 to identify the origin of high fecal coliform concentrations found during early sampling. NPStoret is the NPS database used to store and update the water quality results discussed below. It includes data from all sampling periods until the end of 2007. Of the stations in the park unit, Kings Creek has the greatest flow and is the only stream that originates outside the park boundary. It represents a drainage area of 5100 ha, and as a result demonstrates properties unique from the other stations (Figure 8). Because the other streams originate inside the park, all sampling stations are located on the unit boundary to maximize the representative flow area from inside the park. Meiman (2009a), who coordinates water quality monitoring activities at all CUPN parks, describes this 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 headwater status of many of the streams in the park aids in protecting them from unknown sources of runoff or contamination. As a result, geology is likely the main contributor to surface chemistry attributes, and wildlife influence is attributed as the main cause of bacterial contamination. Although sampling intensities and methods performed at KIMO sometimes do not meet the sampling requirements for SCDHEC standards, they are still useful as a baseline for comparative purposes.

Stream Use Classification

The South Carolina Department of Health and Environmental Control (SCDHEC) classifies streams throughout the state according to use. By definition, streams or water bodies not included in the state-level classification are categorized based on the class of stream unclear to which they are tributary (SCDHEC 2008a). Consequently, all of the locations of water monitoring within KIMO are classified as freshwater use (Meiman 2007). This classification means that the waters 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 EPA Water Quality Handbook defines primary contact recreation as activities involving the potential for ingestion of, or immersion in, water. Secondary contact is reserved for activities where immersion is unlikely, such as boating, wading, or fishing (EPA 2007). The SCDHEC also defines quality standards for the core parameters monitored at KIMO, with the exception of specific conductance and ANC (SCDHEC 2008b).

Temperature

The SCDHEC Water Classification Standards limit acceptable temperatures to increases < 2.8ºC above natural conditions, with a maximum of 32.2º C. Natural conditions are defined as "water quality conditions which are unaffected by anthropogenic sources of pollution" (SCDHEC 2008b). These temperature regulations are mainly intended to prevent discharge of heated liquids by industries.

Meiman (2007) reported normal average temperatures of ~14-16º C at all of the sampling stations within KIMO. NPStoret data from 2002-2007 reflected the same range of temperatures, with the highest observation of any of the six monitoring sites (24.4º C) well below the maximum threshold of 32.2º C (Figure 9). Confidence intervals ($\alpha = 0.05$) showed no significant temperature differences among sites. The same trend was observed at the SCDHEC Long Branch site, where all observed values were well below the upper limit (Figure 9).

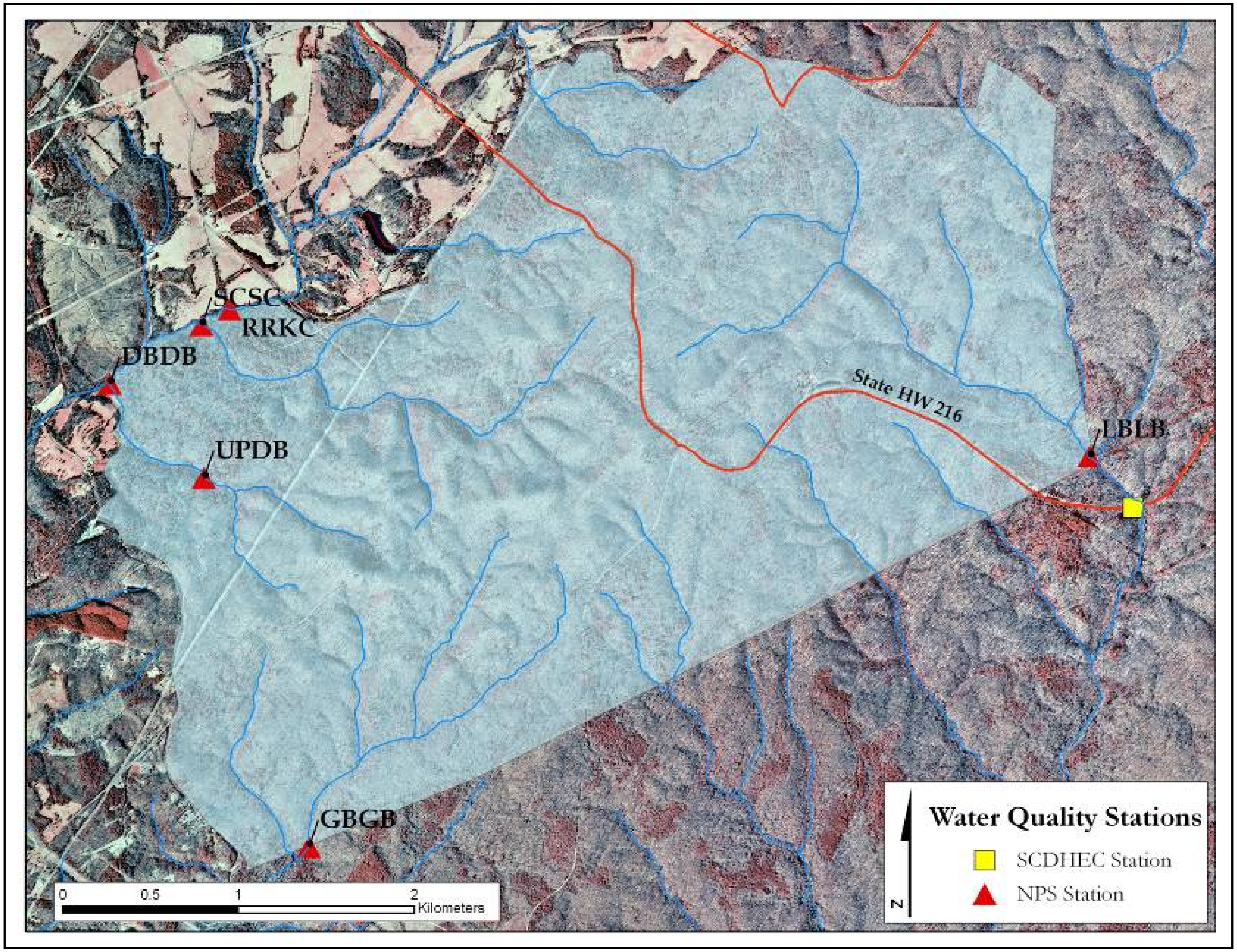


Figure 7. There are six water quality and monitoring stations located within KIMO, and one SCDHEC station on Long Branch 400 meters downstream of the park boundary.

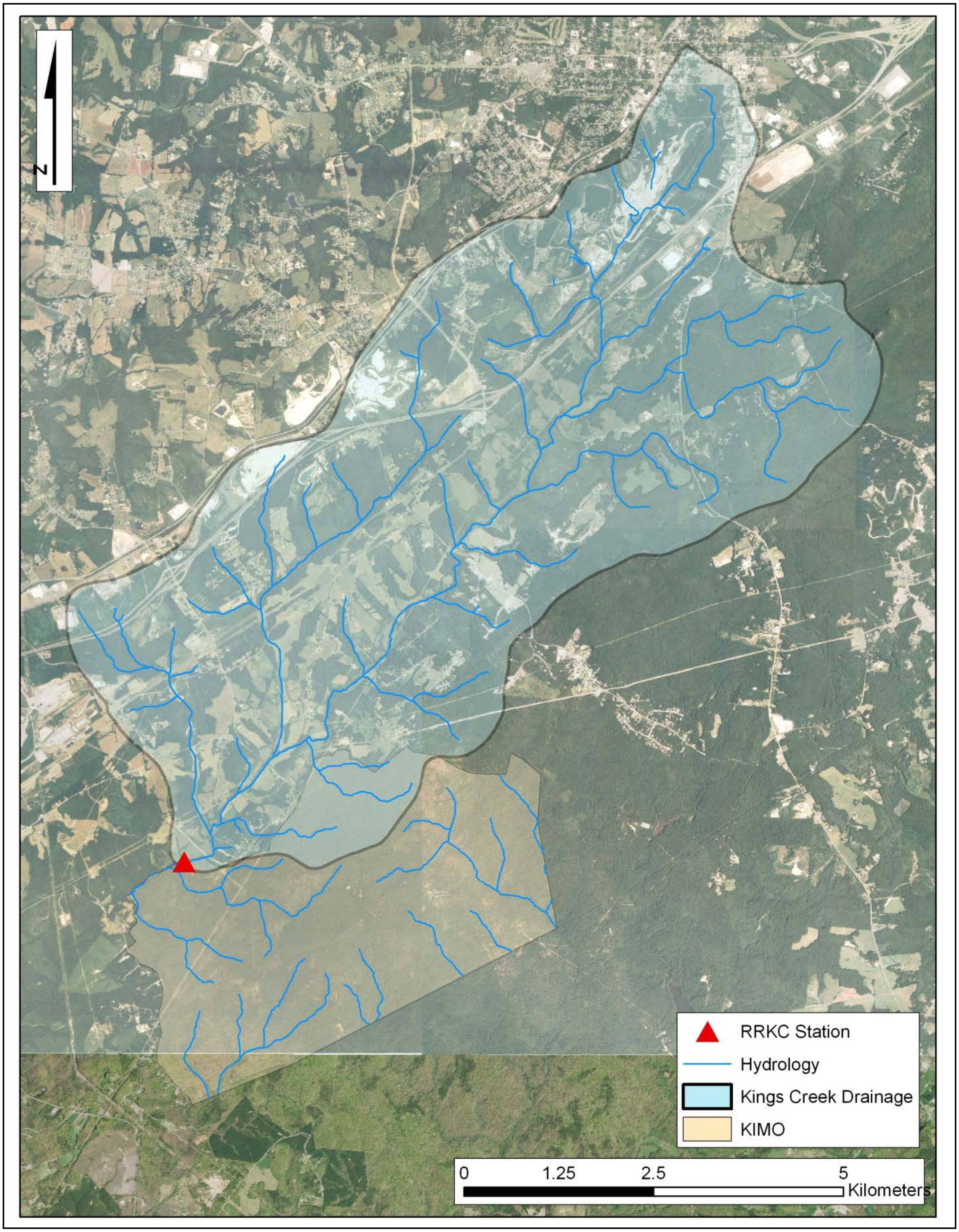


Figure 8. Kings Creek, which borders the northwest section of KIMO, has the largest drainage area (5100 ha) and flow, and is the only sampling station representative of areas outside KIMO.

Specific Conductance
Specific conductance, or conductivity, 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). Specific conductance is measured as the reciprocal of resistance and expressed in micro-Siemens/cm (µS/cm). 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." Once again, specific conductance values for Kings Creek differed significantly from those of other streams, which probably reflects the large size of its drainage area. Values at the other stations ranged from 43-61 µS/cm, while Kings Creek averaged 204 µS/cm over the 5-year monitoring period (Figure 9). Meiman (2007) notes that the lithology within the park is largely crystalline, and thus insoluble, but that the geology of Kings Creek is different and more soluble which also presents the potential for increased non-point runoff loading. Confidence intervals ($\alpha = 0.05$) showed several differences between sites, most notably greater values of specific conductance at Kings Creek. There is no SCDHEC standard for this parameter.

pH
Measurement of pH is an important water quality attribute because it affects almost all biological processes in aquatic systems. Extreme values of pH are toxic to many aquatic species and low values in particular may increase the mobility and uptake of toxicants by aquatic life (EPA 1997). Basic pH levels may also result in the precipitation of certain metals like magnesium, iron, or manganese (Sauer et al. 2009). Mean observations for pH over the 5-year monitoring period varied from 6.5 to 6.8, with the exception of Kings Creek, which averaged 7.4. These all fall within the range of 6.0 to 8.5 outlined by the SCDHEC for freshwater use classification (SCDHEC 2008b; Figure 9). Confidence intervals ($\alpha = 0.05$) showed significantly higher values at Kings Creek than the other sampling sites. Several observations at both Dellingham and Garner Branch did fall below the 6.0 threshold, which Meiman (2007) attributes to lithology of the area. Because these sites occur within the park, this explanation seems likely. At the SCDHEC site on Long Branch, pH values had a wider range, though all of the 146 observations save three fell within the 6.0 – 8.0 range (Figure 9).

Acid Neutralizing Capacity
Meiman (2007) reports that the higher alkalinity in Kings Creek is most likely due to bicarbonates, which may serve to buffer acidic loading potentially caused by acid rain. The large drainage area of Kings Creek overlaps two main striations of phyllitic metasiltstone and quartz-sericite phyllite/schist which the other sampling stations do not, and therefore may serve as a source of bicarbonates or other buffering agents. This explanation is supported by the ANC measurements, which were collected *in situ* until August 2005, while laboratory measurements of ANC began in February 2005. These values show a higher amount of calcium carbonate ($CaCO_3$) in Kings Creek compared to Dellingham Branch, Stonehouse Creek, and Upper Dellingham Branch, each of which had the three lowest values. Overall, values for this parameter ranged from 17 to 60 mg/L $CaCO_3$.

Dissolved Oxygen

Dissolved oxygen (DO) is the final of the 4 core water quality parameters monitored at KIMO, and is measured *in situ* using a sensor that adjusts for temperature. The significance of this observation 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. Concentrations of DO are also important to the survival of virtually all aquatic species (Meiman 2007).

The SCDHEC standard for DO is daily averages of at least 5.0 mg/L with absolute minimums of 4.0 mg/L. It is important to note, however, that park measurements do not meet sampling protocol standards of the SCDHEC, which stipulates a comparison of daily averages. Because these data are not available, only the 4.0 mg/L minimum threshold is applicable to our comparisons. The EPA also created national standards for DO in invertebrate habitat, stipulating levels of at least 8 mg/L for no production impairment (EPA 1986). Data show that mean concentrations for all monitoring sites were fairly consistent and ranged from 9.6 to 10.3 mg/L—well within the regulated range. Confidence intervals ($\alpha = 0.05$) showed no differences among sites. However, measurements at Stonehouse Creek and Garner Branch reached lows of 2.68 and 2.69 mg/L, respectively, both of which occurred on the final sampling date of the dataset in September 2007 (Figure 9). Such high overall DO concentrations suggest the absence of any chronic condition, though given the current sampling schedule, it is possible that even a few days with low DO could cause some mortality of aquatic organisms, yet remain undetected in the collected data.

Of the 145 measurements recorded at Long Branch by the SCDHEC, 93 stations, or 64%, met the EPA requirements for invertebrate habitat under no apparent temporal trend (Figure 9). With the exception of a single monthly average in 1988, none of the observations fell below the lower limits outlined by the SCDHEC.

Turbidity

Although not considered an official parameter vital sign for KIMO, turbidity measurements were also collected during the first round of sampling at each of the stations using a nephelometer (NTUs). A nephelometer measures the intensity of scattered light caused by suspended particles, which may include clay, silt, organic and inorganic matter, plankton, and microscopic organisms (Meiman 2005). The SCDHEC outlines 50 NTUs as the upper acceptable limit for flowing freshwater, which is well above even the maximum measurements observed at any of the stations over the five-year monitoring period. Average values ranged from 2.1 – 9.3 NTUs for all of the stations, and with the exception of higher values at Kings Creek did not show any significant differences among sites ($\alpha = 0.05$; Figure 9).

Summary

Overall, we have ranked surface water quality at KIMO as good (
Table 10)—there is no evidence of substandard water quality conditions occurring on a chronic or acute basis. Water quality measurements for all monitoring stations were within the "unimpaired" range, with only a few errant observations such as the low DO concentrations observed during a single sampling date. In general, water quality at KIMO does not represent a management problem because most of the streams originate inside the park. Kings Creek has the

only monitoring station on a water body originating outside the park. As a result, the status for water chemistry at KIMO receives a condition ranking of "good." There is no apparent trend in available data, though the three years of monitoring data would be insufficient to recognize long-term patterns anyway, and thus no trend is assigned (
Table 10).

Table 10. The condition status for water chemistry at KIMO 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**
Water Chemistry	(green circle)	✓	✓	✓
		3 of 3: Good		

Microorganisms

In addition to the core parameters previously discussed, measurements of *Escherichia coli* and total coliform bacteria were included in the CUPN monitoring plan, although the SCDHEC (2008b) only has standards for fecal coliform in freshwater. Total coliform bacteria are a group of bacteria that live in the intestines of warm and cold-blooded organisms, and typically are used as indicators of health risks presented by associated viruses and pathogens. Total coliform counts themselves do not necessarily present a health risk. Fecal coliform are a subset of total coliform bacteria that exist only in warm-blooded organisms (Figure 11), and because all of the streams except Kings Creek originate inside the park, any source of these bacteria are most likely to enter the waters of KIMO via wildlife feces.

Standard Development

During 1940-50, the US Public Health Service (USPHS) conducted a series of studies aimed at relating various health effects to concentrations of certain coliform bacteria in marine and freshwater environments. One of the study locations on the Ohio River in Dayton, Kentucky compared gastrointestinal illness occurrence rates with geometric mean total coliform concentrations and found a threshold of significantly greater illnesses at 2300 colonies per 100mL compared to relatively unimpacted waters with 43 colonies per 100mL. Using the ratio of fecal coliform occurrence to total coliform at the Ohio River site, the National Technical Advisory Committee (NTAC) recommended the conversion of the total coliform concentrations to fecal coliform, because these concentrations were considered more stable due to lower variation during storm runoff events. Using these concentrations, a recommended limit of 400 fecal colonies per 100ml was derived for <10% of samples during a 30-day period, as well as a more stringent one-half of the detectable risk level, or 200 fecal coliform per 100mL, when collecting 5 consecutive samples within a 30-day period. Despite criticisms of the USPHS study that resulted in this recommendation and the overall lack of epidemiological research on water quality, the EPA continues to use this limit for recreational-use waters, and it has also been adopted by the SCDHEC as the state water quality standard (EPA 1989).

Monitoring

At KIMO, fecal coliform was sampled for the first round of sampling before being replaced by measurements of *E. coli* and total coliform during subsequent collections. Concentrations of fecal coliform during this first collection were highest at both Dellingham stations, exceeding 1299 colonies $100mL^{-1}$ at the lower station. Although samples were not collected consecutively within 30-day periods as per the SCDHEC protocol, the mean of 9 samples collected during the first round exceeded 200 colonies per 100mL at every station except Long Branch and Stonehouse Creek. Confidence intervals ($\alpha = 0.05$) showed a significantly higher concentration at Dellingham Branch than other stations, which showed no differences. As a result, Meiman (2007) suggests continued sampling to monitor levels of fecal contamination, especially at Dellingham and Garner Branch.

The SCDHEC site on Long Branch has analyzed monthly concentrations of fecal coliform since collections began in 1975. These observations do not adhere to the SCDHEC collection protocol, though they are still useful as a reference. Of the 141 data points, 71% were higher than the 5-day 200 colonies per 100mL limit, with roughly 15% overall exceeding the absolute limit of 400 colonies per 100mL (Figure 9). Because fecal coliform measurements were only collected for a single round within KIMO, comparisons with SCDHEC data are not particularly informative. Of note, however, is that although 71% of the SCDHEC observations exceeded the minimum standard for fecal coliform, the lowest fecal concentrations observed within KIMO were at Long Branch. This might imply even greater long-term values for fecal coliform at other stations within KIMO, particularly Kings Creek and Upper Dellingham. Although Meiman (2007) attributed that high rates of coliform are present at these stations as the result of wildlife contact, the combination of these observations within and without KIMO support additional efforts to locate the source of fecal contamination, given that these measurements suggest state non-compliance in the park. Ideally, increasing sampling frequency to adhere to the SCDHEC protocol would also help make this determination.

E. coli is one of the most commonly monitored types of bacteria in the fecal coliform group (EPA 1989), but it was not monitored at KIMO until April 2005. Like fecal coliform, concentrations are expressed by the number of colonies per 100 ml sample. Although there is no state standard for this bacterium, the EPA recommends an *E. coli* single-sample limit of 576 colonies per 100mL for infrequent recreational contact (EPA 1986). The eight measurements during two years of monitoring averaged 114 to 434 colonies per 100mL across sites (Figure 9), which is below the EPA threshold. Because of its lower variability, confidence intervals ($\alpha = 0.05$) showed significantly higher *E. coli* concentrations at Kings Creek than in Dellingham and Garner Branches, though Upper Dellingham had the highest overall average concentration.

Total coliform monitoring also began in 2005, and average concentrations across sites ranged from 1040 to 1632 colonies per 100mL, though several of the sites are missing samples. Meiman (2007) notes that the higher ends of these values correspond to high rainfall events, and the measurements collected at Long Branch, Garner Branch, and Stonehouse Creek are for the most part within the range expected for areas with high populations of wildlife, which would contribute to high fecal coliform levels. Initially, it was suggested that proximity to trails might cause contamination from runoff in areas with a high rate of horse usage, though trail maps show that areas of usage only cross Garner Branch, Long Branch, and Stonehouse Creek, which in fact are the only unaffected streams. There is no SCDHEC standard for total coliform.

Summary

Despite occasional high concentrations, microorganisms do not pose a great threat to water quality at KIMO. As Meiman (2007) pointed out, most, if any bacterial contamination is likely from wildlife resident to the park, because all sampled streams originate in the park with the exception of Kings Creek. With that in mind, only Dellingham Branch exceeded the 400 colonies $100mL^{-1}$ SCDHEC standard for fecal coliform, and none of the sites exceeded the 576 colonies $100mL^{-1}$ EPA for *E. coli*. Consequently, we ranked the condition status of microorganisms at KIMO as "good" (Table 11). Finally, the time series data, though minimal, show no evidence of a trend for these parameters, so no trend is assigned.

Table 11. The condition status for microorganisms at KIMO was good. The data quality used to make this assessment was good. No trend was assigned to this condition.

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

Water Quantity

Discharge, or flow, is monitored at each of the monitoring stations to scale the flux of other parameters measured in concentration. Highly variable flows such as those that result from power generation by impoundments or large areas of impervious surface may adversely affect water quality and in turn alter aquatic biodiversity (Bunn and Arthington 2002). Discharge averages ranged from 14 to 42 l sec^{-1}, with the exception of Kings Creek, which averaged 697 l sec^{-1} over the 5 year monitoring period (Figure 9). Kings Creek showed significantly higher discharge levels than the remaining streams. Kings Creek is charged by two additional flows upstream, both of which are impounded approximately 9 and 10 km upstream from the sampling station. These impoundments, however, are highly unlikely to affect flow cycles along the park boundary. Because all streams originate in the park except Kings Creek, rainfall events and natural cycles are the greatest source of flow variability at KIMO, and the condition status for flow receives a ranking of "good," with no trend assigned (Table 12).

Table 12. The condition status for water quantity at KIMO was good. The data quality used to make this assessment was good. No trend was assigned to this condition.

Attribute	Condition & Trend	Data Quality		
		Thematic	Spatial	Temporal
Water Quantity		✓	✓	✓
		3 of 3: Good		

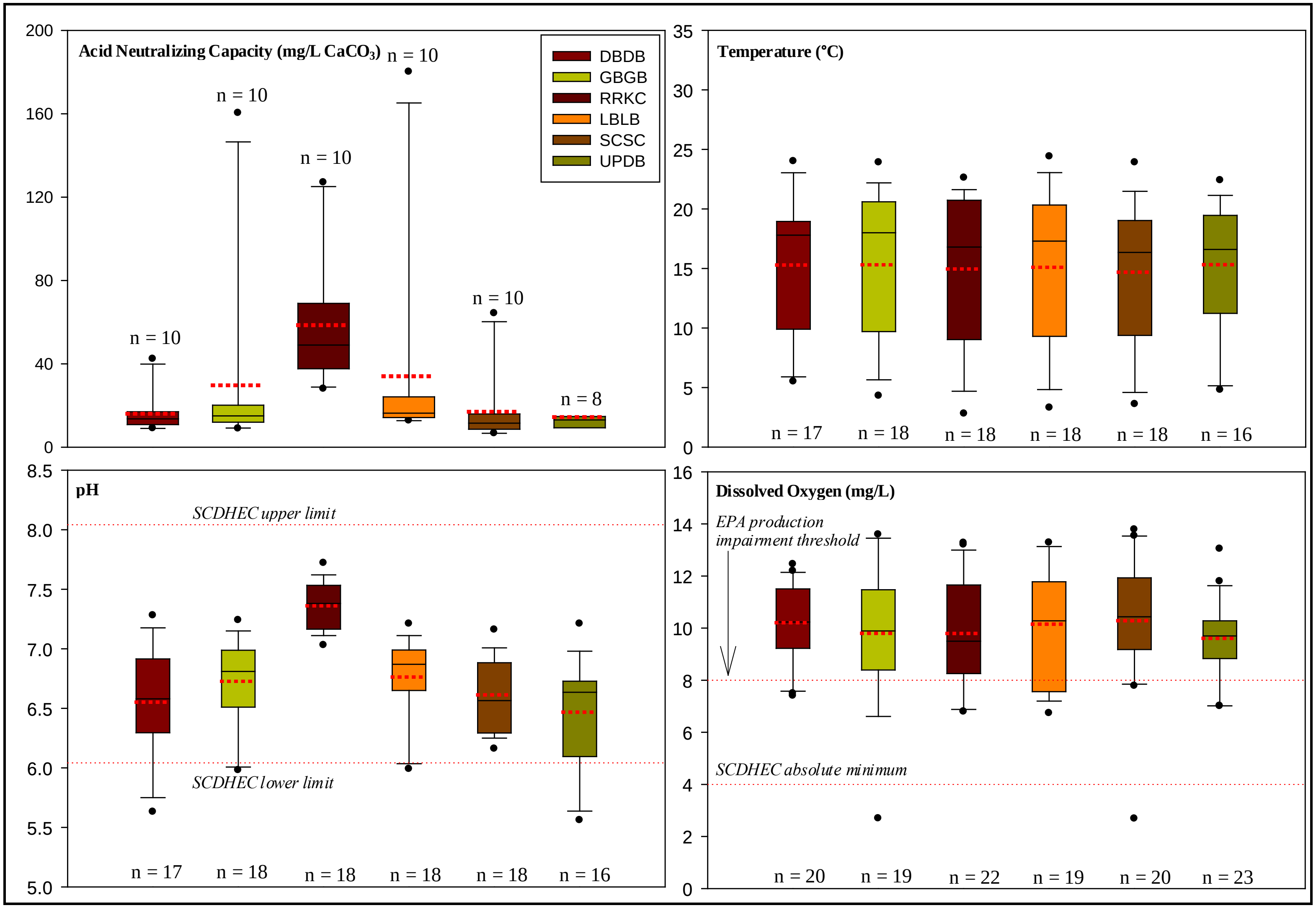
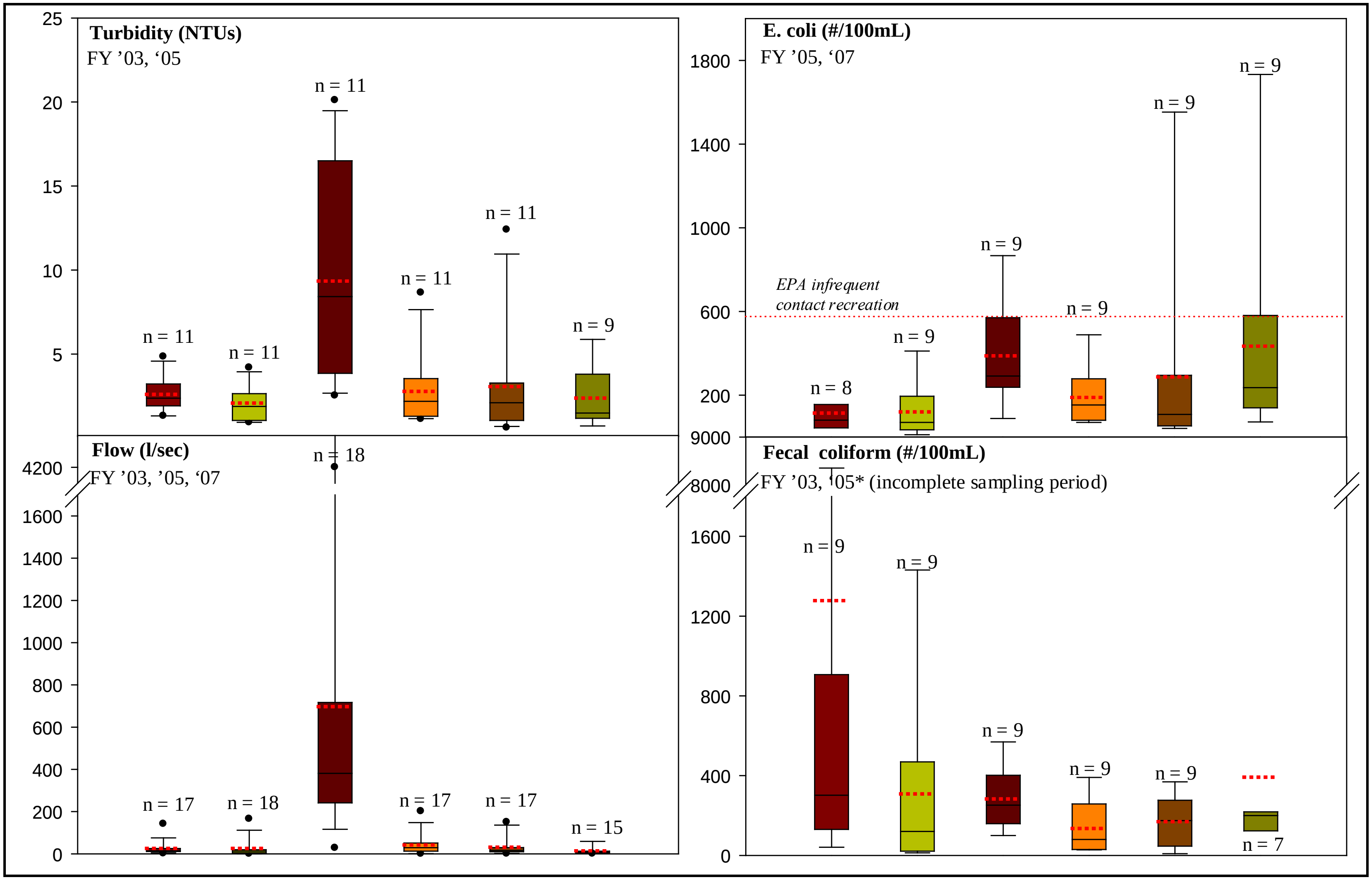


Figure 9. Box and whisker plots showing data collected from six monitoring locations on five reaches in KIMO. Parameters depicted are the core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli*, flow, turbidity, and fecal coliform as stipulated by the CUPN. SCDHEC or EPA standards are shown where relevant. Points represent outliers, while red dotted lines depict means.



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

Figure 9. Box and whisker plots showing data collected from six monitoring locations on five reaches in KIMO. Parameters depicted are the core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli*, flow, turbidity, and fecal coliform as stipulated by the CUPN. SCDHEC or EPA standards are shown where relevant. Points represent outliers, while red dotted lines depict means (continued).

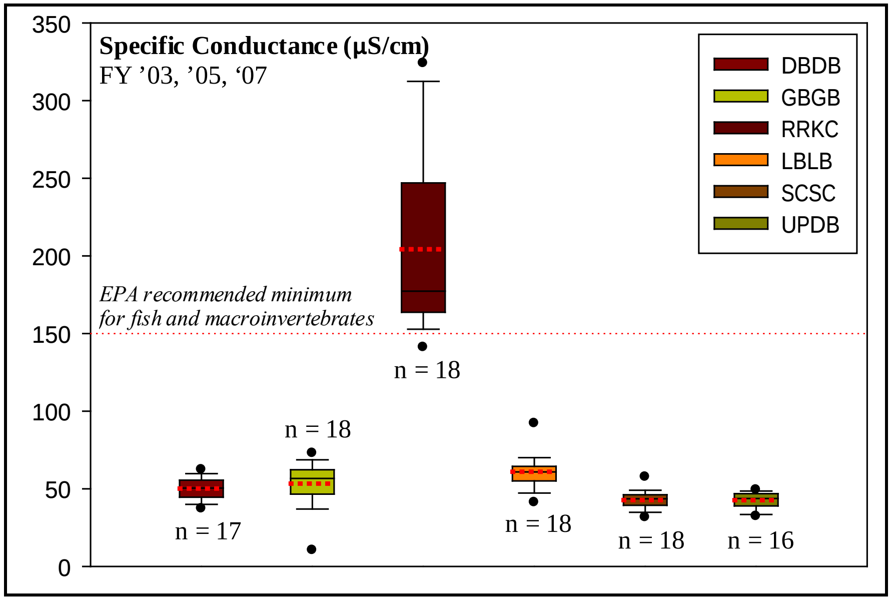
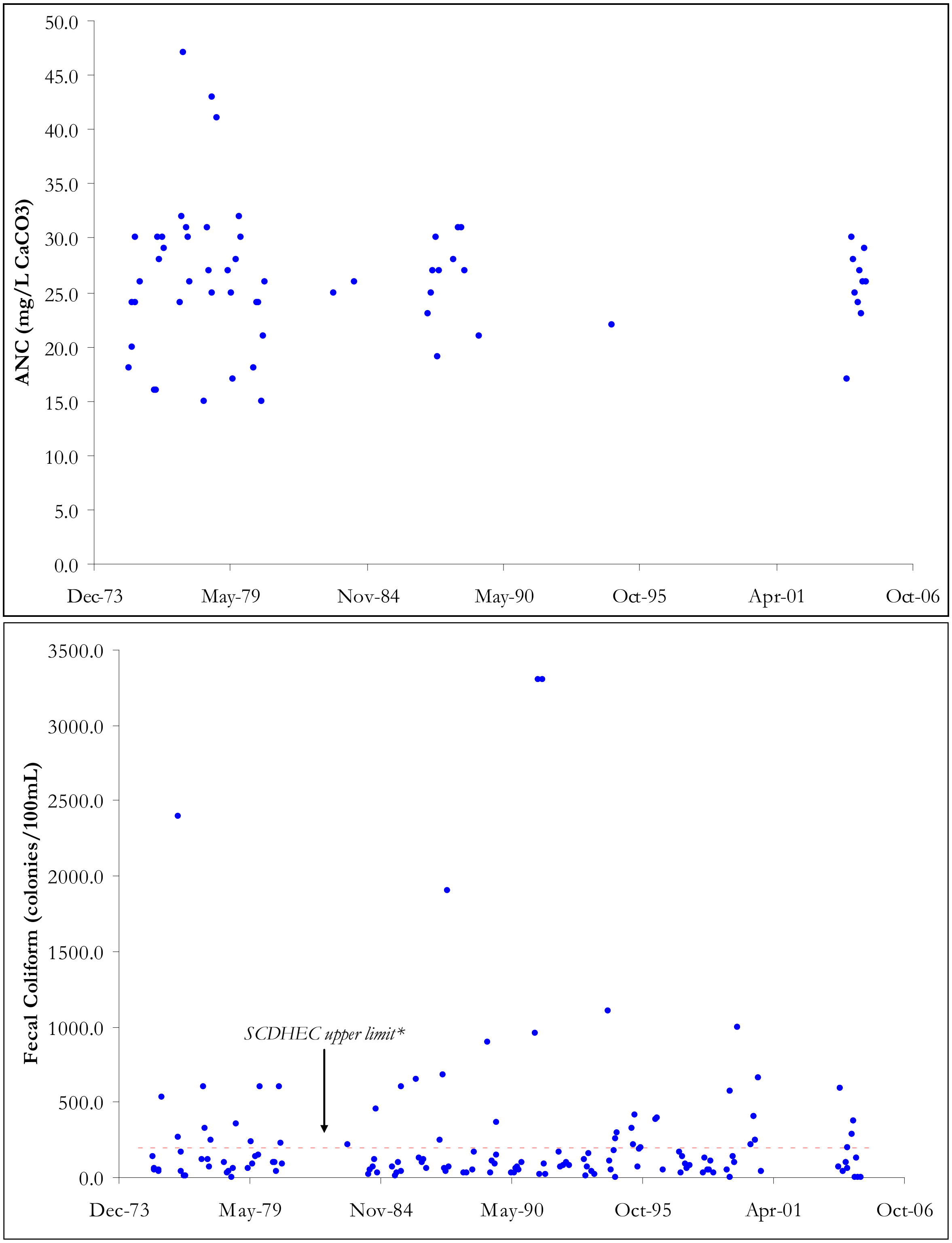
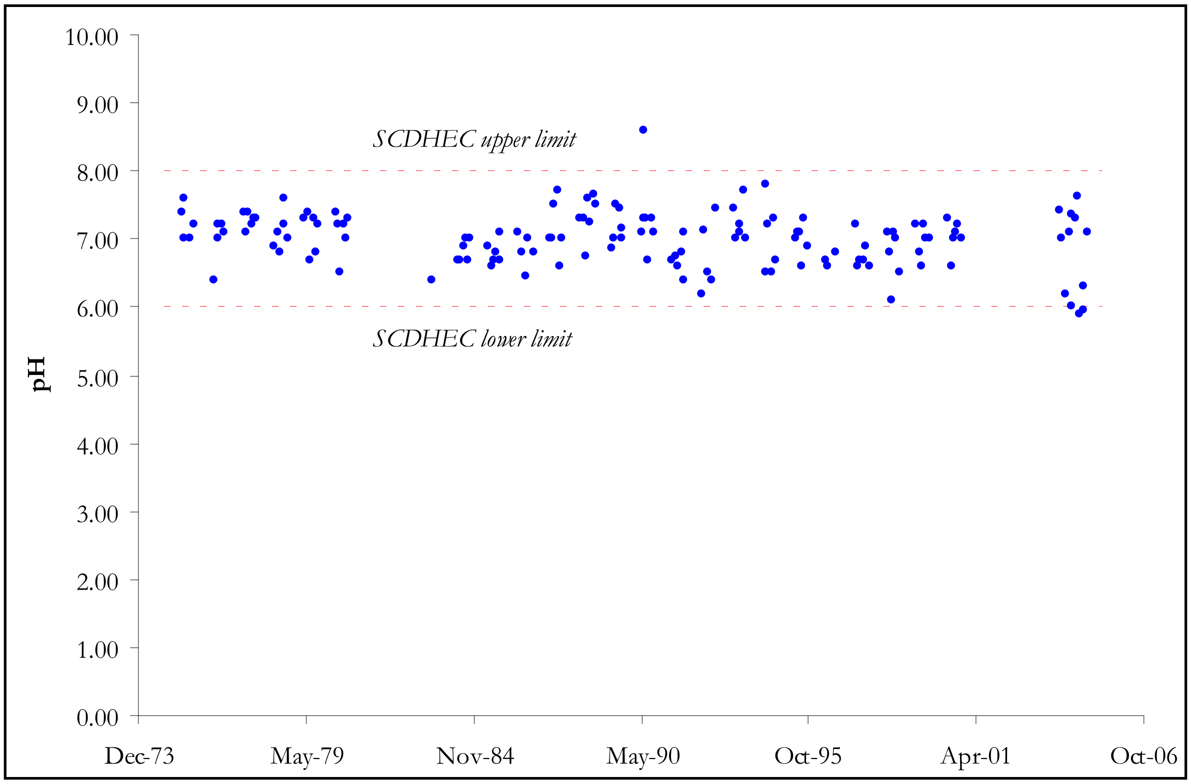


Figure 9. Box and whisker plots showing data collected from six monitoring locations on five reaches in KIMO. Parameters depicted are the core water quality measurements (temperature, pH, specific conductivity, and dissolved oxygen), in addition to *E. coli*, flow, turbidity, and fecal coliform as stipulated by the CUPN. SCDHEC or EPA standards are shown where relevant. Points represent outliers, while red dotted lines depict means (continued).



*SCDHEC standard for fecal coliform compliance is based on 5 consecutive measurements within a 30-day period. These data express monthly measurements, and thus serve only as a reference.

Figure 10. Monthly SCDHEC surface water quality monitoring data at Long Branch Creek near the KIMO boundary. Samples were collected 1975 - 2004 and include turbidity, fecal coliform, ANC (alkalinity), and I&M core parameters with the exception of specific conductance. Where available, SCDHEC or EPA standards are given.



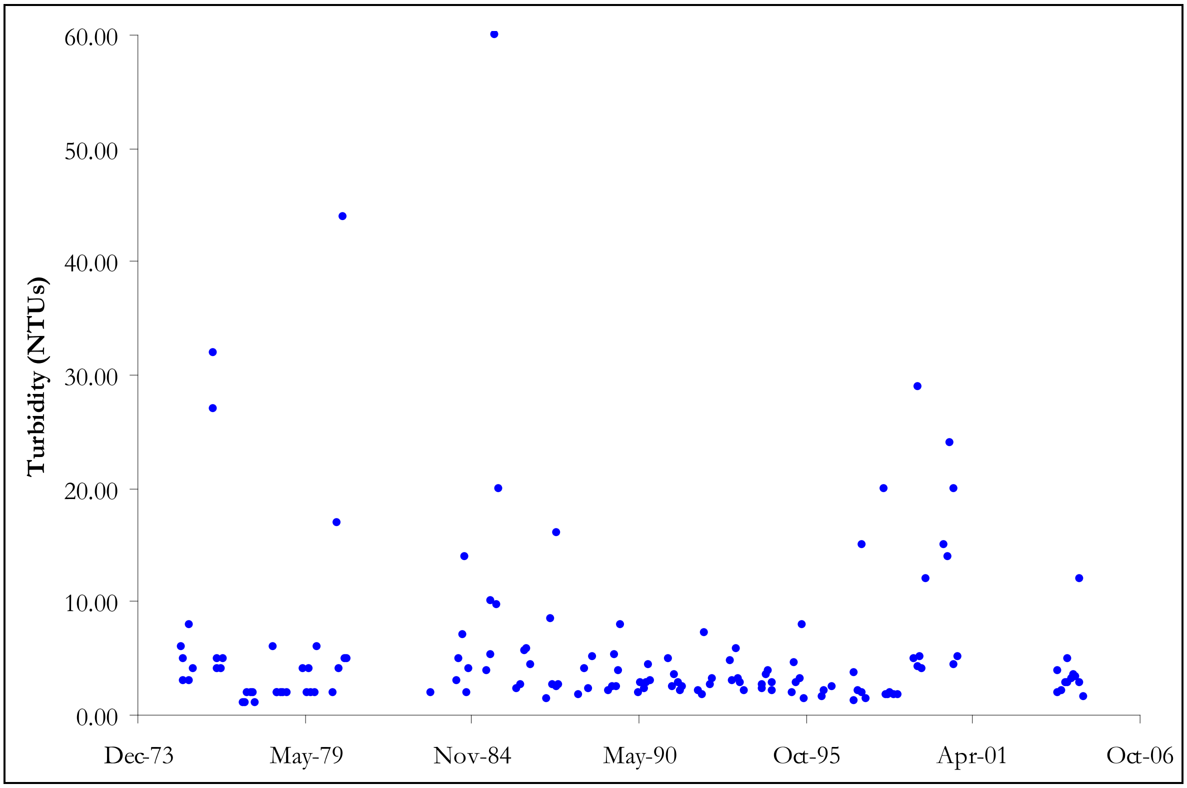


Figure 10. Monthly SCDHEC surface water quality monitoring data at Long Branch Creek near the KIMO boundary. Samples were collected 1975 - 2004 and include turbidity, fecal coliform, ANC (alkalinity), and I&M core parameters with the exception of specific conductance. Where available, SCDHEC or EPA standards are given (continued).

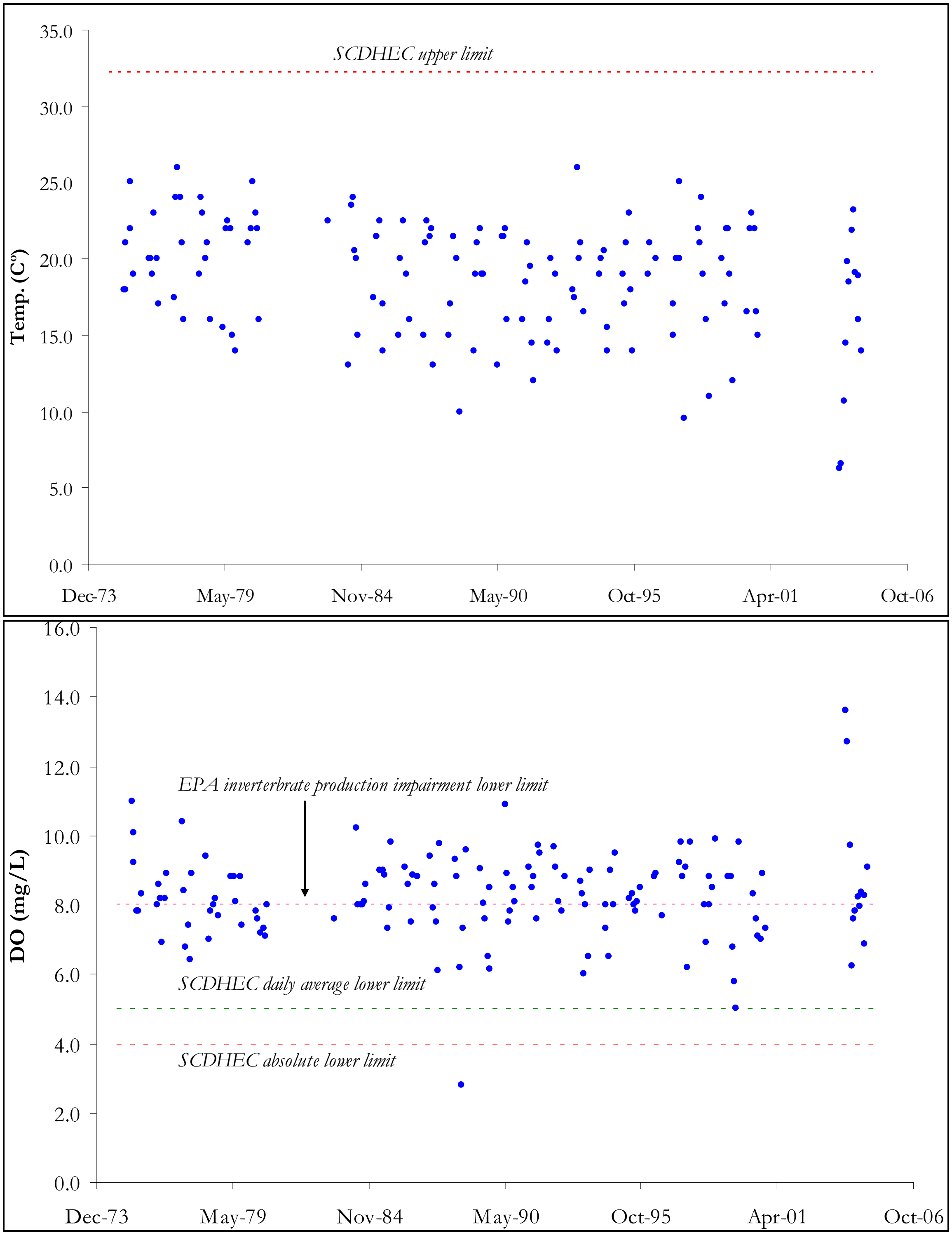


Figure 10. Monthly SCDHEC surface water quality monitoring data at Long Branch Creek near the KIMO boundary. Samples were collected 1975 - 2004 and include turbidity, fecal coliform, ANC (alkalinity), and I&M core parameters with the exception of specific conductance. Where available, SCDHEC or EPA standards are given (continued).

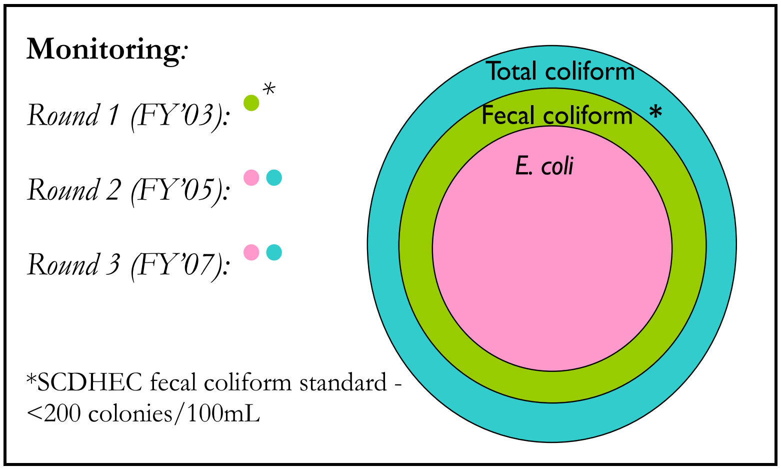


Figure 11. Bacteria monitoring at KIMO changed from fecal coliform to *E. coli* during the last two fiscal years.

Invasive Species

Approximately 11% of the plant species documented at KIMO (58 of 508 species) were exotics, mostly from escaped plantings or seed mixes (White and Govus 2004). By contrast, the statewide mean is 15% exotics (NatureServe 2008). Fifteen invasives at KIMO appear on the South Carolina Exotic Pest Plants Council (2001) list of severe or significant threats (Table 13). These species include wisteria (*Wisteria* spp.), Chinese privet (*Ligustrum sinense*), and Japanese stiltgrass (*Microstegium vimineum*), each of which colonize and outcompete native species in specific vegetation types, such as the Piedmont Small Stream Sweetgum Forest and the Piedmont Seepage Wetland present at KIMO. Both of these community types, in particular, are susceptible to stiltgrass invasion (White and Govus 2004).

Morse et al. (2004) developed a methodology to quantify the threat posed by exotics to native species and ecosystems, called the I-rank. The overall I-rank consists of 20 questions which together cover four main subranks: ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty. We recalculated the I-ranks for each species, excluding consideration of current distribution and abundance, because that metric is relevant to the rangewide status and we desired a park unit-level status. These rankings are shown in Table 13 and are expressed on a scale of zero to three, with three representing the greatest threat to park resources. Following this approach, only one species, Japanese honeysuckle, resulted in an I-Rank in the highest category (>2.00).

The first category—ecological impact—generally relates to the effects of the species on community structure and composition, or to more general ecosystem processes. The second category—current distribution and abundance—considers the broad-scale range of the species and the diversity of communities it invades. The greater the area and amount of habitat a species invades, the more damage it can potentially cause. However, this abundance measure does not address localized presence, such as at the scale of KIMO. As a result, widespread species with a high ranking for this category may in fact be sparse at KIMO, or species with relatively constrained broad-scale distributions may be common and widespread in the park, resulting in conflicting influence on the overall I-Rank. Consequently, this category is not used to recalculate the quantitative I-Rank for species at KIMO. The third category—trend in distribution and abundance—is used to inform the I-Rank because it is scale-independent, and generally addresses its rate of spread and increase in abundance. Lastly, management difficulty addresses how hard the species is, once identified, to eradicate or control. This category also addresses the potential of common control methods to cause collateral damage to other native species (Morse et al. 2004). These rankings are shown in Table 9 and are expressed on a scale of zero to three, with three representing the greatest threat to native species and communities. Following this approach, Japanese honeysuckle (Figure 12) received the highest I-Rank of 2.33, though 11 species scored in the medium rank.

Table 13. Of the 58 non-native plant species at KIMO, 15 appear on the 2008 South Carolina Exotic Pest Plant Council Invasive Species List.

Species		SCEPPC Rank	I-Rank
Lonicera japonica	Japanese honeysuckle	Severe	2.33
Lespedeza cuneata	Sericea	Significant	2
Hedera helix	English ivy	Severe	2
Ligustrum sinense	Chinese privet	Severe	2
Microstegium vimineum	Japanese stiltgrass	Severe	2
Pueraria montana	Kudzu	Severe	1.83
Albizia julibrissin	Mimosa	Severe	1.67
Ailanthus altissima	Tree-of-heaven	Severe	1.5
Wisteria sinensis	Chinese wisteria	Severe	1.5
Paulownia tomentosa	Princesstree	Severe	1.33
Wisteria floribunda	Japanese wisteria	Severe	1.33
Rosa multiflora	Multiflora rose	Severe	1.17
Vinca minor	Periwinkle	Severe	1
Daucus carota	Queen Anne's Lace	Significant	0.33
Paspalum dilatatum	Dallis grass	Significant	Not Ranked

I-Rank is calculated as an average of ecological impact, trend in distribution and abundance, and general management difficulty, each of which is assigned a value of 1 to 3 (Morse et al., 2004). Each category is assigned a number based on its categorical rating and averaged to give the overall I-Rank: low (0.01-1.00), medium (1.01-2.00), or high (2.01-3.00). Ranks do not reflect overall abundance within the park unit.

During 2002, NatureServe conducted a survey of KIMO vegetation using 21 permanent monitoring plots (Figure 13), and recommended that the Piedmont Small Stream Sweetgum Forest and Piedmont Seepage Wetlands be targeted for exotics species control, in addition to the two power line right-of-ways which traverse the park. In these areas, Japanese honeysuckle and Chinese privet were identified as the most invasive of exotics (White and Govus 2004).

Overall, KIMO receives a condition status ranking of good for exotic plants (Table 14). Although several exotics are present in the park, in general the diversity and predominance of exotic species is undoubtedly lower at KIMO than on a regional level. Moore (2009) indicates that KIMO has the lowest number of exotics of any of the CUPN parks. In addition, woodland and forested areas most vulnerable to non-native invasion, such as the Piedmont Chestnut Oak – Blackjack Oak Woodland, benefit from management using established burning regimes that mimic natural fire cycles. These actions inhibit establishment of exotics. This assessment for this condition ranking is based mainly on the report by White & Govus (2004). Because the positive cycle of management will undoubtedly continue to benefit the natural areas and communities within the park unit, the condition status is assigned a trend of "stable." However, Moore (2009) points out that new exotic species encroaching on the region continue to pose a risk to the park. In anticipation of this, early detection of exotic plants is scheduled for development and implementation as a high priority vital sign for CUPN.

Figure 12. Japanese honeysuckle (*Lonicera japonica*) scored the highest I-Rank of the highly invasive exotic plant species at KIMO. [Source: Chris Evans, River to River CWMA, Bugwood.org]

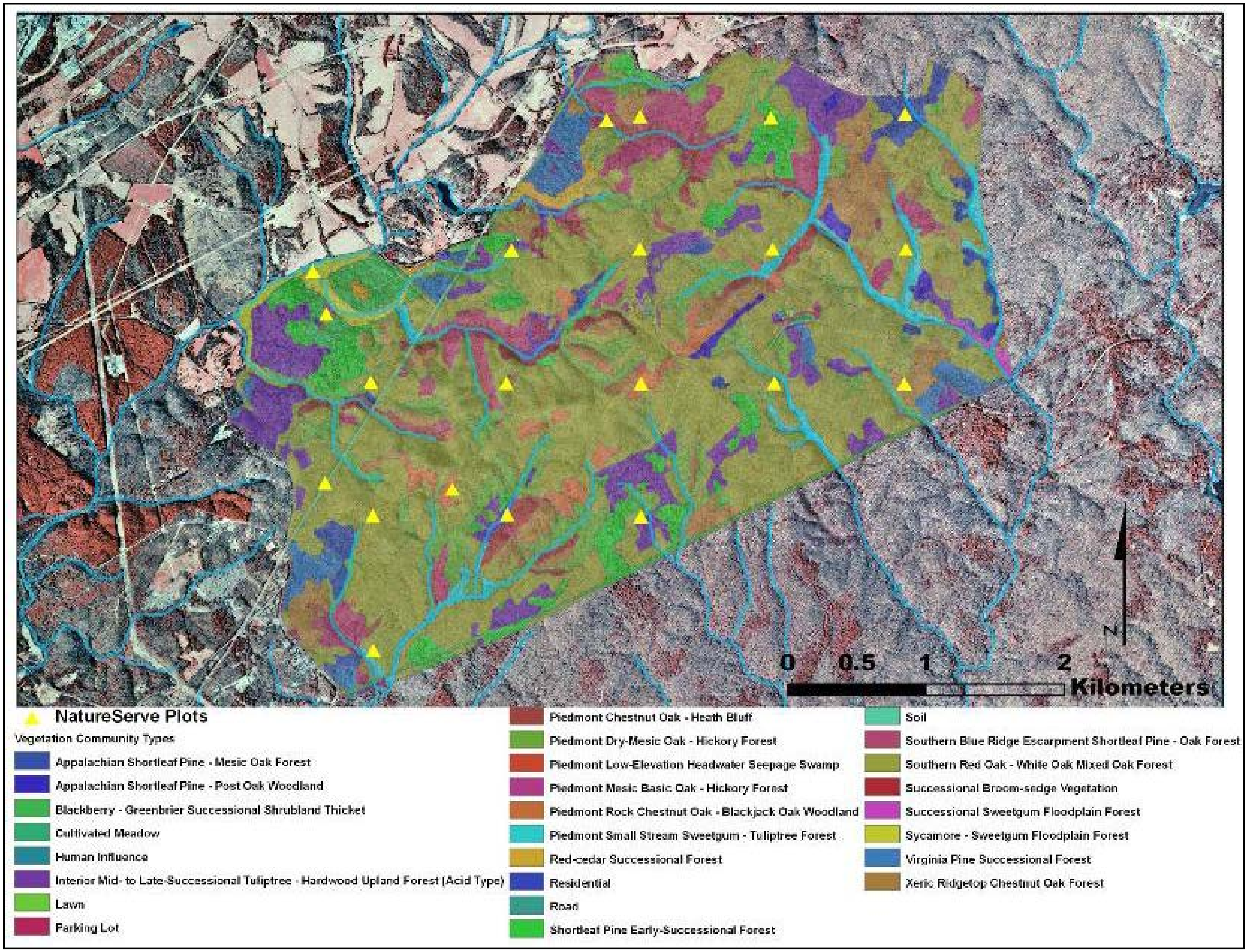


Figure 13. NatureServe established vegetation monitoring plots in 2001-2002 and helped the Center for Remote Sensing and Mapping Science (CRMS) outline 20 vegetation community types for KIMO (Jordan and Madden 2008).

Table 14. The condition status for invasive plants at KIMO was good. The data quality used to make this assessment was fair. A trend of stable was assigned to this condition.

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

Forest Pests

Because such a large portion of KIMO is forested, this park unit is susceptible to infestation by forest pests that can defoliate and kill tree stands and make them more susceptible to disease. The native southern pine beetle (*Dendroctonus frontalis*) is a significant forest pest in the southeast, and may causes high tree mortality. Typically beetle infestations last from 3 to 4 years (Fettig et al. 2007).

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 KIMO were slope, southern pine basal area, aspect, and soil clay content. Figure 14, adapted from that model, shows that the overall risk within KIMO is quite low compared to surrounding areas (Ellenwood & Krist 2007; Krist 2009). Cherokee county, shown to the west of the pink boundary line in Figure 14, appears to show a greater total area of low risk than on the east side in York County. Overall, there appears to be a decreasing gradient of infestation risk from west to east, which appears to be associated with a similar gradient of decreasing development encroachment from west to east.

Fire also plays an important role in pine beetle outbreaks. While some evidence suggests that fire can stress trees and increase their susceptibility to an infestation (Santoro et al., 2001), others maintain that increased oleoresin production in pines, such as what follows a period of fire, can boost their resistance to southern pine beetle attack (Knebel and Wentworth 2007; Strom et al. 2002). This is especially true for low to moderate intensity fires, like those of a prescribed burn, whereas intense fires associated with crown damage may predispose trees to an attack (McHugh et al. 2003). Knebel and Wentworth (2007) observed elevated oleoresin levels in pine-dominated experimental plots for up to 18 months after low to moderate intensity fires. Because of its susceptibility to southern pine beetle and the regularity of prescribed burns at KIMO, this management might aid in protecting stands from beetle attack.

White and Govus (2004) mention the susceptibility to pine beetles of three forest communities in particular (Figure 15). The first, Appalachian Shortleaf Pine Mesic Oak Forest (CEGL008427), comprises 37 ha in 16 stands, and has experienced a lack of fire over the past 50 years at KIMO in particular. Without fire, hardwoods could eventually replace shortleaf pine in this community. The second community, Shortleaf Pine early Successional Forest (CEGL006327), encompasses 89 ha in 33 stands and grades in places into the Loblolly Pine - Sweetgum Semi-natural Forest (CEGL008462). This latter vegetation type is not common within the park unit, however, and is not classified as either dominant or secondary vegetation anywhere within the park by the Center for Remote Sensing and Mapping Science (Jordan and Madden 2008). The last vulnerable vegetation type White and Govus (2004) mention is the Southern Blue Ridge Escarpment Shortleaf Pine – Oak Forest (CEGL007493) which comprises 86 ha in 37 stands (Jordan and Madden 2008). This community is somewhat fire dependent; fires in these communities stimulate shortleaf pine regeneration and may potentially control invasives like Japanese privet (*Ligustrum japonica*), Chinese yam (*Dioscorea oppositifolia*), and Japanese honeysuckle.

Ips Beetle

The ips beetle (*Ips avulsus*) is another insect pest that can potentially affect forest stands in KIMO. Along with the southern pine beetle, this pest is responsible for the majority of pine mortality in the southern US region. This species of ips beetle is known to attack loblolly, shortleaf, and Virginia pine, all of which occur at KIMO. However, the ips beetle is only known to infest weakened and unhealthy trees, such as ones following an extreme disturbance like fire, storms, drought, or cutting (Connor and Wilkinson 1983). In particular, the threat of an infestation is closely tied to areas experiencing altered fire regimes, modified species composition, and nonnative introduction (Strom et al. 2002; Fettig et al. 2007).

Gypsy Moth

Finally, the invasive gypsy moth (*Lymantria dispar*) has also been shown to affect tree health via infestation and defoliation (Schultz and Baldwin 1982; Elkinton and Liebhold 1990). Gypsy moth is a hardwood pest, originally introduced to the New England area and now continually spreading south and west at a rate of approximately 21 km year^{-1} (Liebhold 2003). The Forest Health and Monitoring division of the US Forest Service has annual reports for gypsy moth traps from 2002-2007, during which 2-4 traps were placed in the park. Throughout this period, none of the traps captured any moths. Although there are several monitoring stations throughout South Carolina, none of these traps have shown gypsy moth captures for the duration of the reports since 2002, which suggests they are not currently a species of concern for this park unit (Puckett 2008). According to the National Agricultural Pest Information System (NAPIS), only seven counties in SC had reported presence of gypsy moth in 2008, though several nearby counties in NC had reported infestations, including Mecklenburg County, which borders York County in SC. Because several potential hardwood host species such as oak (*Quercus* spp.), Sweetgum (*Liquidambar styraciflua*), and American basswood (*Tilia americana*) are present at KIMO, it is important that any infestation of gypsy moth within the park unit is detected at an early point to improve chances of eradication.

Summary

Overall, it is not likely that insect pests present a significant risk to KIMO, mainly because the susceptible communities identified in the NatureServe report represent only a small proportion of the total area. It is also a possibility that the continuation of natural fire regimes via controlled burning also minimizes susceptibility of these areas. For these reasons, the status of insect pests at KIMO receives a condition ranking of “good,” with insufficient information to assign a trend (Table 15).

Table 15. The condition status for insect pests at KIMO 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		✓	✓	✓
		3 of 3: Good		

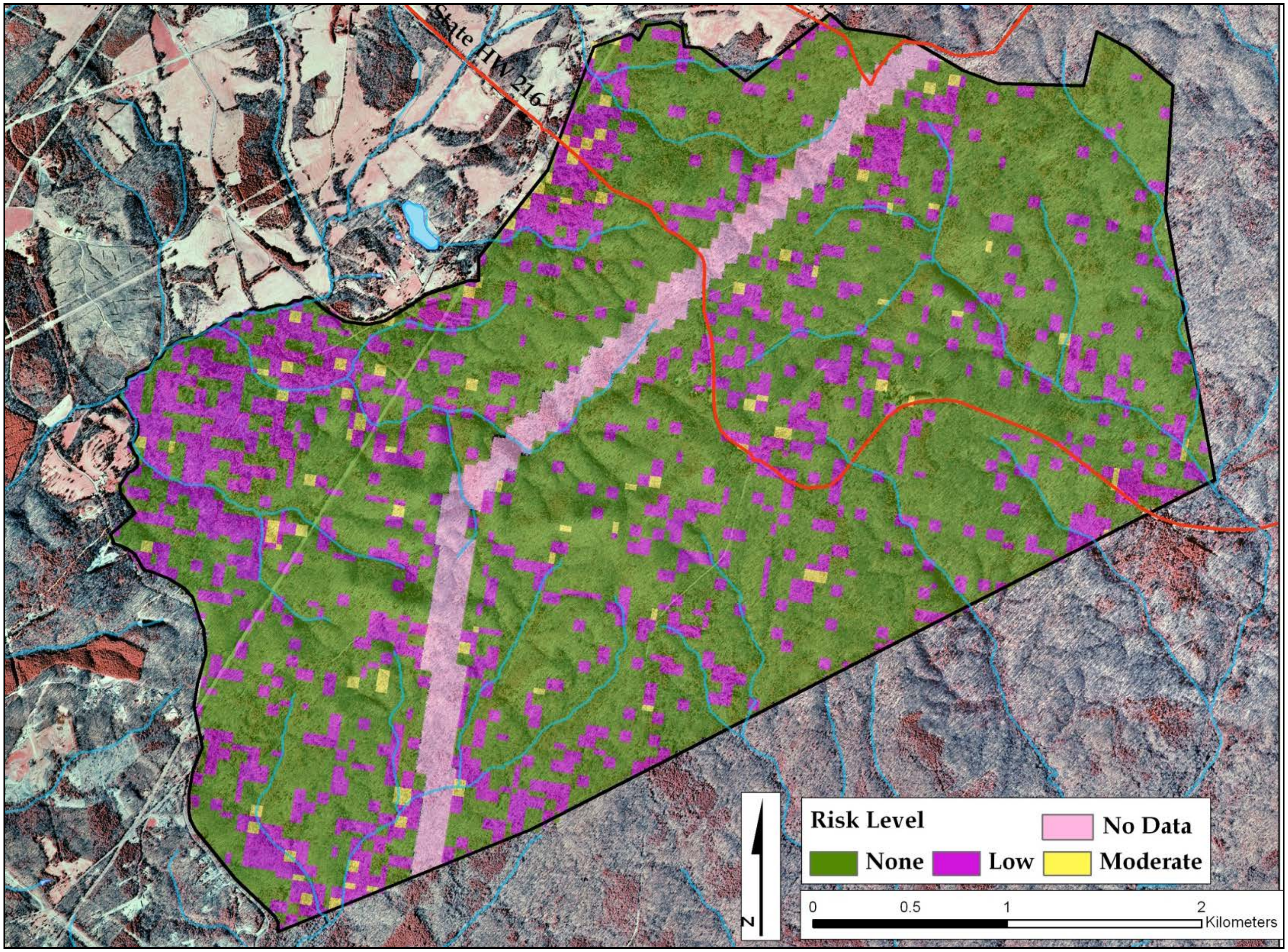


Figure 14. Southern Pine Beetle Infestation Risk in KIMO. The pink line representing 'No Data' delineates the boundary between Cherokee and York counties. [Source: Southern Pine Beetle Hazard Map. 2007. Forest Health Technology Enterprise Team. USDA Forest Service. Ft. Collins, CO.]

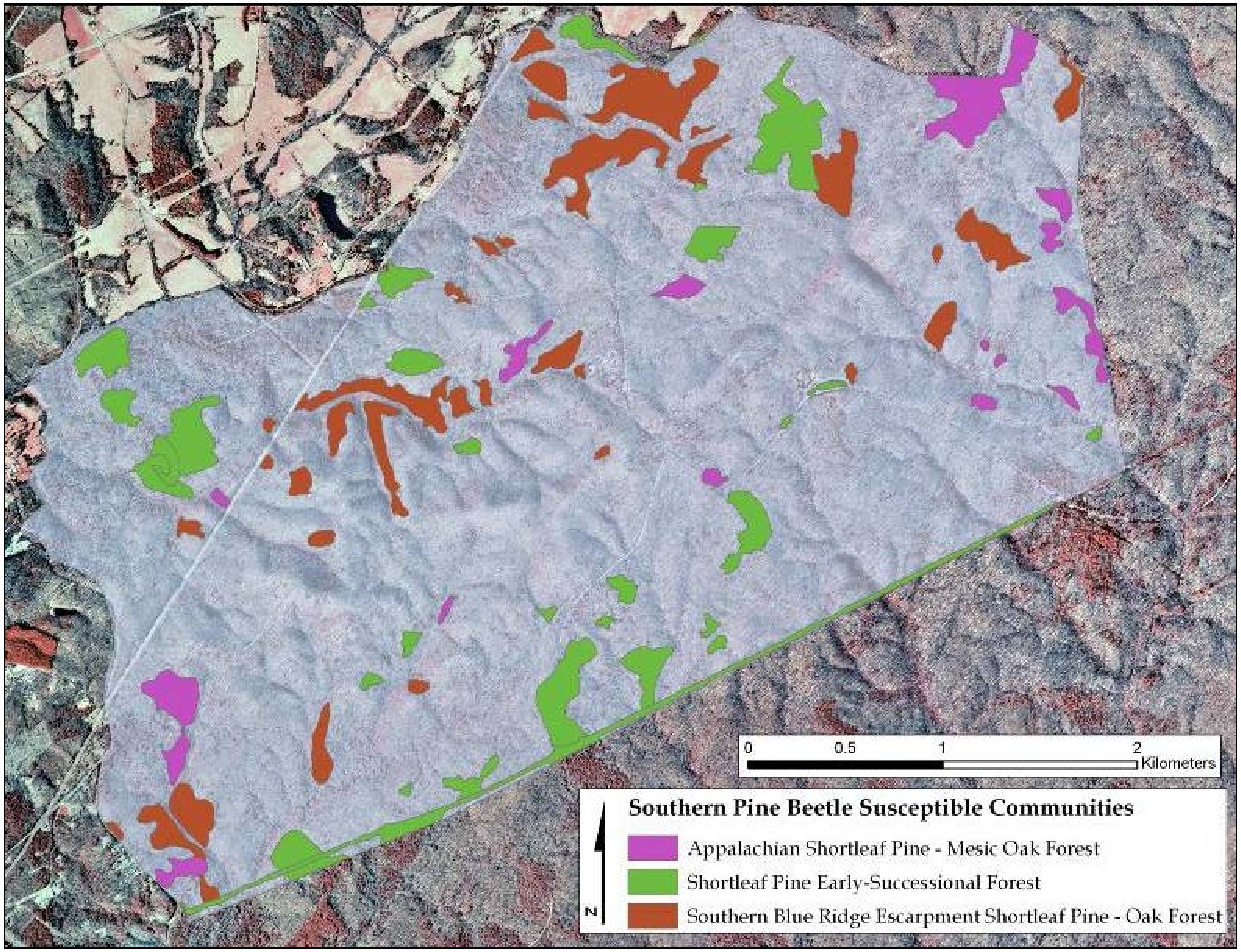


Figure 15. Three communities at KIMO in particular were identified in the vegetation report by White and Govus (2004) as susceptible to southern pine beetle infestation.

Vegetation Communities

Forest Communities

Overall, NatureServe outlined 25 unique vegetation types in the park based on surveys in 2002 (White and Govus 2004). According to their report, three of the rarer US National Vegetation Classification (USNVC) types containing a large portion of the vascular plant biodiversity are the Piedmont Small-Stream Sweetgum Forest (CEGL004418; 39 ha), Piedmont Low-Elevation Headwater Seepage Swamp (CEGL004426; <1 ha), and Piedmont Mesic Basic Oak-Hickory Forest (CEGL003949; <1 ha) (Figure 13; Grossman et al. 1998a; NatureServe 2009). The community receiving the highest NatureServe global-rank assignment of G2G3 is the Piedmont Chestnut Oak – Blackjack Oak Woodland (CEGL003708) (2 ha).

NatureServe assigns each community type in its database a conservation status rank based on their overall risk of elimination. These rankings are assigned after the name of a community with a number from 1 to 5 (1=critically imperiled, 2=imperiled, 3=vulnerable, 4=apparently secure, 5=secure), along with a letter denoting the scale of the assignment (G=Global, N=National, S=Subnational). For example, a community assigned a rank of G1 would indicate global critical imperilment. Ranks with a question mark are inexact, denoting uncertainty (NatureServe 2009).

Focal Communities

In KIMO, the Piedmont Small-Stream Sweetgum Forest (CEGL004418; G3), is affected by exotic species and other factors such that patches remaining at KIMO are of low quality (White and Govus 2004). Within the park, this community has also been influenced by human activities like historical agriculture, grazing, timber harvest and upstream erosion, resulting in low-quality examples despite its relatively high global ranking (Figure 17).

The Piedmont Low-Elevation Headwater Seepage Swamp (CEGL004426; G3?) is unique for its presence of wetland species such as rush (*Juncus* spp.) and sedge (*Carex* spp.). At KIMO, it occurs in small patches throughout the park, potentially occupying hundreds of locations in upper watershed areas (Figure 17). It is characterized by a red maple canopy (>25% canopy cover) and cinnamon fern understory (*Osmunda cinnamomea*; White and Govus 2004).

Piedmont Mesic Basic (alkaline) Oak-Hickory Forest (CEGL003949; G3?) is a rare forest type, and has only been officially documented at KIMO according to the NatureServe (2009) database (Figure 17), though it predicts additional sporadic locations in areas throughout the southeast. NatureServe (2009) speculates this forest type most likely exists elsewhere in the Piedmont of VA, GA, AL, or SC, thus earning a G3 ranking with uncertainty. The NatureServe database also indicates, however, that any other potential occurrences of this community type are most likely not currently protected. The single patch at KIMO is located on a predominately north-facing ravine in a creek slope, and contains rich, mesic, and basic soil properties that are most often associated with Appalachian cove forests. These unique conditions may be the result of geologic properties of the site, such as a diabase intrusion as predicted by White and Govus (2004).

Piedmont Chestnut Oak – Blackjack Oak Woodland (G2/G3) is associated with the regional Battleground schist geologic association, and is usually linked with a southern aspect downslope of monadnock forests at KIMO (Figure 17). This community type depends on periodic fire, a xeric environment, and quartzite soil formations—a rare combination which explains its regional infrequency. It is classified as a woodland due to its low canopy cover (<60%), and is dominated by chestnut oak (*Quercus prinus*) and blackjack oak (*Quercus marilandica*) in the overstory and typically panicgrass (*Dichanthelium* spp.), brackenfern (*Pteridium aquilinium*), and little bluestem (*Schizachyrium scoparium*) in the herbaceous layer, along with a wide assortment of wildflowers.

White and Govus (2004) recorded disturbance information for vegetation types at each of the 21 NatureServe plots (Figure 16). These disturbances ranged from 1 to 3 specific observations for each plot. The most common disturbance was evidence of historical logging on nine of the plots, whereas six of the plots showed evidence of pine beetle and dogwood anthracnose. Surprisingly, most of the plots with southern pine beetle occurred in the northeast section of the park, whereas the highest areas of the risk depicted for KIMO by the FHM regional models (Figure 14) falls within the western section of the park. Plot 17 in the northwest boundary of the park was the only plot noted for significant invasives, which most likely stems from its proximity to the surrounding landscape and development.

Wetland Communities
Wetlands contain a unique vegetation composition, and in turn can provide habitat for a distinctive set of animal species. In 1998, the NPS issued a directive proclaiming a goal of "no net loss of wetlands," as well as the adoption of the wetlands classification system described by Cowardin et al. (1979) as the standard for NPS wetlands inventories (Mainella 2002). Using this system, wetlands are classified into 1 of 5 general categories, and then subcategorized based on hydrologic regime, water chemistry, or plant composition (Roberts et al. 2006). A shorthand notation corresponds with each combination of descriptors. Although National Wetlands Inventory (NWI) imagery from 1989 does not identify any wetlands at KIMO, field work conducted by Roberts et al. (2006) identified 74 wetland areas totaling 1.72 ha (Figure 18). Wetland presence was identified in part by surface water presence, vegetation type, and indicator species such as sedge (*Carex* spp.), royal fern (*Osmunda regalis*), giant cane (*Arundinaria gigantea*), and alder (*Alnus serrulata*; Roberts and Morgan 2006).

Based on the Cowardin et al. (1979) system, Roberts et al. (2006) classified the majority (46) of the wetlands as palustrine under deciduous forest (PF01). Twenty-six were classified as palustrine scrub-shrub (PSS). The remaining two were classified as palustrine emergent (PEM) and a rubble-dominated streambed (R4SB). Each of these four classes were further subdivided according to hydrologic regime as either temporarily flooded (flooded <2 weeks during the growing season), seasonally flooded (flooded >2 weeks during the growing season), or saturated (saturated substrate for most of the growing season, but rarely flooded; Roberts et al. 2006). Palustrine generally refers to inland areas with persistent vegetation such as trees, shrubs, emergent vascular plants, mosses, and lichens (Cowardin et al. 1979). Only one wetland area was riverine, which refers to its location contained within a river channel where water is usually moving. In all, twenty-six of the wetlands were dominated by scrub-shrub vegetation, whereas 3 were dominated by evergreen vegetation (Roberts et al. 2006).

Because the Cowardin et al. (1979) wetland classification system does not incorporate the source of hydrology for each wetland, their landscape position, or hydrodynamics, Roberts et al. (2006) further provided a hydrogeomorphic class for each wetland based on Brinson (1993). Wetlands were hydrogeomorphically classified according to Brinson (1993), which complements the plant community and hydrologic regime description of Cowardin et al. (1979) by also indicating the landscape setting and hydrological source. Using this classification, seventy-one of the sites were identified as slope wetlands, implying that they would not store surface water. The remaining riverine classes would store surface water and also maintain higher levels of nutrient and carbon export (Roberts et al. 2006). Carbon export is highest for wetland areas adjacent to a stream or river due to long periods of contact between litter and surface water (Mulholland and Kuenzler 1979), and vegetative cover also plays a large role in the amount of organic carbon loading (Mattson et al. 2009). At the 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 and even effects of climate change.

Roberts et al. (2006) also classified each wetland area according to its ability to provide cultural, research, and economic values based on accessibility, past history, aesthetics, presence of unique species, and flood mitigation potential. Consequently, only the single 0.1 ha riverine wetland was identified as having economic value due to its flood mitigation ability. Fifteen wetlands were identified as important scientifically, due mainly to their size and presence of breeding amphibians. Eleven sites were identified as culturally significant, either due to past human use or their location adjacent to trails that would facilitate educational access. Finally, Roberts et al. (2006) identified exotic species present at each site, the most common of which included multiflora rose (*Rosa multiflora*), Japanese stiltgrass, and Japanese honeysuckle.

Summary
There is currently no recommended protocol or ranking system in place for vegetation communities, and as a result, we did not assign a ranking to this vital sign for forest and wetland areas, which together form the main vegetation communities at KIMO (Table 16). Despite this, data collected by NatureServe and vegetation classifications performed by the CRMS provide a thorough baseline knowledge of vegetation resources at KIMO. 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 16. The condition status for vegetation communities at KIMO 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		

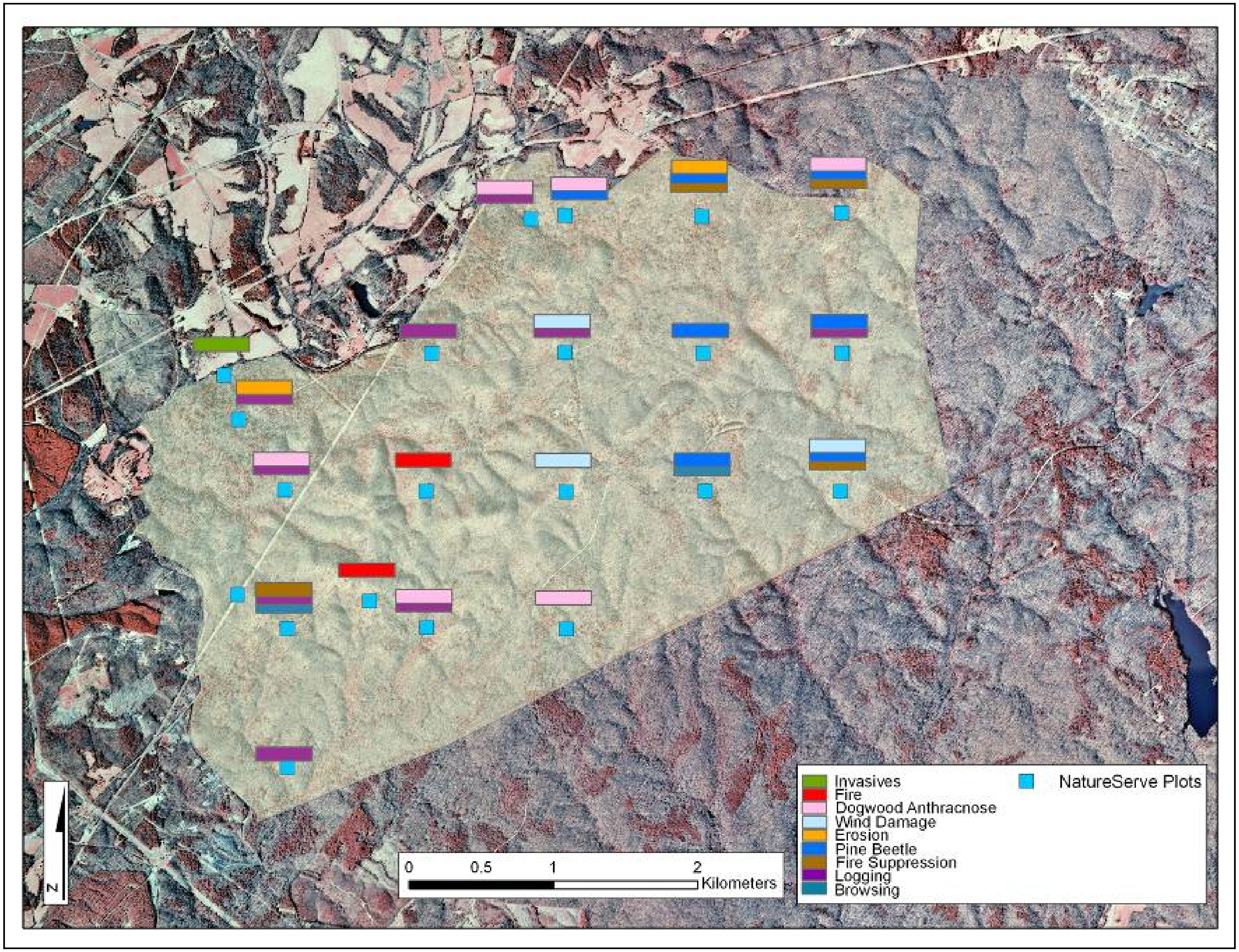


Figure 16. Threats or disturbances identified within each of the vegetation survey plots in KIMO during 2001-2002 NatureServe sampling (White and Govus 2004). Colored bars represent disturbances identified at each plot corresponding to bars in the legend.

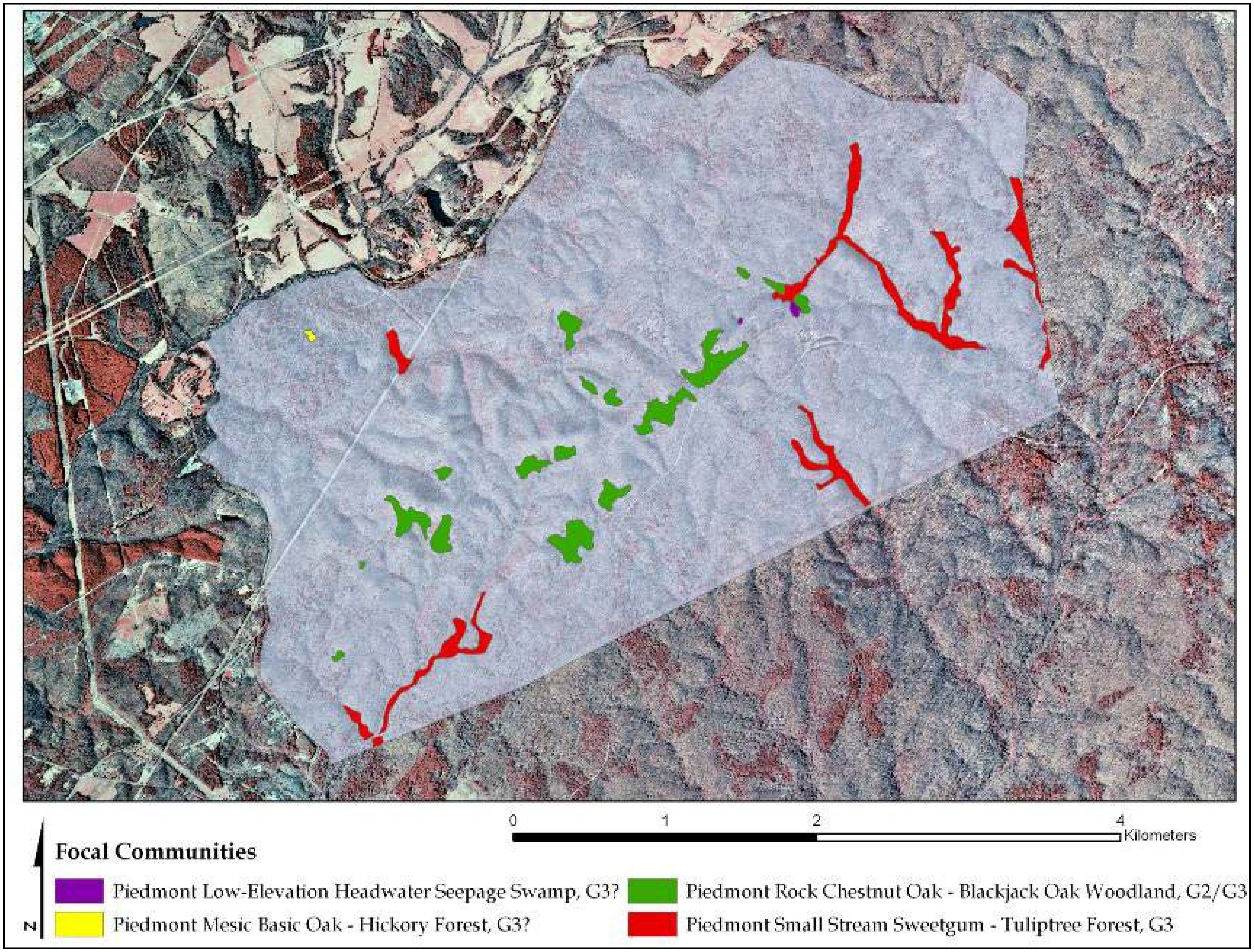


Figure 17. Four vegetation communities classified by Jordan and Madden (2008) at KIMO have significant global ranking status (NatureServe 2009).

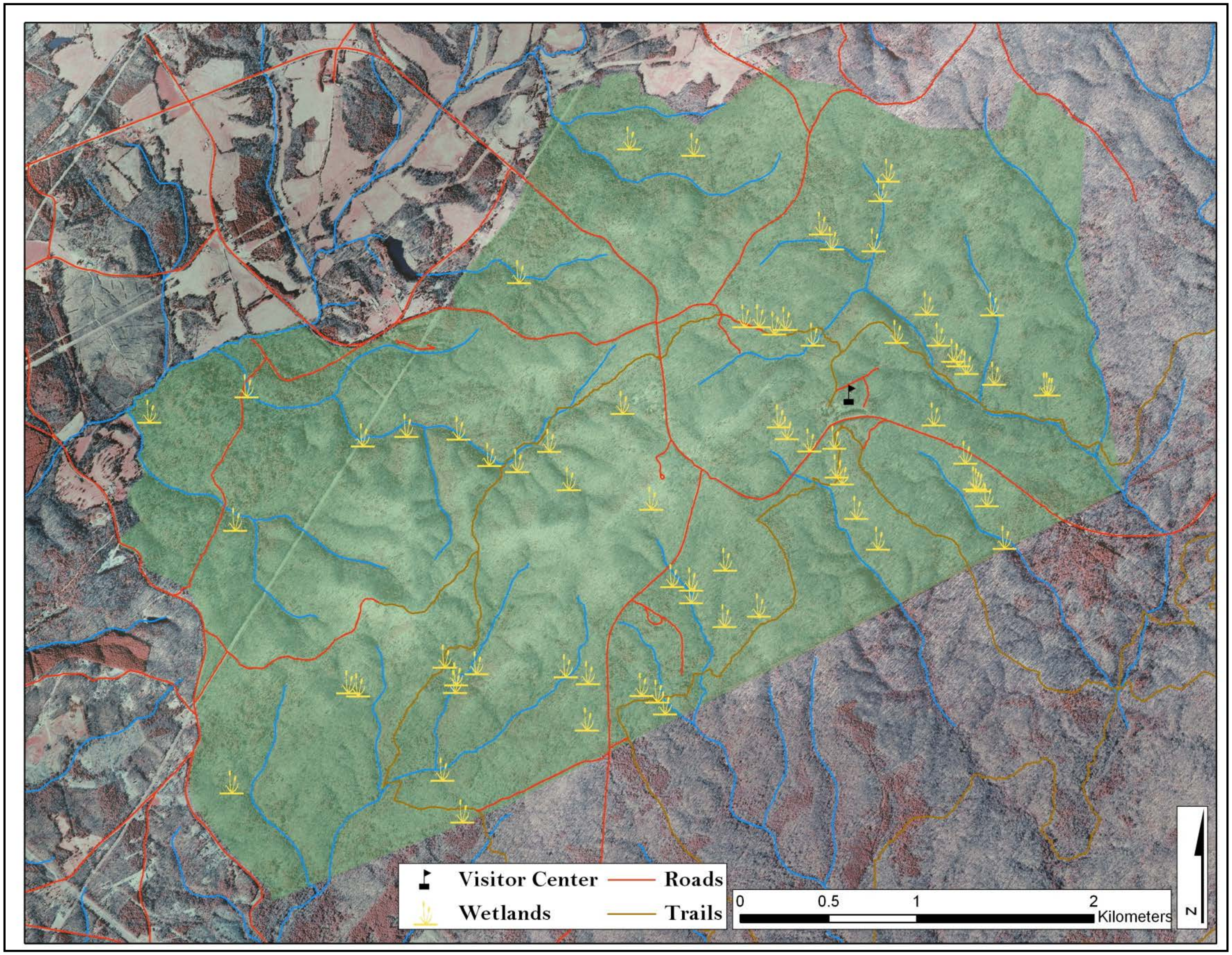


Figure 18. Roberts et al. (2006) identified 74 wetlands in KIMO during field work conducted in spring and summer 2003.

Fish Communities

The southeastern United States supports the richest fish diversity in North America, north of Mexico, and native fishes are of great conservation concern in the region (Warren et al. 2000). Kings Mountain NMP contains over 20 streams, totaling around 29 km in length, the majority of which are first order headwaters. Park streams drain two catchments of the Upper Broad River basin, which is included in the Santee River drainage. Long Branch and its tributaries drain the eastern portion of the park, and Kings Creek and its tributaries drain the northern and western portions (Figure 19). All park streams except Kings Creek originate within or near park boundaries. Portions of flows downstream of KIMO to the south and east are further protected by Kings Mountain State Park.

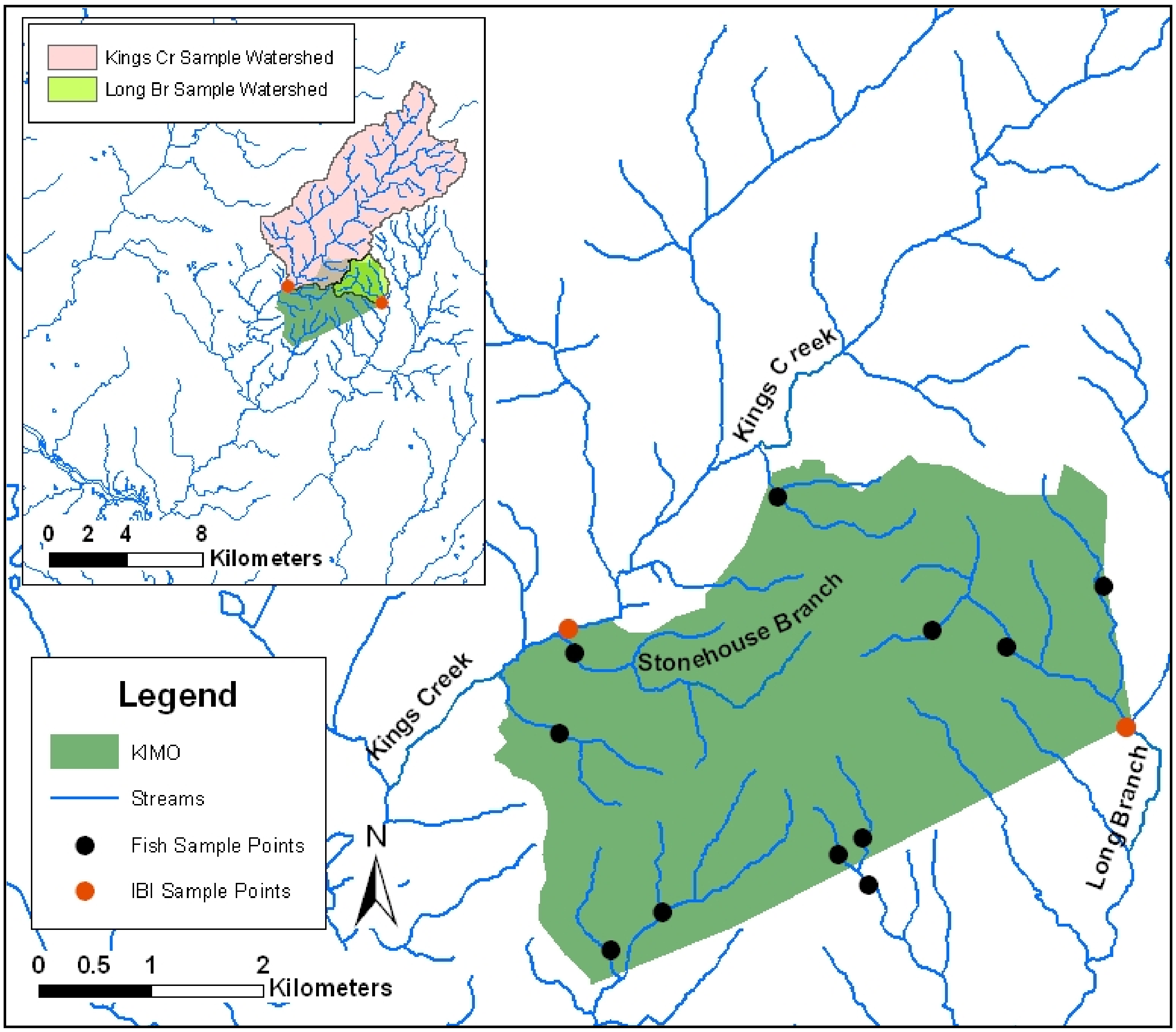


Figure 19. Streams in and around Kings Mountain National Military Park showing fish sampling locations from a 2001-2003 survey and a 2006 survey. Orange points identify samples used to calculate IBI scores. Inset shows the broader area including the watershed areas upstream of Kings Creek and Long Branch sampling locations (Rogers 2003; Scott 2006).

Two surveys of KIMO fishes have been conducted. Rogers (2003) conducted a two-year survey of KIMO fishes. From March, 2001 to February, 2003, he sampled on 12 days at 11 stream sites from which he identified around 25 unique sampling locations consisting of individual pools, runs, or short reaches. Rogers (2003) used backpack electrofishing equipment and reported 930 individuals of 19 species from five families (Table 17). He observed higher species richness in the Kings Creek drainage than in the Long Branch drainage, and the most commonly reported species were members of the Cyprinidae family (Rogers 2003). Scott (2006) used single-pass upstream backpack electrofishing to inventory KIMO fishes in the summer of 2006. On three days in late May and early June, he sampled eight park streams over reaches ranging from 20 to 168 meters (Scott 2006). Scott (2006) reported 1329 individuals of 19 species from five families (Table 17). The most commonly sampled species were members of the Cyprinidae family (Scott 2006). The single smallmouth bass (*Micropterus dolomieu*) found in Kings Creek was not endemic to the drainage (Warren et al. 2000; Scott 2006). No federal or state threatened or endangered fishes have been reported from the park, although the Carolina darter (*Etheostoma collis*) and the fantail darter (*Etheostoma flabellare*) are listed as species of state concern (SCDNR 2010). Seven species reported from KIMO, V-lip redhorse (*Moxostoma pappillosum*), greenfin shiner (*Cyprinella chloristia*), greenhead shiner (*Notropis chlorocephalus*), highback chub (*Hybopsis hypsinotus*), flat bullhead (*Ameiurus platycephalus*), Carolina darter, and fantail darter, were included in the state's Comprehensive Wildlife Conservation Strategy (CWCS) as species of priority conservation concern (SCDNR 2005).

The combined efforts of these inventories reported 27 fish species in KIMO (Rogers 2003; Scott 2006; Table 17). Several differences between the results of these inventories were noteworthy. Of six species of Catostomidae (suckers) reported, none were common to both efforts. The brassy jumprock (*Scartomyzon* sp), an undescribed species reported by Rogers (2003), was possibly the same species as the striped jumprock (*Scartomyzon rupiscartes*) reported by Scott (2006). Furthermore, suckers were relatively uncommon in both samples and random factors might account for differences in observed assemblages. More important differences were reported between Cyprinidae assemblages. Rogers (2003) reported greenhead shiners (*Notropis chlorocephalus*) and dusky shiners (*Notropis cummingsae*) and did not report yellowfin shiners (*Notropis lutipinnis*). Scott (2006) did not report greenhead or dusky shiners, but reported yellowfin shiners as the fourth most abundant species in his sample (7%). Furthermore, Scott (2006) reported a greater relative abundance of creek chubs (*Semotilus atromaculatus*) and a lower relative abundance of sandbar shiners (*Notropis scepticus*) compared to Rogers (2003).

Table 17. Fish families, species, and individuals reported from the streams of Kings Mountain NMP by Rogers (2003) and Scott (2006).

Scientific Name	Common Name	N (Rogers)	N (Scott)
Catostomidae			
Catostomus commersonii	White sucker		5
Hypentelium nigricans	Northern hog sucker		17
Moxostoma macrolepidotum	Shorthead redhorse	3	
Moxostoma pappillosum	V-lip redhorse	1	
Scartomyzon rupiscartes	Striped jumprock		9
Scartomyzon sp.	Brassy jumprock	11	
Centrarchidae			
Lepomis auritus	Redbreast sunfish	20	64
Lepomis cyanellus	Green sunfish	1	
Lepomis macrochirus	Bluegill		2
Lepomis microlophus	Redear sunfish	1	
Micropterus dolomieu	Smallmouth bass		1
Cyprinidae			
Clinostomus funduloides	Rosyside dace	311	359
Cyprinella chloristia	Greenfin shiner	19	4
Hybopsis hypsinotus	Highback chub	5	79
Nocomis leptocephalus	Bluehead chub	109	296
Notropis chlorocephalus	Greenhead shiner	20	
Notropis cummingsae	Dusky shiner	48	
Notropis hudsonius	Spottail shiner	1	
Notropis lutipinnis	Yellowfin shiner		158
Notropis scepticus	Sandbar shiner	236	21
Semotilus atromaculatus	Creek chub	31	257
Ictaluridae			
Ameiurus platycephalus	Flat bullhead		1
Noturus insignis	Margined madtom	5	11
Percidae			
E. flabellare complex	Fantail darter	27	11
Etheostoma collis	Carolina darter		1
Etheostoma olmstedi	Tessellated darter	54	26
Etheostoma thalassinum	Seagreen darter	27	7

These reported differences could result from actual changes in fish assemblages, differences in sampling, misidentification of species, random sampling error, or a combination of these factors. Both inventories were conducted during periods of relative drought. We used data available from the National Climate Data Center (South Carolina, Division 3; NCDC 2010) to examine the monthly drought severity over a period including both inventories. We used the monthly Standardized Precipitation Index (SPI) for a 12-month period (McKee et al. 1993; Figure 20). This index is based upon accumulated precipitation and ranges from -3 to +3 with negative values denoting dry periods and positive numbers denoting wet periods (McKee et al. 1993). Most of Rogers' (2003) sampling was conducted during an unusually severe drought, including months with the lowest 12-month SPI observed since 1955. Scott's (2006) sampling was conducted over a shorter time frame during a period of moderate drought. Drought conditions and flow regimes can affect stream fish assemblages (Grossman et al. 1998; Keaton et al. 2005; Grossman et al. 2010), and could account for some of the differences between the studies. Grossman et al. (2010) observed higher Shannon's Diversity (H') values for fish assemblages sampled during drought relative to assemblages sampled during non-drought flows. The H' calculated from the entire combined samples collected by Rogers (2003) was 2.0, and the H' calculated from Scott's (2006) samples was 1.4, suggesting that severe drought in the region in 2001-2002 may have caused assemblage level changes in KIMO fish. Rogers (2003) collected fish over a longer time period and sampled a greater number of locations than Scott (2006) did, raising the possibility that differences in sampling could contribute to the different assemblages reported by the inventories. Rogers (2003) did not report reach distances sampled so effort is not directly comparable between studies. However, because species richness was identical for both studies, and because Scott (2006) reported more individuals from his sampling, there is no support for the theory that total sampling effort differed between studies. The greenhead shiner and the yellowfin shiner are closely related and morphologically similar species (Wood and Mayden 1992). Yellowfin shiners in the Broad-Santee basin have exhibited subtle morphological differences from other populations, making them potentially even more difficult to distinguish from greenhead shiners (Wood and Mayden 1992). Therefore, we believe it is quite possible that the greenhead and yellowfin shiners reported from these efforts were the same species.

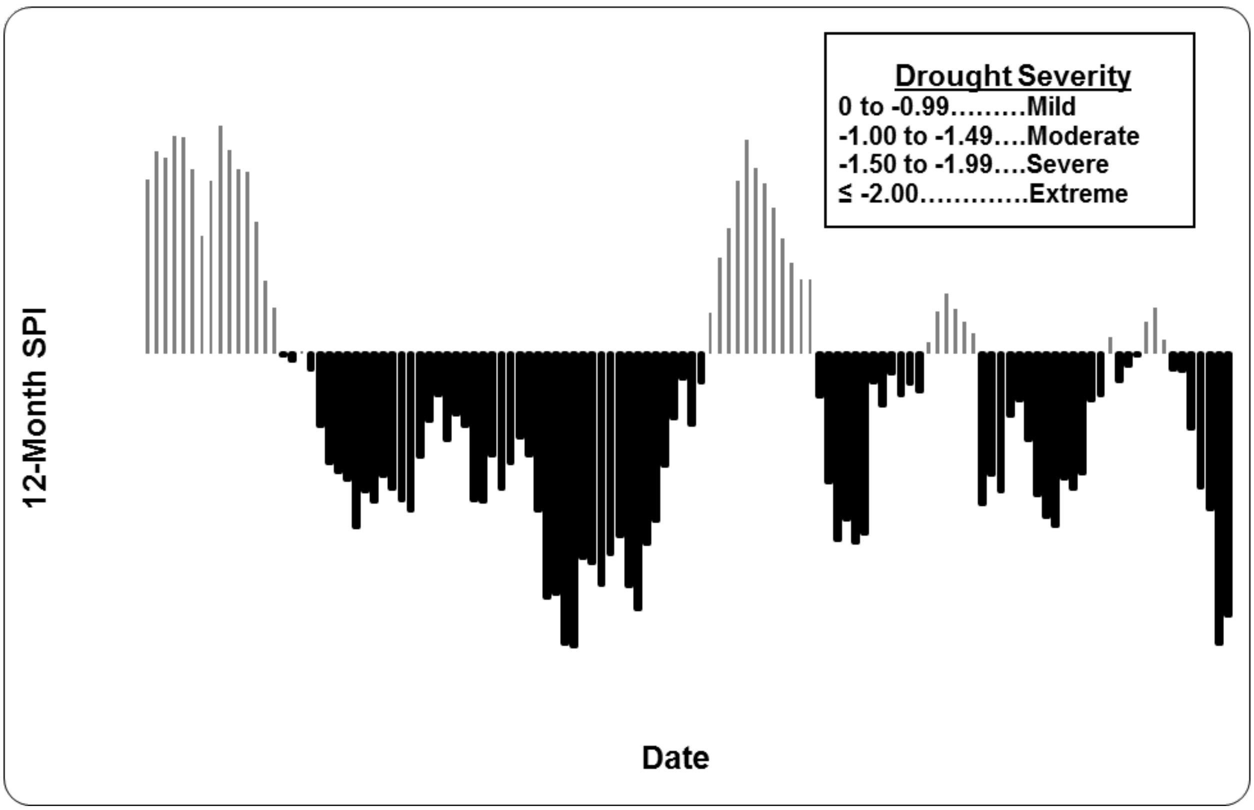


Figure 20. Monthly Standardized Precipitation Index values calculated from accumulated precipitation over preceding 12-month periods. Values are for a 10-year period for the climate district containing Kings Mountain NMP. Red bars indicate months during which Rogers (2003) collected fish samples in the park, green bars indicate months during which Scott (2006) sampled fish in the park.

Fish are good indicators of freshwater habitat quality. They are nearly ubiquitous in freshwater streams, occur in diverse communities including multiple trophic levels, are relatively easy to sample and identify, and are widely studied (Karr 1981). To assess the condition of fish assemblages and habitat at KIMO, we used an index of biotic integrity (IBI) to evaluate the Scott (2006) samples for Kings Creek and Long Branch. The IBI approach to evaluating aquatic resources assesses fish communities based upon relative density and diversity of sampled populations, as well as the life history attributes and the ecological roles of community species. Generally, sites in good condition contain a wide diversity of trophic specialists, and relatively high proportions of specialized and sensitive species. The North Carolina IBI (NCIBI) was developed, tested, and widely used as an assessment tool across the mountain and piedmont ecoregions of North Carolina (NCDENR 2006). The index was developed for applicability across a broad region including the Upper Broad drainage basin, and all fish species reported at KIMO were included in the NCIBI species list. Therefore, we believed it to be robust for use in KIMO. The NCIBI was developed using samples taken over 600-foot reaches. The Kings Creek sample was taken over a 551-foot (168 m) reach, and the Long Branch sample was taken over a 367-foot (112 m) reach (Scott 2006). The NCIBI was designed to assess watersheds of 2.8 square miles and larger (NCDENR 2006). The Long Branch sample watershed was 1.8 mi^2. Because the park sample did not include data about fish condition or size, two metrics could not be calculated and raw scores were adjusted for a 10-metric index as suggested by the authors (NCDENR 2006). Due to these caveats, some caution is warranted when interpreting this index for KIMO habitats.

Kings Creek and Long Branch samples both scored high within the “good” category (Table 18). Scott (2006), commenting upon KIMO fish assemblages, suggested that park aquatic resources were “among the highest quality in the state.” Although the differences between the two sampling efforts may be important, the assemblage reported by the most recent inventory, considered alone, indicated that the park contained high-quality fish habitat and robust populations of native fishes. We ranked the quality of the KIMO fish communities as good (Table 19). The quality of the data was good. We did not assign a trend to fish community quality.

Kings Mountain NMP contains significant aquatic resources as evidenced by sampled fish populations. The differences between the reported assemblages from the two fish inventories at KIMO may be worth exploring in future sampling efforts at the park. We recommend that future efforts conform to the sample design used by Scott (2006). If managers desire to use the NCIBI for future assessment at KIMO, then sampling reaches of 600 feet should be considered. However, if reaches of this size are sampled, a sub-sample from reaches equal to those used by Scott (2006) should be sampled to provide the most accurate comparison with the baseline inventory. If time and funding are sufficient in future inventories, then collection of fish length, weight, and data on obvious deformities could provide insight on individual fish condition.

Table 18. Metrics and scores from applying the North Carolina fish IBI to fish community samples from Kings Creek and Long Branch during a 2006 fish survey (NCDENR 2006; Scott 2006). X=Log10*watershed area in miles2. IBI interpretation values were: ≤ 34 = Poor; ≥ 36 and ≤ 40 = Fair; ≥ 42 and ≤ 46 = Good/Fair; ≥ 48 and ≤ 52 = Good; ≥ 54 = Excellent.

Metric	**Scoring Criteria**			**Kings Creek**		**Long Branch**	
	1	3	5	Value	Rank	Value	Rank
1: # species	<4.8*X+0.08	≥4.8*X+0.08	≥9.5*X+1.6	16	5	10	5
2: # of fish	<100	100-149	≥150	227	5	459	5
3: # darter spp.	<0.8*X	≥0.8*X	≥1.6*X	3	5	2	5
4: # sunfish/bass spp.	0 or 1	2	≥ 3	3	5	1	1
5: # sucker spp.	0	1	≥ 2	2	5	1	3
6: # intolerant spp	0		≥ 1	3	5	1	5
7: % tolerant	>35%	26-35%	≤25%	19%	5	14%	5
8: % omnivores	<10%, >50%	36-50%	10-35%	38%	3	28%	5
9: % insectivores	<45%, >90%	45-59%	60-90%	60%	5	72%	5
10: % piscivores	<0.24%	0.25-1.0%	≥1.0	0	1	0	1
			Raw score		44		40
			Adjusted NCIBI		**52**		**48**

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

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

Bird Communities

Birds specialize in a variety of terrestrial habitats and are relatively easy to monitor, making them valuable indicators of ecosystem quality and function (Maurer 1993). From March, 2003 to April, 2005, 118 bird species were reported from KIMO (Rogers 2005; Appendix D). In 57 visits to the park covering all seasons, Rogers (2005) used 5-minute point counts taken at 500-meter intervals along established roads and trails. No samples were collected in June, a month in which breeding birds are commonly sampled (Sauer et al. 2008). Rogers (2005) designated 79 of the observed species as permanent or summer residents. Rogers (2005) determined the relative encounter rate of each species based upon the number of individuals sampled per hour during times when the species could conceivably be present in the park. Table 20 shows the 10 most common species, based upon this relative encounter rate.

Table 20. Ten most commonly encountered bird species reported by Rogers (2005) in a KIMO bird survey. Park status is as designated by Rogers (2005). Relative encounter rate is the number of individuals reported per hour for times when the bird could conceivably occur in the park.

Common Name	Scientific Name	Park Status	Relative Encounter Rate
Red-eyed Vireo	*Vireo olivaceus*	Summer Resident	2.62
Tufted Titmouse	*Baeolophus bicolor*	Permanent Resident	2.57
Carolina Chickadee	*Parus carolinensis*	Permanent Resident	2.19
Carolina Wren	*Thryothorus ludovicianus*	Permanent Resident	1.57
American Robin	*Turdus migratorius*	Permanent Resident	1.34
Red-bellied Woodpecker	*Melanerpes carolinus*	Permanent Resident	1.19
American Crow	*Corvus brachyrhynchos*	Permanent Resident	1.08
Blue Jay	*Cyanocitta cristata*	Permanent Resident	1.03
Golden-crowned Kinglet	*Regulus satrapa*	Winter Resident	0.96
American Goldfinch	*Carduelis tristis*	Permanent Resident	0.93

An Avian Conservation Implementation Plan (ACIP) prepared for KIMO suggested managing for several umbrella species that are recognized by Partners in Flight (PIF) as important indicator species for the southern Piedmont physiographic region (Watson 2004). 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 in the baseline bird survey (Rogers 2005). Summer Tanagers were reported 53 times. This species prefers open hardwood or pine-oak stands, often near gaps or habitat edges (Robinson 1996). It is not known to be declining in its eastern range (Robinson 1996). Wood Thrushes were reported 32 times. This interior forest species has been well-studied and has declined in abundance over much of its range since the 1970s (Roth et al. 1996). Although it also nests near edges and in small forest patches, it shows a marked preference for the interior of mature, mixed hardwood forests (Roth et al. 1996). The Wood Thrush is vulnerable to nest predation and nest parasitism, and experiences lower nest success in smaller fragments (Roth et al. 1996). Prairie Warblers were reported three times. This bird nests in a variety of early successional habitat and has been reported as declining in upland habitats while remaining stable in lowland habitats in the southeastern U.S. (Nolan et al. 1999). Acadian Flycatchers were reported nine times. This species requires mature forest containing streams or swampy woodlands (Whitehead and Taylor 2002). Although it is believed to be relatively stable throughout its range, it has been accorded high management priority because it is sensitive to habitat fragmentation and cowbird parasitism (Whitehad and Taylor 2002). A single Louisiana Waterthrush was reported in the survey. The Louisiana Waterthrush nests in hardwood-canopied riparian zones and prefers low order, high gradient flows with robust macroinvertebrate communities (Mattsson et al. 2009). Rogers (2005) did not report Northern Bobwhites from direct observation, but reported second-hand observations from park staff.

Bird 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 forest birds during breeding season in the region containing Kings Mountain NMP. This index was developed by analyzing characteristics of bird species sampled across a range of independently-assessed habitats. Higher scores result when disturbance-sensitive species and species with forest-specialist life history traits are more commonly present relative to nest disrupting species, urban-tolerant species, and exotic species. Using this tool was attractive because it produces a result that can be directly interpreted in terms of quality (defined in terms of anthropogenic disturbance), and also because it uses simple presence data and does not require knowledge of abundance or population parameters. The BCI was developed using a specific standardized sampling protocol, but has been used to compare the relative quality of bird habitat among locations where samples were collected using different protocols (O'Connell et al. 2007). However, even assuming considerable robustness of the tool to some variation in sampling methods, the KIMO bird data were inappropriate for a rigorous application. Therefore we applied the index in a broad and non-spatially explicit manner and present the results only for purposes of discussion.

The BCI was developed using species lists compiled from sets of five 10-minute, unlimited radius point counts spaced along 1-km, randomly-located transects (O'Connell et al. 2003). Kings Mountain point count data were collected using 5-minute, unlimited radius point counts taken at 500-meter intervals along established roads and trails. Available KIMO data were not sufficiently explicit to allow a subsample of observations to be attributed to any specific time, location, or amount of effort. Therefore, we calculated a BCI score from the sub-list of birds designated as summer or permanent residents by Rogers (2005) that were also reported during late spring or summer months in the 2003-2005 KIMO bird survey. The resulting BCI score was 0.75, corresponding to an interpretation of "naturalistic" and representing habitat with relatively low levels of anthropogenic disturbance (O'Connell et al. 2003). Because our bird list represented an unknown but greater amount of effort than was used in the development of the BCI, we examined the sensitivity of the index using randomly reduced versions of our list. Specifically, we randomly removed species from the list until a desired reduction was achieved. We repeated this process five times with a list reduced by 10% and five times with a list reduced by 20%. The mean score for the 10%-reduced list was 0.76 (SD±0.023) and the mean score for the 20%-reduced list was 0.74 (SD±0.036).

Kings Mountain NMP demonstrably contains a relatively rich assemblage of native breeding forest birds, including species specializing in mature, interior forest habitats. A bird condition index calculated from the entire list of breeding birds indicated undisturbed habitat. The baseline bird survey conducted at KIMO provided useful information about the species richness in the park. Sampling was conducted on roads and trails, and not based on a systematic, random, or habitat-based stratified random sampling design. Therefore, the adequacy of coverage of the park is difficult to assess. Although sampling was conducted during all seasons, no samples were collected June in either year of the survey, although June is the peak breeding season for many species. The data were not summarized in a digital format such that the results of individual point counts could be attributed to their specific time and location.

Although the available observations are consistent with those expected from a survey of a good quality bird community, we did not assign a condition to KIMO bird communities (Table 21). Although the data represented a significant amount of effort and made an excellent start at documenting the species richness of the park, we believe the data were insufficient to make a defensible assessment. The data did not receive a thematic check because of the non-standardized methods used to collect the data. The quality of the data was fair and no trend was assigned to bird community condition (Table 21).

Table 21. No condition was assigned to the quality of KIMO bird communities. The quality of the data was fair. No trend was assigned to this condition ranking

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

If future monitoring occurs in the park, we recommend the use of a more standardized approach. If point counts are used, we recommend that counts are collected using an appropriate systematic, random, or stratified random sampling design that covers all park habitats. We recommend using 10-minute point counts and differentiating birds sampled during 0-3, 3-5, and 5-10 minute intervals. We recommend that this data is recorded and stored in an explicit digital format such that results from specific time segments of individual point counts are easily distinguishable.

Mammal Communities

Mammals are important components of grassland and forest ecosystems where they affect plant communities, engineer landscapes, and play roles at multiple trophic levels (Ryszkowski 1975; Marti et al. 1993; Rooney and Waller 2003). Because of great variation in size, behavior, and life history, they are inherently difficult to sample. A survey of terrestrial mammals was conducted at KIMO from March 2004 to April 2005 (Fields 2005). A 2005-2007 baseline bat survey at several piedmont National Park units included KIMO (Loeb 2007). These inventories reported 20 mammal species in the park, including one ungulate, four carnivores, four bats, one marsupial, three insectivores, one lagomorph, and six rodents, representing 53% of the 38 expected mammal species (Table 22).

Fields (2005; 2007b) used Sherman live traps, pitfall traps, bottle surveys, scent station surveys, and trail cameras at set plots in the park, for a combined total of 2,542 trap nights. Fields (2005) also reported on data from previous unpublished efforts by Sewell in 1998-1999. Because of the age and uncertainty of these data, mammals observed only from the Sewell effort were not included here. Fields (2005) further reported mammal sightings by NPS staff and consultants during his study period. These species were included in this report. A single muskrat (*Ondatra zibethica*) was reported from sign but was not included here because of reported uncertainty in the identification (Fields 2005). Using several studies and publications by the author of the KIMO mammal inventory, we prepared a list of 32 terrestrial mammals expected to occur in the park (Fields 2005; Fields 2007a; Fields 2007b; Table 22). Fields' (2005) efforts reported 16 (50%) of these expected species. The expected list included two range expanding species, the coyote (*Canis latrans*), and woodchuck (*Marmota monax*), and three exotic species, the house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), and black rat (*Rattus rattus*). None of these species were observed at KIMO during the inventory. Therefore 59% of expected native species were reported. No state or federally threatened or endangered species were found in these samples. The most commonly encountered mammal was the white-footed mouse (*Peromyscus leucopus*; Fields 2005). Four other unique terrestrial mammal species were reported by Sewell (unpublished) and are not included in Table 22. These were: mink (*Mustela vison*), eastern harvest mouse (*Reithrodontomys humulis*), hispid cotton rat (*Sigmodon hispidus*), and red fox (*Vulpes vulpes*).

Loeb (2007) sampled during winter, spring, and summer months and reported four species of bats (Table 22). Loeb (2007) used the literature and expert knowledge to prepare an expected species list of six bats expected to occur in the park. Of these, the silver-haired bat (*Lasionycteris noctivagans*) and the hoary bat (*Lasiurus cenereus*) were only expected as winter migrants. Bat sampling effort included mist netting at four sites over six nights during the summer, and electronic sampling with AnabatII bat detectors on four summer nights and two winter nights (Loeb 2007). The study reported three of the four (75%) expected residents and o*n*e of the two (50%) expected winter migrants. The adult female red bat captured by mist netting was lactating (Loeb 2007). Bats were detected at nine of the 21 sites where acoustic sampling was used (Loeb 2007). No state or federally listed threatened or endangered species were found in these samples, although the hoary bat (*Lasiurus cinereus*) is considered by the state as a migratory species with poor documentation in the state (SCDNR 2010).

Around 61% of the expected native mammals were reported from KIMO by these combined studies, with 59% of the native terrestrial mammals and 67% of expected bats. Of the missing carnivores, the mink and long-tailed weasel are cryptic, patchily distributed, and difficult to trap (Fields 2007a; Linehan et al. 2008). Of the missing bats, the silver-haired bat was only expected as a winter migrant (Loeb 2007). Fields (2007b) stated that both diversity and abundance of mammals seemed low at KIMO during the 2004-2005 terrestrial mammal survey. Combined trap success for all trapping methods was 1.77% (Fields 2007b). 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). From the 2005-2007 bat survey data, Loeb (2007) stated that the bat captures and bat activity were relatively low at KIMO and that the sampled population was male-biased. She suggested that the heavily forested habitat found at most sample sites might have precluded high bat activity or lowered bat detectability, and suggested that the continuing burn program in the park could positively affect bat populations (Loeb 2007). Exotic, range expanding, and domestic species were not reported in the park (Fields 2005; Loeb 2007).

Table 22. Mammal species expected to occur in Kings Mountain NMP and species actually reported from a terrestrial mammal survey (2004-2005) and a bat survey (2005-2007). Fields=reported by Fields (2005); L=reported by Loeb (2007).

Scientific Name	Common name	Reporter
Order Artiodactyla		
Odocoileus virginianus	White-tailed deer	F
Order Carnivora		
Canis latrans	Coyote	
Lontra canadensis	River otter	
Lynx rufus	Bobcat	F
Mephitis mephitis	Striped skunk	F
Mustela frenata	Long-tailed weasel	
Mustela vison	Mink	
Procyon lotor	Raccoon	F
Urocyon cinereoargenteus	Gray fox	F
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 pipistrelle	L
Order Didelphimorphia		
Didelphis virginiana	Possum	F
Order insectivora		
Blarina carolinensis	Southern short-tailed shrew	F
Cryptotis parva	Least shrew	F
Scalopus aquaticus	Eastern mole	F
Sorex longirostris	Southeastern shrew	
Order Lagomorpha		
Sylvilagus floridanus	Eastern cottontail	F
Order Rodentia		
Castor canadensis	Beaver	F
Glaucomys volans	Southern flying squirrel	F
Marmota monax	Woodchuck	
Microtus pennsylvanicus	Meadow vole	
Microtus pinetorum	Pine vole	
Mus musculus	House mouse	
Ochrotomys nuttalli	Golden mouse	F
Ondatra zibethicus	Muskrat	
Oryzomys palustris	Marsh rice rat	
Peromyscus leucopus	White-footed mouse	F
Rattus norvegicus	Norway rat	
Rattus Rattus	Black rat	
Reithrodontomys humulis	Eastern harvest mouse	
Sciurus carolinensis	Gray squirrel	F
Sigmodon hispidus	Hispid cotton rat	
Tamias striatus	Eastern chipmunk	F

The effort directed toward terrestrial mammal surveys at KIMO had been relatively low at the time of our analysis, with 2,542 trap nights from combined methods. Drift-fence pitfall arrays had not been used in the park. 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 can be particularly effective at sampling shrews and some rodents (Briese and Smith 1974; Bury and Corn 1987). Traditional lethal snap mouse traps are effective at sampling small rodents (Mengak and Guynn 1987; Linehan et al. 2008), but may be undesirable in some settings. Successful trapping programs have specifically targeted edge and riparian habitats as well as open field and upland habitats (Osbourne et al. 2005; Linehan et al. 2008).

Around 61% of the expected native mammals were reported from KIMO by these combined studies, with 59% of the native terrestrial mammals and 67% of expected bats. Of the missing carnivores, the mink and long-tailed weasel are cryptic, patchily distributed, and difficult to trap (Fields 2007a; Linehan et al. 2008). Of the missing bats, the silver-haired bat was only expected as a winter migrant (Loeb 2007). Fields (2007b) stated that both diversity and abundance of mammals seemed low at KIMO during the 2004-2005 terrestrial mammal survey. Combined trap success for all trapping methods was 1.77% (Fields 2007b). 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). From the 2005-2007 bat survey data, Loeb (2007) stated that the bat captures and bat activity were relatively low at KIMO and that the sampled population was male-biased. She suggested that the heavily forested habitat found at most sample sites might have precluded high bat activity or lowered bat detectability, and suggested that the continuing burn program in the park could positively affect bat populations (Loeb 2007). Exotic, range expanding, and domestic species were not reported in the park (Fields 2005; Loeb 2007).

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Recent mammal inventories at Kings Mountain NMP have produced a baseline for understanding mammal diversity in the park. The low observation rate of terrestrial mammals and bats at KIMO, as evidenced by low capture rates, has been remarked upon by researchers performing studies of non-volant mammals (Fields 2005, 2007b), and bats (Loeb 2007). Low catch rates and low observed richness may be partly attributable to the mature forested habitat that dominates KIMO and which may affect both detectability and richness of mammal assemblages. If further sampling is conducted at KIMO, and particularly if efforts have the goal of documenting most of the non-volant mammals present, we recommend the use of significant trapping effort with multiple trapping methods. Comprehensive sampling should include at least small and large live traps, baited camera stations, and drift fence pitfall arrays. Drift fence pitfall arrays are labor intensive to install and are easily visible if placed in areas with high human visitation. However, once in place they can be used over long time periods with minimal maintenance and can be periodically deactivated during non-sampling periods. Furthermore, this sampling method is also effective for sampling herpetofauna and can thus accomplish multiple goals (Bury and Corn 1987; Greenberg et al. 1994; Metts et al. 2001). We recommend that future mammal sampling at KIMO specifically target edge and riparian habitats in addition to forested and open habitats.

We did not assign a condition rank to the mammal community at Kings Mountain NMP (Table 23). The quality of the data was fair, and did not receive a check for the thematic component. Although mammal sampling efforts have been of good quality, we believe that more effort with additional sampling methods would more completely document a representative sample of KIMO mammals.

Table 23. No condition was assigned to the KIMO mammal community. The quality of mammal data was fair. No trend was assigned to mammal community condition.

		Data Quality		
Attribute	**Condition & Trend**	**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 reptiles and amphibians 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 as reproductive and nursery habitat for both amphibians and reptiles (Semlitsch 2000; Gibbons et al. 2000). Kings Mountain NMP has a number of small isolated wetlands (Figure 18) and a number of headwater streams that potentially provide quality habitat for amphibians and reptiles.

There have been two herpetofauna surveys at Kings Mountain NMP. Thomas (2002) used coverboard arrays, dip-netting, glue boards, and unconstrained searches to sample reptiles and amphibians. This effort reported 160 individuals of 35 species: 15 amphibians and 20 reptiles. Reed and Gibbons (2005) used unconstrained searches and road cruising, with minimal use of coverboards for consistency with previous work. This effort reported 37 species: 14 amphibians and 23 reptiles. These surveys, combined, reported 42 species in KIMO (Table 24). Five species were unique to the Thomas (2002) survey, and seven were unique to the Reed and Gibbons (2005) survey. No state or federal threatened or endangered species have been reported from KIMO. The northern cricket frog (*Acris crepitans*), the canebrake rattlesnake (*Crotalus horridus*), and the common snapping turtle (C*helydra serpentine*) were included as species of conservation priority in South Carolina's Comprehensive Wildlife Conservation Strategy (SCDNR 2005). Although Reed and Gibbons (2005) stated that their sampling methods were not suited to producing numerical estimates of relative abundance for individual species, they provided an ordinal rank, based upon their knowledge and experience, indicating which species were relatively most commonly encountered in KIMO. The four species they reported as "very common" were the five-lined skink (*Eumeces fasciatus*), the bullfrog (*Rana catesbeiana*), the northern dusky salamander (*Desmognathus fuscus*), and members of the slimy salamander complex (*Plethodon glutinosus* complex).

The herpetofaunal species richness reported from the combined KIMO inventory results included around 75% of the species expected by Reed and Gibbons (2005; Table 25). Reed and Gibbons (2005) used museum specimen searches, published range maps, and expert knowledge to compile a list of 56 species likely to occur in KIMO (Table 24). The richness reported from KIMO was within the broad range observed from other studies in protected forests in the South Carolina piedmont. Floyd et al. (2002) used drift fences and pitfalls to sample 29 species from the Clemson Experimental Forest in north-western South Carolina. Metts et al. (2001) reported 49 species from the Clemson Forest following sampling with drift fences, minnow and hoop traps, and coverboards. In KIMO, all herpetofaunal groups were relatively well represented by the combined inventories (Table 25). Because a previous study existed, Reed and Gibbons (2005) focused on finding species not previously reported in the park. Reed and Gibbons (2005) stated that the "extensive overlap" between the survey results suggested that the combined efforts had reported a "good portion" of the herpetofaunal species occurring in KIMO. Reed and Gibbons (2005) suggest that species presently unreported from the park but likely to occur include spring peepers (*Pseudacris crucifer*), eastern spadefoot toad (*Scaphiopus holbrookii*), pickerel frogs (*Rana palustris*), four-toed salamanders (*Hemidactylium scutatum*), and one or more species of aquatic turtle. In most cases, these missing species are cryptic and use specialized habitat and could easily be missed in herpetofauna surveys. They suggested that Dellingham Branch and Stonehouse Branch, both on the west side of the park, were locations deserving of further efforts directed at finding hitherto unreported species (Reed and Gibbons 2005).

Table 24. Herpetofauna species likely to occur in Kings Mountain NMP by Reed and Gibbons (2005), and species actually reported during two inventories. T=reported by Thomas (2002); R=reported by Reed and Gibbons (2005).

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

Table 25. Number of species of herpetofauna expected and Kings Mountain National Historical Park, and numbers and percentages of species actually observed during inventories by Thomas (2002) and Reed and Gibbons (2005).

	# Expected	# Observed	% Expected Observed
All Species	56	42	75
Amphibians	22	17	77
Reptiles	34	25	74
Anurans	11	8	73
Salamanders	11	9	82
Lizards	8	6	75
Snakes	21	16	76
Turtles	5	3	60

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

We did not assign a condition to the herpetofaunal community at Kings Mountain NMP (Table 26), although the herpetofaunal community at KIMO is demonstrably rich with around 75% of likely species reported. The observations from KIMO are consistent with observations expected from a high quality assemblage of reptiles and amphibians. Reed and Gibbons (2005) noted that KIMO exhibited the "best" herpetofaunal community sampled among five piedmont parks surveyed. However, we believe that further effort with additional techniques is needed to adequately document a representative sample of KIMO herpetofauna. There are species not included on the "likely" list reported here that could possibly occur in the park. We also acknowledge the difficulty of defensibly ranking herpetofaunal assemblages given the lack of tools and published methods for doing so.

If further herpetofaunal sampling is conducted at KIMO, 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 excellent early understanding of herpetofaunal diversity in the park. Moreover, the understanding of park herpetofauna has greatly benefitted from multiple surveys. The presence of ≥ 5 unique species in each survey highlights the importance of repeated sampling when attempting to document assemblages as completely as possible. 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 et al. (2006; Figure 18), and near the areas in the west of the park identified by Reed and Gibbons (2005) as potentially productive sampling areas.

Table 26. No condition was assigned to the herpetofaunal community at Kings Mountain NMP. The quality of herpetofaunal data was good. No trend was assigned to herpetofaunal communities.

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

At-risk Biota

Although no species at the park are listed as federally threatened or endangered, 22 species were found to be of special concern due to their local and small-scale rarity or habitat vulnerability Sunfacing coneflower (*Rudbeckia heliopsidis*), for instance, exists at only five remaining documented locations in SC, whereas Georgia aster (*Symphyotrichum georgianum*) populations have been reduced to about 63 within their native range. Currently, Georgia aster is included as a candidate for federal listing (Moore 2009). Only 13 populations of Virginia thistle (*Cirsium virginianum*) remain in SC as well. This species is mainly adapted to longleaf/wiregrass savannah ecosystems and moist ecotone regions between dry uplands and streamheads. According to Radford et al. (1968), hairy wild indigo (*Baptisia cinerea*) is documented in 15 SC counties and is accustomed to xeric woodland border regions. Dwarf-flowered heartleaf, a federally threatened species which is the focus of recovery and protection efforts at nearby Cowpens NB, has not been documented at KIMO (Moore 2009).

For their vegetation survey, NatureServe established twenty-one 50 x 20 m monitoring plots within the park spaced on a regular grid (n = 15), with additional plots placed in unique habitat (n = 6) that were unlikely to be sampled via gridded placement (White & Govus 2004). The most recent and comprehensive plant inventories at KIMO were conducted by Kennemore (1995) and White and Govus (2004). The latter documented a total of 525 (γ) species. Average species richness per plot (α) was 45.6. 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 (Whittaker 1972). At KIMO, this value was 6.1. Figure 22 depicts species richness for each of the vegetation types included in the plots, some of which occur in more than one of the sampling plots. The Piedmont Small Stream Sweetgum – Tuliptree forest (CEGL004418) had the highest species richness (S = 112), though this community was represented by only one of the sampling plots. Figure 22 depicts differences in species richness among communities sampled by White and Govus (2004). Other communities with high richness included the Appalachian Shortleaf Pine – Mesic Oak Forest (CEGL8427), Successional Black Walnut Forest (CEGL 7879), Shortleaf Pine Early Successional Forest (CEGL6327), and Piedmont Mesic Basic Oak – Hickory Forest (CEGL3949).

Georgia aster, along with eastern turkeybeard (*Xerophyllum asphodeloides*), are the only two species specifically mentioned in the CUPN monitoring plan for the rare plants vital sign at KIMO. Georgia aster, a G2G3 species, is documented in only three SC counties (USDA 2009), and usually only occurs in populations smaller than $10m^2$. It is currently listed as a candidate for federal-listing status (Moore, 2009). A relict species from fire-maintained post oak savannas, it is subject to numerous stressors in its overall habitat, including general land development, roadside expansion, fire suppression, and kudzu encroachment (NatureServe 2009). Consequently, isolated populations become particularly susceptible to genetic depression because it is non-selfing. This species also is adapted to dispersal via disturbance, and has suffered from fire suppression throughout its range. A unique stressor is a shift towards the use of herbicide control in lieu of mowing. Mowing can enhance dispersal by suppressing competing vegetation, especially around the power line right-of-ways at KIMO where this species generally occurs (NatureServe 2009; White and Govus 2004). Fortunately, the park unit does not currently allow herbicide control in these right-of-way areas (Chris Revels, pers. comm., January 2010).

Eastern turkeybeard has declined in overall range from land-use change, fragmentation, and fire suppression (NatureServe 2009). Currently, eastern turkeybeard exists in only four counties in SC. Because KIMO maintains a regular burn schedule and does not allow herbicide application in sensitive right-of-way areas, it is unlikely that these deleterious conditions affect either eastern turkeybeard or Georgia aster within the park unit. Throughout the overall range of each of these species, however, the condition appears notably more severe.

Figure 21. Georgia aster (*Aster georgianus*) (left) [Photo by Tom Govus; White and Govus 2004] and eastern turkeybeard (*Xerophyllum asphodeloides*) (right) [Photo by Gary Fleming, www.dcr.virginia.gov]

Summary

Of the list of 22 sensitive species found at KIMO (Table 27), only four, including eastern turkeybeard, exist in plot-level records of NatureServe vegetation surveys (White and Govus 2004). Threats and stressors outlined in Table 27 are largely inapplicable at KIMO due to protection afforded by the park unit. As a result, the assigned condition status of “good” (Table 28) for the vital sign rare plants only pertains to the welfare of the populations within the park as they relate to the absence of specific stressors.

Because specific locations and distributions for most of the rare species, including Georgia aster, are unavailable, the spatial data quality criterion was not met (Table 28). Additionally, continued protection and management will likely aid in maintaining these populations of sensitive species, thus the condition status is assigned a trend of “stable,” though more specific data on individual populations, reproduction, persistence, and success for all of the rare plant species would increase the overall data quality of this important resource.

Table 27. List of rare plant species at KIMO (White and Govus, 2004; Kennemore, 2005; Moore, 2009). Threats of decline are as identified by NatureServe (2009).

Species		Conservation status*	Threats of Decline
Soft groovebur	*Agrimonia pubescens*	G5, S1	Unknown
Hairy wild indigo	*Baptisia cinerea*	G3, G4	Fire suppression, habitat loss (pine plantation, development), road maintenance
Meadow sedge	*Carex granularis*	G5, S2	Unknown
Virginia thistle	*Cirsium virginianum*	G3	Habitat loss (pine plantations, development, agricultural clearing), fire suppression
Creeping spikerush	*Eleocharis palustris*	G5, S1?	Unknown
Upland boneset	*Eupatorium sessilifolium* var. *vaseyi*	G5/T3/T5[†]	Unknown
Black huckleberry	*Gaylussacia baccata*	G5, S1	Unknown
Smooth sunflower	*Helianthus laevigatus*	G3/G4, S2	Fire suppression, exotic species (spotted knapweed (*Centaurea maculosa*); Japanese honeysuckle)
Ashy hydrangea	*Hydrangea cinerea*	G4, S1	Unknown
Pale jewelweed	*Impatiens pallida*	G5, S1	
Canada moonseed	*Menispermum canadense*	G5, S2/S3	Unknown
Slender Naiad	*Najas flexilis*	G5, S1	Unknown
Southern Adder's-tongue	*Ophioglossum vulgatum*	G5, S2	Unknown
One-flowered broomrape	*Orobanche uniflora*	G5, S2	Unknown
Grove meadow grass	*Poa alsodes*	G4/G5, S1?	Unknown
Clammy locust	*Robinia viscose*	G3	Unknown
Sunfacing coneflower	*Rudbeckia heliopsidis*	G2, S1/S2	Fire suppression, development, grazing, hydrologic alteration
Biltmore's carrionflower	*Smilax biltmoreana*	G4, S2	Development
Georgia aster	*Symphyotrichum georgianum*	G2/G3	Road maintenance / expansion, development, invasive plants (kudzu), fire suppression
Soft-haired Thermopsis	*Thermopsis mollis*	G3/G4	Land-use conversion and fragmentation, interspecific competition
Pale Manna grass	*Torreyochloa pallida.*	G5, S1	Land-use conversion and fragmentation, sedimentation, forest management
Eastern turkeybeard	*Xerophyllum asphodeloides*	G4, S2	Land-use conversion, habitat fragmentation, forest management, fire suppression

*Listed are global ranking statuses and state status for South Carolina, if any.
[†] Interspecific global classification ranking—although species is secure, variety is only apparently secure.

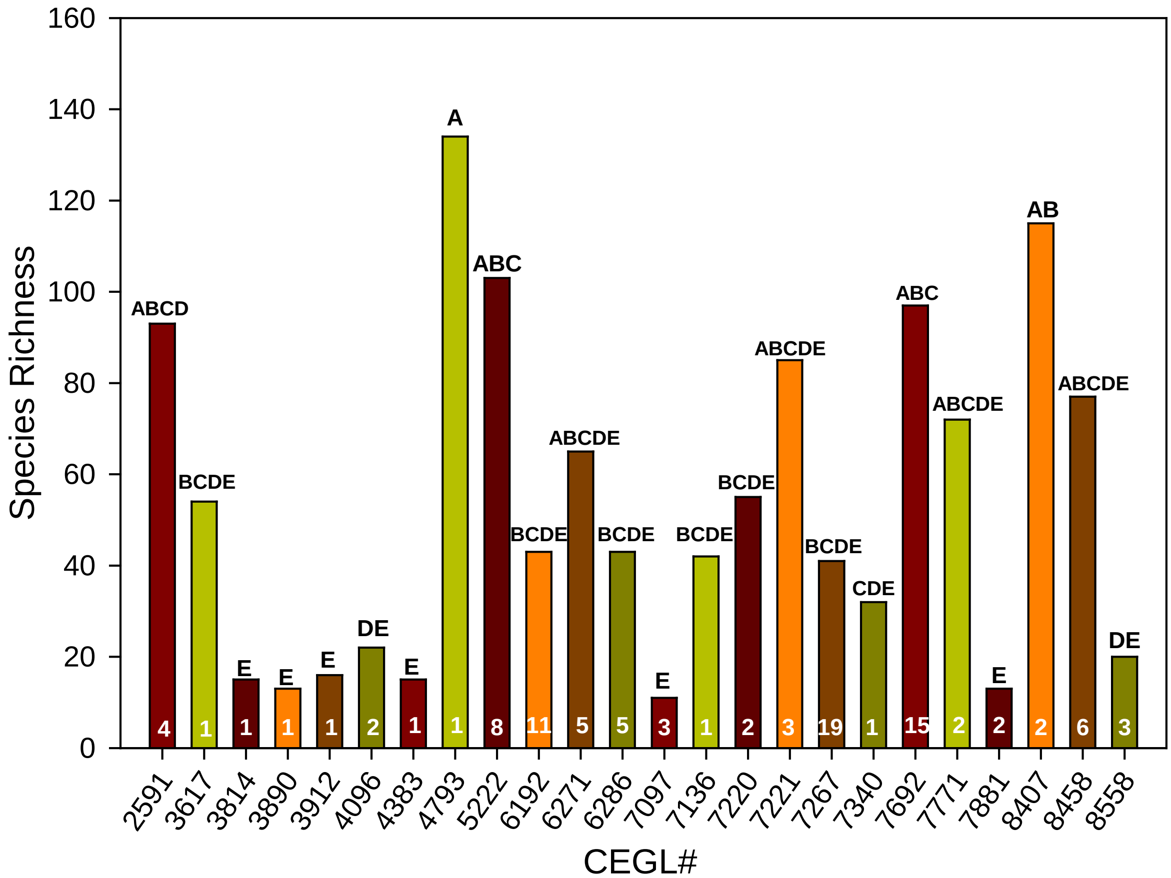

Figure 22. Species richness for each of the community types sampled in the NatureServe plots during sampling in fall 2001 (White and Govus 2004). Significance letters (a - e) depict differences from SAS LSMeans procedure. Plot sample size (*n*) is also given for each CEGL#.

Table 28. The condition status for rare plants at KIMO was good. The data quality used to make this assessment was fair. A trend of stable was assigned to this condition.

Attribute	Condition & Trend	Thematic	Spatial	Temporal
Rare Plants		✓		✓
		2 of 3: Fair		

Landscape Dynamics

CRMS

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 of its location along the I-85 corridor near Greenville and Charlotte, KIMO is particularly prone to the influence and alteration from continued land use change. Infringements on the boundary of the park can serve as vectors for invasive species (Vila and Ibanez 2011), contribute to increased air and depositional pollution, and facilitate water quality degradation. 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 most comprehensive source of landcover information is a detailed classification compiled by the Center for Remote Sensing and Mapping Service (CRMS) at UGA (Jordan and Madden 2008). These data are classified according to NatureServe's list of vegetation community types for NPS units in the southeast, which are in turn outlined by the Federal Geographic Data Committee as the National Vegetation Classification Standard (FGDC 2008).

During fall 2002, aerial color infrared photos were collected during leaf-on by US Forest Service Air Photographics. These images were orthorectified and interpreted using software and manual analysis to assign vegetation types to specific signatures, in addition to repeated ground-truthing to agree on and modify vegetation classifications. Overall, there are 411 patches of 20 vegetation types classified for the 1632 ha encompassing KIMO (Jordan and Madden 2008).

By far, the predominant community is the Southern Red Oak – White Oak Mixed Oak Forest, which comprises 45% of the total area. It is ranked as a G4/G5 community, and occurs on acidic soils away from mesic and riparian creek areas. This community is possibly more closed now than in the past due to an altered fire regime (White & Govus 2004). The forest canopy is typically dominated by southern red oak (*Quercus falcata*), scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*), and black oak (*Quercus velutina*), and the sub-canopy is typically composed of blackgum (*Nyssa sylvatica*) and sourwood (*Oxydendrum arboreum*). Heaths are common in the shrublayer.

The CRMS also used a 400m buffer around the boundary of the park to facilitate landcover comparison within and outside the park (Table 29). Data from the NatureServe categories were reclassified to general landcover types based on their descriptions. Overall, all types of forested land (deciduous, early successional forest, mixed forest) are present in moderately higher proportions within KIMO than in the buffer region, with the exception of coniferous forest. This may be due to a greater number of managed stands surrounding the park area. In addition, the relative abundance of the "other" class, which includes developed land, is higher in the buffer region than within the park unit.

Table 29. Landcover at KIMO and 400m buffer.

Landcover	**400 m buffer**	**KIMO**
	-----ha (%cover)-----	
Coniferous	85 (11%)	47 (3%)
Deciduous	459 (61%)	1283 (78%)
Early Successional	52 (7%)	178 (11%)
Graminoid	87 (11%)	1 (<1%)
Other	34 (4%)	4 (<1%)
Mixed Forest	33 (4%)	134 (8%)
Bare Soil	8 (1%)	<1 (<1%)
Total	**758**	**1647**

TNC

An additional source of landcover data is available from a 1994-1995 classification by the Southeast Regional Office of The Nature Conservancy, who adapted work by Slocumb (1996). Slocumb (1996) produced vegetation maps for 5 small NPS units according to the National Vegetation Classification formation levels, which The Nature Conservancy developed (Maybury 1999). These levels were classified by association based on height and percent cover of the upper canopy strata and are much broader than the specific community types used by NatureServe and CRMS. This method of classification resulted in 356 individual vegetation units within KIMO. After reclassifying the CRMS data to the class level (woodland, forest, shrubland, etc.), 1995 landcover was compared to the 2002 version (Table 30). This comparison documented a transition from woodland to forested areas in KIMO, which may be the result of natural succession. Although this comparison is useful, a 2004 accuracy assessment of the 1995 TNC classification was conducted by NatureServe, which showed an overall poor accuracy of the original TNC classification at KIMO (O'Donaghue, 2005). An overall 67.6% accuracy rate and a 59.2% Kappa index resulted from this assessment, which do not meet the overall NPS accuracy standard of 80%. The Kappa index accounts for classification agreement due to random chance. The most frequent error, according to this assessment, was the misclassification of mixed forest as evergreen or deciduous. However, the accuracy assessment was performed 10 years after the initial classification and also reflects actual changes in the forest composition. Consequently, the data presented in Table 30 should be interpreted with caution.

Table 30. Comparison of landcover types from 1995 (TNC) to 2002 CRMS classifications (Jordan and Madden 2008).

Landcover class	**1995 (NatureServe)**	**2002 (CRMS)**	**Change**
	------ha (% cover)------		
Woodland	238 (15%)	104 (6%)	-8%
Forest	1325 (83%)	1461 (91%)	+8%
Herbaceous/Shrubland	14 (1%)	32 (2%)	+1%
Developed	21 (1%)	4 (<1%)	~0%
Other	1 (<1%)	2 (<1%)	~0%
Total	**1599**	**1603**	**--**

Summary

Despite the available data from the CRMS and TNC landcover classifications, we did not assign a condition ranking to landscape dynamics at KIMO (Table 31). The stability of landcover classes between time periods in the TNC and CRMS comparison 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 KIMO 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 31. The condition status for landscape dynamics at KIMO 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 KIMO, we have addressed the current condition of fourteen natural resources attributes in the park. We provided qualitative condition ranks for nine of the 14 attributes. Five attributes were discussed and not ranked. Seven attributes (50%) were ranked as good, two (14%) were ranked as fair, and none were ranked as poor. The remaining five attributes (37%) were not ranked. Summarized into broad level-1 categories (Table 1) the ranking were:

1) Air and Climate (two attributes)—100% Fair
2) Water (three attributes)—100% Good
3) Biological Integrity (eight attributes)—50% Good, 50% 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 were ranked as fair for the following attributes: ozone, foliar injury, invasive plants, bird communities, mammal communities, rare plants, and land use.

Natural Resource Conditions

Natural resources at KIMO 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:

Although KIMO only conducted preliminary monitoring in 2005 using a POMS, the proximity of Cowpens NB, which has monitored ozone since 1987, allows for inferences about the level of threat at KIMO. In addition, national interpolation maps by the ARD allow a rough estimate of concentrations over the period 1995 – 2007, for which they showed elevated values. At COWP, recent monitoring has also shown elevated measurements and frequent violations of EPA requirements. Recently, ozone concentrations at COWP have dropped into the region of compliance, though they still fluctuate close to the threshold. As a result of these factors, KIMO received a “fair” condition status ranking. Continued growth of the surrounding Greenville metropolitan region could threaten the air quality at both KIMO and Cowpens NB.

Data quality:

By itself, KIMO has relatively little data on ozone, and much of this assessment was based on inferences from monitoring at Cowpens NB. Because most of the ozone data specific to KIMO was from the NPS ARD, however, this condition did not receive a spatial data quality ranking. As long as Cowpens NB maintains continuous monitoring, it is justifiable to use data from that park unit to assess the relative threat of ozone at KIMO.

As of this writing, however, the Air Resources Division recently loaned a POMS that was installed at KIMO in 2011. In addition, KIMO is scheduled to rotate onto the CUPN’s vital signs monitoring schedule in 2013, so there is planned on-the-ground monitoring of ozone levels and foliar injury by the CUPN.

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 interpreted from national interpolation maps was inconsistent at KIMO, 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:
Foliar injury metrics are derived from ozone concentration data, and thus the lack of on-the-ground monitoring at KIMO led to a missing spatial data quality ranking just as it did for ozone condition. Interpolations by the ARD are helpful but most useful when combined with soil moisture metrics like Palmer-Z to assess vulnerability of vegetation during drought and wet periods. Finally, periodic vegetation inventories at KIMO will ensure that sensitive species lists at the park remain up-to-date and will aid in the quick identification of foliar injury. As mentioned above, the new addition of the POMS at KIMO and scheduled vital signs monitoring in 2013 will help in determining the impact of ozone and foliar injury at KIMO.

Hydrology:
Comprised of three condition rankings, overall water quality at KIMO is in good condition. The first, 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." Although mean DO concentrations were well within the recommended range for aquatic life, some of the sampling locations recorded low DO concentrations in 2007, which may suggest that some periods with low DO could inhibit aquatic species.

The second hydrology condition ranking was for microorganisms, for which the monitored parameter changed from fecal coliform to *E. coli* in the most recent monitoring period. Earlier sampling showed high fecal coliform concentrations at two sampling stations on Dellingham Branch, resulting in a significantly higher mean for this location. Subsequent sampling for *E. coli* resulted in no elevated concentrations. Despite the elevated fecal coliform concentrations at a single site, likely a consequence of wildlife feces, the condition status for microorganisms was assigned a ranking of "good."

The third, surface water, is mainly influenced by flow alterations and is largely irrelevant because of the scale of the park, which contains mostly short flow lengths. In addition, with the exception of Kings Creek, all water flow begins inside the park, suggesting that virtually no flow alterations are imposed in the park unit. As a result, this attribute received a "good" ranking.

Data quality:
Data for these three attributes is collected at six stations bi-monthly every other year. Although the current dataset is sparse due to monitoring originating in 2003, this monitoring regime represents an important beginning for KIMO to develop water quality baselines.

Invasive Plants:
The park unit contains several exotic plant species, as well as a handful of especially noxious invasive species. Because of their ability to affect native species and communities, White and Govus (2004) consider exotic plants as perhaps the greatest threat to the ecological health of the park unit. Japanese honeysuckle and Japanese stiltgrass may pose the greatest risk to sensitive communities like the Piedmont Small Stream Sweetgum Forest and Piedmont Seepage Wetlands, in addition to areas such as power line right-of-ways where Georgia aster, a sensitive species, occurs. Despite the threat presented by these species, KIMO has fewer exotic plants for its size than other CUPN park units, and much fewer than surrounding, unprotected areas. Management from prescribed burns and the Southeast Region Exotic Plant Management Team (EPMT) have certainly played a large role in maintaining natural community types. For these reasons, the condition status of invasive plants received a ranking of "good" with a stable trend.

Data quality:
The most recent vegetation inventory on which this assessment is based was conducted in 2004, and therefore this condition status did not receive a temporal data quality ranking. It is possible that management activities and natural progression since that time have altered patterns of invasives in the park unit. It is important that frequent inventory updates or focused monitoring of infested and sensitive areas can help direct eradication efforts.

Insect Pests:
Based on records of previous infestations, the southern pine beetle is the insect pest that likely presents the greatest risk to vegetation communities at KIMO. 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, gypsy moth and ips beetle appear to present little risk at KIMO. Although patterns and frequency of infestation remain somewhat unpredictable, T in the park unit may play a beneficial role in stand susceptibility. 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 and focal communities that provide unique habitat for plant and animal diversity. Currently, this attribute remains unranked, but with the completion of the vegetation monitoring protocol—currently underway—a systematic approach to using this vegetation data will likely become available.

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:
Kings Mountain NMP contains significant high-quality fish habitat. Two fish inventories in the park each reported 19 species with a combined total of 27 species. The difference in assemblages reported by the two efforts was notable. Differences could have resulted from assemblage changes, differences in sampling approach, random sampling error, or misidentification of species. The most recent survey indicated a rich assemblage of native fish. An index of biotic integrity applied to the results of the recent survey from Kings Creek and Long Branch indicated the quality of fish assemblages and fish habitat was good. Comments by the researcher conducting the most recent survey suggested the park ichthyofauna was a suitable reference for regional potential. The condition of the fish community was ranked as "good." A ranking of "excellent" could be warranted, but the differences between the two reports suggest some possibility of major assemblage changes in recent years. No trend was assigned to this condition.

Data quality:
The available fish data were ranked as good. The most recent report was primarily used for assessment and was of high quality. Samples were collected recently using appropriate standardized methods. Efforts adequately sampled the available habitat.

Bird Communities:
The park contains primarily mature forested habitat suitable for native birds. One hundred eighteen bird species were reported from a recent inventory, suggesting KIMO contains a relatively rich bird assemblage. The bird inventory was conducted using point counts, but the count length, spatial coverage, and seasonal timing of the efforts made comparison with other efforts difficult. The methods of summarizing the results did not facilitate analyses that were spatially or temporally explicit. The park demonstrably hosts a relatively rich community of native breeding birds, including species requiring undisturbed mature forest habitat. The condition of the bird community was not ranked. No trend was assigned to bird community condition.

Data quality:
The available bird data were fair. The data could be considered poor for purposes of comparison with other bird monitoring efforts. However, the data represent a very significant effort to document the richness of birds in the park, which was an important goal of the program under which the data were collected.

Mammal Communities:
Recent inventories of terrestrial mammals and bats reported 20 species from the park, representing about 61% of the expected native mammal diversity, with 59% of expected non-volant mammals, and 67% of expected bats. Researchers suggested that the observed terrestrial mammal diversity and capture success was lower than expected, and that the observed capture success and activity levels of bats were relatively low. The low levels of observed mammal capture success may result, in part, from the dominating heavily forested habitat KIMO which may affect both diversity and detectability of species. The condition of the mammal community was not ranked. No trend was assigned to mammal community condition.

Data quality:

The available mammal data were fair. Bat samples were collected recently using appropriate methods in representative park habitats. 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:
Two inventories of KIMO herpetofauna have been conducted. The assemblage of reptiles and amphibians in the park was demonstrably quite rich. The reported herpetofaunal community at KIMO included 42 species. These represented about 75% of the likely herpetofaunal species, with all groups relatively well-represented and salamander being best-represented with 82% of likely species reported. Agreement between the surveys was good, and researchers stated that a good proportion of reptiles and amphibians in the park had probably been documented by the surveys. Nonetheless, because sampling effort to date has relied heavily upon active searching, the results of these surveys may not represent an accurate understanding of the KIMO herpetofaunal richness. The condition of the herpetofaunal community was not ranked.

Data quality:
The available herpetofaunal data were fair. 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 richness in KIMO. Because efforts were not highly standardized, comparisons between efforts and estimates of relative abundance are not possible with the data. Studies have not used the diversity of trapping methods recommended to appropriately sample the expected park richness.

At-Risk Biota:
Although there are several sensitive species present at KIMO, Georgia aster and eastern turkeybeard are the ones specifically mentioned by the CUPN monitoring plan due to their rarity. Little specific information is available on the abundance of these species in the park unit, though both likely benefit from management activities including mowing right-of-way areas and prescribed burning, and continued protection of their habitat in the park will likely ensure improvement of populations of these species. As a result, the condition is assigned a ranking of “good” for this attribute, with a stable trend.

Data quality:
Assessment of this condition was based mainly on plot observations and vegetation inventory by White and Govus (2004). Specific data on the distribution and viability of other sensitive species 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 mostly higher proportions of deciduous forestland and lower proportions grassland and coniferous forest inside the park boundary than in the surrounding buffer area. Another comparison depicting changes over time (1995-2002) shows a transition from woodland to forestland, perhaps representing

natural succession. 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 will be valuable for this condition once an assessment protocol is in place. These sources include recent vegetation maps of KIMO produced by the CRMS and NatureServe, NLCD layers, road density maps, demographic data, and others.

Natural Resource Synthesis

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

Overall, it is difficult to select a single natural resource attribute with the greatest overarching influence on other ecosystems, though perhaps the most apparent risk at KIMO is posed by competition by exotic plant species. These species have 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 may lack resistance to competition and can easily be extirpated from their habitat. The pervasiveness of exotic species throughout various habitats can make 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. Both of these issues are particularly relevant at KIMO due to its close proximity to developed areas and the overall Greenville, SC region. Encroachment may also have effects on water quality of streams at KIMO via atmospheric deposition, which are already susceptible to acidic loading due to naturally low buffering capacities in the majority of park waterbodies. The unique challenge of landscape dynamics is determining which aspects are worth monitoring due to their pertinence to natural resources of interest.

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Appendices

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

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

Appendix A. Continued.

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

Appendix A. Continued.

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

Appendix B. List of plant species included by White and Govus (2004) in their NatureServe vegetation inventory. '*' indicates species presence in park unconfirmed, but probable.

Species	Common name	Species	Common name
Acalypha gracilens	Slender threeseed mercury	*Lindernia monticola*	Piedmont false pimpernel
Acalypha rhomboidea	Virginia threeseed mercury	*Linum striatum*	Ridged yellow flax
Acer palmatum	Japanese maple	*Linum virginianum*	Woodland flax
Acer rubrum	Red maple	*Liriodendron tulipifera*	Tuliptree
Acer rubrum var. *trilobum*	Red maple	*Lobelia amoena*	Southern lobelia
Acer saccharum var. *saccharum*	Sugar maple	*Lobelia cardinalis*	Cardinalflower
Achillea millefolium	Common yarrow	*Lobelia inflata*	Indian tobacco
Agalinis purpurea	Purple false foxglove	*Lobelia puberula*	Downy lobelia
Ageratina altissima var. *altissima*	White snakeroot	*Lobelia siphilitica*	Great lobelia
Agrimonia parviflora	Harvestlice	*Lolium perenne* ssp. *multiflorum*	Annual rye grass
Agrostis perennans	Autumm bentgrass	*Lonicera flava*	Yellow honeysuckle
Ailanthus altissima	Tree-of-heaven	*Lonicera japonica*	Japanese honeysuckle
Alnus serrulata	Hazel alder	*Lonicera sempervirens*	Trumpet honeysuckle
Ambrosia artemisiifolia	Ragweed	*Ludwigia alternifolia*	Seedbox
Ambrosia trifida	Great ragweed	*Ludwigia palustris*	Marsh primrose-willow
Amelanchier arborea	Downy serviceberry	*Lycopodium digitatum*	Fan clubmoss
Amelanchier arborea var. *laevis*	Smooth serviceberry	*Lycopodium obscurum*	Ground pine
Amelanchier laevis	Allegheny serviceberry	*Lycopus uniflorus*	Northern bugleweed
Ampelopsis brevipedunculata	Porcelainberry	*Lycopus virginicus*	Virginia bugleweed
Amphicarpaea bracteata	American hogpeanut	*Lyonia ligustrina*	Maleberry
Aneilema keisak	Aneilema	*Lysimachia ciliata*	Fringed loosestrife
Antennaria plantaginifolia	Plantainleaf pussytoes	*Lysimachia lanceolata*	Lanceleaf loosestrife
Anthoxanthum odoratum	Sweet vernalgrass	*Lysimachia quadrifolia*	Lanceleaf loosestrife
Apios americana	Groundnut	*Lysimachia terrestris*	Earth loosestrife
Aplectrum hyemale	Adam and Eve	*Magnolia fraseri*	Fraser's magnolia
Apocynum androsaemifolium	Flytrap dogbane	*Mahonia bealei*	Beale's Oregon-grape
Apocynum cannabinum	Indianhemp	*Mahonia japonica* X *lorariifolia*	Japanese Oregon-grape
Aquilegia canadensis	American columbine	*Maianthemum canadense*	Canada mayflower
Arabidopsis thaliana	Mouseear cress	*Maianthemum racemosum* ssp. *racemosum*	False Solomon's seal
Aralia spinosa	Devil's walkingstick	*Medeola virginiana*	Indian cucumber
Arctium minus	Lesser burrdock	*Medicago lupulina*	Black medic clover

Appendix B. List of plant species included by White and Govus (2004) in their NatureServe vegetation inventory. '*' indicates species presence in park unconfirmed, but probable (continued).

Species	Common name	Species	Common name
Arenaria serpyllifolia	Thymeleaf sandwort	*Melica mutica*	Oniongrass
Arisaema triphyllum	Jack-in-the-pulpit	*Mentha spicata*	Spearmint
Aristida dichotoma	Churchmouse threeawn	*Mentha piperita* ssp. *piperita*	Peppermint
Aristolochia serpentaria	Virginia snakeroot	*Microstegium vimineum*	Japanese stiltgrass
Aronia melanocarpa	Black chokeberry	*Mimulus ringens*	Allegheny monkeyflower
Artemisia vulgaris	Mugwort	*Minuartia glabra*	Appalachian stitchwort
Arthraxon hispidus	Hairy jointgrass	*Minuartia groenlandica*	Sandwort
Asclepias amplexicaulis	Clasping milkweed	*Miscanthus sinensis*	Chinese silvergrass
Asclepias incarnata ssp. *pulchra*	Swamp milkweed	*Mitchella repens*	Partridgeberry
Asclepias syriaca	Common milkweed	*Mollugo verticillata*	Carpetweed
Asclepias tuberosa ssp. *tuberosa*	Butterfly milkweed	*Monarda clinopodia*	White bergamot
Asclepias variegata	White milkweed	*Monotropa hypopithys*	Pinesap
Asparagus officinalis	Garden asparagus	*Monotropa uniflora*	Indianpipe
Asplenium platyneuron	Ebony spleenwort	*Morus alba*	White mulberry
Aster divaricatus var. *divaricatus*	Heart-leaved aster	*Muhlenbergia schreberi*	Nimblewill
*Aster dumosus**	Bushy aster	*Murdannia keisak*	Aneilima
*Aster lateriflorus**	Calico aster	*Myriophyllum aquaticum*	Brazilian watermilfoil
*Aster patens**	Late purple aster	*Myriophyllum spicatum*	Eurasian water-milfoil
Aster pilosus var. *pilosus**	White old field aster	*Nymphaea odorata*	American white waterlily
Aster solidagineus	White-topped aster	*Nyssa sylvatica*	Blackgum
Aster surculosus	Creeping aster	*Oenothera biennis*	Common evening primrose
*Athyrium asplenioides**	Southern lady fern	*Osmunda cinnamomea*	Cinnamon fern
Athyrium filix-femina ssp. *asplenioides*	Asplenium ladyfern	*Oxalis stricta*	Sourgrass
Aureolaria laevigata	Entireleaf yellow false foxglove	*Oxydendrum arboreum*	Sourwood
Aureolaria virginica	Downy yellow false foxglove	*Oxypolis rigidior*	Stiff cowbane
Barbarea verna	Early yellowrocket	*Packera anonyma*	Small's ragwort
Barbarea vulgaris	Yellow rocket	*Packera aurea*	Golden ragwort
Berberis thunbergii	Japanese barberry	*Packera millefolia*	Piedmont ragwort
Betula lenta	Sweet birch	*Panicum anceps*	Beaked panicgrass
Betula nigra	River birch	*Panicum dichotomiflorum*	Fall panicgrass
Bidens bipinnata	Spanish needles	*Panicum dichotomum* var. *dichotomum*	Forked witch grass
Bidens frondosa	Devil's beggarticks	*Panicum flexile*	Wiry panicgrass

Appendix B. List of plant species included by White and Govus (2004) in their NatureServe vegetation inventory. '*' indicates species presence in park unconfirmed, but probable (continued).

Species	Common name	Species	Common name
Boehmeria cylindrica	Small-spike false nettle	*Panicum virgatum* var. *virgatum*	Switchgrass
Botrychium dissectum	Cutleaf grapefern	*Parthenocissus quinquefolia*	Virginia creeper
Botrychium virginianum	Rattlesnake fern	*Paspalum laeve*	Field paspalum
Bromus cathartica	Rescue brome	*Passiflora lutea*	Passionflower
Bulbostylis capillaris	Densetuft hairsedge	*Paulownia tomentosa*	Princess tree
Buxus sempervirens	Common boxwood	*Perilla frutescens*	Beefsteakplant
Calamagrostis cinnoides	Arctic reedgrass	*Phlox amoena*	Hairy phlox
Calycanthus floridus var. *glaucus*	Eastern sweet-shrub	*Photinia melanocarpa*	Black chokeberry
Calycanthus floridus var. *laevigatus*	Eastern sweet-shrub	*Physalis longifolia* var. *subglabrata*	Longleaf groundcherry
Calystegia sepium	Hedge bindweed	*Physocarpus opulifolius*	Common ninebark
Campanula divaricata	Small bonny bellflower	*Phytolacca americana*	Pokeweed
Cardamine hirsuta	Hairy bittercress	*Pilea pumila*	Canada clearweed
Carex aestivalis	Summer sedge	*Pinus echinata*	Shortleaf pine
Carex atlantica ssp. *atlantica*	Atlantic sedge	*Pinus rigida*	Pitch pine
Carex cephalophora	Oval-leaf sedge	*Pinus strobus*	White pine
Carex crinita	Fringed sedge	*Pinus virginiana*	Virginia pine
Carex debilis	White edge sedge	*Piptochaetium avenaceum*	Blackseed needlegrass
Carex debilis var. *pubera*	White edge sedge	*Pityopsis graminifolia* var. *graminifolia*	Narrowleaf silkgrass
Carex gracilescens	Slender looseflower sedge	*Plantago aristata*	Largebracted plantain
Carex intumescens	Greater bladder sedge	*Plantago lanceolata*	English plantain
Carex laevivaginata	Wooly sedge	*Plantago rugelii*	Rugel's plantain
Carex lurida	Shallow sedge	*Plantago rugellii*	Rugel's plantain
Carex pensylvanica	Pennsylvania sedge	*Platanthera clavellata*	Small green wood orchid
Carex retroflexa	Reflexed sedge	*Platanus occidentalis*	Sycamore
Carex scoparia	Pointed broom sedge	*Poa annua*	Annual bluegrass
Carex styloflexa	Bent sedge	*Polygala curtissii*	Curtiss' milkwort
Carex swanii	Swan's sedge	*Polygala polygama*	Bitter milkwort
Carex virescens	Ribbed sedge	*Polygonatum biflorum* var. *biflorum*	King Solomon's seal
Carya alba	Mockernut hickory	*Polygonatum pubescens*	Hairy Solomon's seal
Carya glabra	Pignut hickory	*Polygonum caespitosum* var. *longisetum*	Oriental ladysthumb
Carya ovalis	Red hickory	*Polygonum cespitosum* var. *longisetum*	Water pepper
Carya pallida	Sand hickory	*Polygonum cuspidatum*	Japanese knotweed

Appendix B. List of plant species included by White and Govus (2004) in their NatureServe vegetation inventory. '*' indicates species presence in park unconfirmed, but probable (continued).

Species	Common name	Species	Common name
Castanea dentata	American chestnut	*Polygonum sagittatum*	Arrowleaf tearthumb
Catalpa speciosa	Northern catalpa	*Polygonum scandens* var. *scandens*	Climbing knotweed
Ceanothus americanus	New Jersey tea	*Polygonum tenue*	Pleatleaf knotweed
Celastrus orbiculatus	Oriental bittersweet	*Polypodium virginianum*	Rock polypody
Cerastium brachypetalum	Gray chickweed	*Polystichum acrostichoides*	Christmas fern
Cerastium fontanum ssp. *vulgare*	Common mouse-ear chickweed	*Populus alba*	White poplar
Cercis canadensis var. *canadensis*	Redbud	*Portulaca oleracea*	Common purslane
Chamaecrista nictitans ssp. *nictitans* var. *nictitans*	Sensitive partridge pea	*Potentilla canadensis*	Dwarf cinquefoil
Chamaelirium luteum	Fairywand	*Potentilla recta*	Roughfruit cinquefoil
Chamaesyce maculata	Spotted sandmat	*Prenanthes altissima*	Tall rattlesnakeroot
Chamaesyce nutans	Spotted sandmat	*Prunella vulgaris*	Heal all
Chelone sp.	Turtlehead	*Prunus cerasus*	Sour cherry
Chelone glabra	White turtlehead	*Prunus serotina* var. *serotina*	Black cherry
Chenopodium album	Lambsquarters	*Pteridium aquilinum*	Bracken fern
Chenopodium ambrosioides	Mexican tea	*Pycnanthemum flexuosum*	Appalachian mountain mint
Chimaphila maculata	Striped prince's pine	*Pycnanthemum verticillatum*	Whorled mountain mint
Chionanthus virginicus	Fringetree	*Pyrularia pubera*	Buffalo nut
Chrysopsis mariana	Maryland goldenaster	*Quercus alba*	White oak
Cimicifuga racemosa	Black cohosh	*Quercus coccinea*	Scarlet oak
Cirsium vulgare	Bull thistle	*Quercus falcata*	Southern red oak
Clematis virginiana	Devil's darning needles	*Quercus marilandica*	Blackjack oak
Clethra acuminata	Mountain sweetpepperbush	*Quercus prinus*	Chestnut oak
Collinsonia canadensis	Richweed	*Quercus rubra*	Northern red oak
Comandra umbellata	Bastard-toadflax	*Quercus stellata*	Post oak
Commandra umbellate	Bastard-toadflax	*Quercus velutina*	Black oak
Commelina communis	Asiatic dayflower	*Ranunculus abortivus*	Smallflower buttercup
Commelina virginica	Virginia dayflower	*Ranunculus bulbosus*	Bulbous buttercup
Conium maculatum	Poison hemlock	*Ranunculus hispidus*	Bristly buttercup
Convallaria majuscula	American lily of the valley	*Ranunculus recurvatus*	Littleleaf buttercup
Conyza canadensis var. *pusilla*	Canadian horseweed	*Ranunculus repens*	Creeping buttercup
Coreopsis major	Stiffleaf coreopsis	*Rhexia mariana* var. *mariana*	Maryland meadowbeauty

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Species	Common name	Species	Common name
Coreopsis tripteris	Tall tickseed	*Rhexia virginica* var. *virginica*	Virginia meadow-beauty
Cornus amomum	Silky dogwood	*Rhododendron arborescens*	Smooth azalea
Cornus florida	Flowering dogwood	*Rhododendron calendulaceum*	Flame azalea
Corydalis sempervirens	Rock harlequin	*Rhododendron maximum*	Rosebay rhododendron
Corylus americana	American hazelnut	*Rhododendron periclymenoides*	Pink azalea
Crataegus flava	Yellowleaf hawthorn	*Rhus copallinum* var. *latifolia*	Winged sumac
Croton willdenowii	Two-fruit rushfoil	*Rhynchospora capitellata*	Brownish beaksedge
Crotonopsis elliptica	Rushfoil	*Rhynchospora recognita*	Globe beaksedge
Cunila origanoides	Common dittany	*Robinia hispida* var. *kelseyi*	Kelsey's locust
Cuscuta	Dodder	*Robinia pseudoacacia*	Black locust
Cymbalaria muralis	Kenilworth ivy	*Rosa bracteata*	Macartney rose
Cyperus retrorsus	Pine barren flatsedge	*Rosa canina*	Dog rose
Cyperus strigosus	Strawcolored flatsedge	*Rosa carolina*	Carolina rose
Cypripedium acaule	Pink lady's slipper	*Rosa multiflora*	Multiflora rose
Dactylis glomerata	Orchard grass	*Rosa palustris*	Swamp rose
Danthonia compressa	Flattened oatgrass	*Rubus argutus*	Sawtooth blackberry
Danthonia sericea	Downy danthonia	*Rubus flagellaris*	Northern dewberry
Danthonia spicata	Poverty oatgrass	*Rubus hispidus*	Bristly dewberry
Daucus carota	Queen Anne's lace	*Rubus occidentalis*	Black raspberry
Dennstaedtia punctilobula	Eastern hay-scented fern	*Rudbeckia hirta*	Blackeyed Susan
Deschampsia flexuosa	Wavy hairgrass	*Rumex acetosella*	Sheep sorrel
Desmodium nudiflorum	Nakedflower ticktrefoil	*Rumex crispus*	Curly dock
Desmodium nuttallii	Nuttall's ticktrefoil	*Sagittaria latifolia* var. *pubescens*	Hairy broadleaf arrowhead
Desmodium rotundifolium	Prostrate ticktrefoil	*Salix caprea*	Goat willow
Dichanthelium boscii	Bosc's panicgrass	*Salix nigra*	Black willow
Dichanthelium clandestinum	Deertongue panicgrass	*Sambucus canadensis*	American elder
Dichanthelium commutatum	Variable panicgrass	*Sanicula canadensis*	Canada blacksnakeroot
Dichanthelium depauperatum	Starved panicgrass	*Sassafras albidum*	Sassafras
Dichanthelium dichotomum	Cypress panicgrass	*Saxifraga michauxii*	Michaux's saxifrage
Dichanthelium dichotomum var. *yadkinense*	Forked witch grass	*Schizachyrium scoparium* var. *scoparium*	Little bluestem
Dichanthelium leucothrix	Rough panicgrass	*Schoenoplectus purshianus*	Weakstalk bulrush
Dichanthelium sphaerocarpon var. *sphaerocarpon*	Roundseed panicum	*Scirpus atrovirens*	Green bulrush

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Species	Common name	Species	Common name
Digitaria sanguinalis	Hairy crabgrass	*Scirpus cyperinus*	Bulrush
Diodia teres	Poor joe	*Scirpus expansus*	Woodland bulrush
Diodia virginiana	Virginia buttonweed	*Scleria reticularis*	Netted nutrush
Dioscorea batatas	Chinese yam, cinnamon vine	*Scutellaria elliptica*	Hairy skullcap
Dioscorea oppositifolia	Chinese yam	*Scutellaria integrifolia* var. *integrifolia*	Hyssop skullcap
Dioscorea quaternata	Whorled wild yam	*Scutellaria lateriflora*	Mad dog skullcap
Diospyros virginiana	Persimmon	*Selaginella rupestris*	Rock spikemoss
Drosera rotundifolia	Roundleaf sundew	*Senecio anonymus*	Small's ragwort
Dryopteris intermedia	Intermediate woodfern	*Senecio memmingeri*	Memminger's ragwort
Dryopteris marginalis	Marginal woodfern	*Senecio* X *memmingeri*	Memminger's ragwort
Duchesnea indica	Indian strawberry	*Sericocarpus linifolius*	Narrowleaf whitetop aster
Dulichium arundinaceum	Threeway sedge	*Sericocarpus asteroides*	White-topped aster
Echinochloa crus-galli var. *crus-galli*	Large barnyardgrass	*Setaria geniculata*	Marsh bristlegrass
Elaeagnus umbellata	Silverberry	*Setaria glauca*	Pearl millet
Eleocharis	Spikerush	*Sida spinosa*	Prickly sida
Eleocharis obtusa	Blunt spikerush	*Silene stellata*	Widowsfrill
Elephantopus tomentosus	Hairy elephantfoot	*Silene virginica*	Firepink
Eleusine indica	Indian goosegrass	*Sisymbrium officinale*	Hedge mustard
Elymus virginicus	Virginia wildrye	*Sisyrinchium mucronatum*	Needle-tip blue-eyed-grass
Epigaea repens	Trailing arbutus	*Smilacena racemosa*	Solomon's plume
Epilobium ciliatum	Hairy willowherb	*Smilax biltmoreana*	Biltmore carrionflower
Eragrostis capillaris	Lace grass	*Smilax glauca*	Cat greenbrier
Eragrostis cilianensis	Lovegrass	*Smilax rotundifolia*	Roundleaf greenbrier
Erechtites hieracifolia	Pilewort	*Solanum americanum*	Smallflower nightshade
Erigeron annuus	Annual fleabane	*Solanum carolinense*	Carolina horsenettle
Erigeron philadelphicus	Philadelphia fleabane	*Solidago arguta*	Atlantic goldenrod
Erigeron pulchellus	Robin's plantain	*Solidago caesia*	Wreath goldenrod
Erigeron strigosus	Daisy fleabane	*Solidago caesia* var. *curtisii*	Mountain decumbent goldenrod
Euonymus alata	Burning bush	*Solidago canadensis* var. *scabra*	Tall goldenrod
Euonymus americana	Strawberry bush	*Solidago curtisii*	Curtis' goldenrod
Euonymus fortunei	Climbing euonymus	*Solidago gigantea*	Late goldenrod
Eupatorium capillifolium	Dogfennel	*Solidago juncea*	Early goldenrod
Eupatorium maculatum	Spotted joepyeweed	*Solidago odora*	Licorice goldenrod

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Species	Common name	Species	Common name
Eupatorium perfoliatum	Boneset	*Solidago odora v. odora*	Licorice goldenrod
Eupatorium purpureum	Sweetscented joepyeweed	*Solidago patula*	Roundleaf goldenrod
Eupatorium rotundifolium var. *rotundifolium*	Round-leaf thoroughwort	*Solidago roanensis*	Roan Mountain goldenrod
Euphorbia corollata var. *corollata*	Northern flowering spurge	*Solidago rugosa*	Wrinkleleaf goldenrod
Euphorbia pubentissima	False flowering spurge	*Sorbus arbutifolia v. arbutifolia*	Red chokeberry
Eurybia divaricata	White wood aster	*Sorbus melanocarpa*	Black chokeberry
Eurybia macrophylla	Bigleaf aster	*Sparganium americanum*	American bur-reed
Eurybia surculosa	Creeping aster	*Sphenopholis nitida*	Shiny wedgescale
Fagus grandifolia	American beech	*Spiraea japonica*	Japanese spiraea
Fragaria virginiana	Wild strawberry	*Spiranthes cernua*	Nodding ladies'-tresses
Fraxinus americana	White ash	*Spiranthes odorata*	Marsh ladies'-tresses
Galax urceolata	Galax	*Stellaria graminea*	Grassy starwort
Galinsoga ciliata	Shaggysoldier	*Stellaria media*	Common chickweed
Galium aparine	Stickywilly	*Stellaria pubera*	Star chickweed
Galium circaezans	Woods bedstraw	*Stipa avenacea*	Eastern needlegrass
Galium latifolium	Purple bedstraw	*Symphyotrichum dumosum*	Rice button aster
Galium tinctorium	Stiff marsh bedstraw	*Symphyotrichum lateriflorum*	Calico aster
Galium triflorum	Fragrant bedstraw	*Symphyotrichum patens*	Late purple aster
Gaura biennis	Biennial beeblossom	*Symphyotrichum puniceum*	Purplestem aster
Gaylussacia baccata	Black huckleberry	*Talinum teretifolium*	Quill fameflower
Gaylussacia ursina	Bear huckleberry	*Taraxacum officinale*	Dandelion
Geranium carolinianum	Carolina geranium	*Teucrium canadense*	Germander
Geum canadense	White avens	*Thalictrum clavatum*	Mountain meadow-rue
Geum vernum	Heartleaf avens	*Thalictrum dioicum*	Early meadowrue
Glandularia canadensis	Rose mock vervain	*Thalictrum revolutum*	Waxyleaf meadowrue
Glecoma hederacea	Creeping charlie	*Thelypteris noveboracensis*	New York fern
Glyceria striata	Fowl mannagrass	*Thermopsis mollis*	Allegheny Mountain goldenbanner
Gnaphalium obtusifolium	Rabbit tobacco	*Thlaspi arvense*	Field penny-cress
Goodyera pubescens	Downy rattlesnake plantain	*Tilia americana* var. *heterophylla*	American basswood
Gratiola viscidula	Short's hedgehyssop	*Tipularia discolor*	Crippled cranefly
Hamamelis virginiana	Witch-hazel	*Toxicodendron radicans*	Poison ivy
Hedera helix	English-ivy	*Tradescantia subaspera*	Zigzag spiderwort
Helianthus divaricatus	Woodland sunflower	*Trautvetteria caroliniensis*	Carolina bugbane
Heuchera americana	American alumroot	*Trifolium pratense*	Red clover
Hexastylis rhombiformis	North Fork heartleaf	*Trifolium repens*	White clover
Hieracium gronovii	Gronovi's hawkweed	*Trillium catesbaei*	Bashful wakerobin

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Species	Common name	Species	Common name
Hieracium paniculatum	Appalachian hawkweed	*Triodanis perfoliata*	Clasping Venus' looking glass
Hieracium venosum	Rattlesnakeweed	*Tsuga canadensis*	Canada hemlock
Hosta sp.	Hosta	*Tsuga caroliniana*	Carolina hemlock
Hosta ventricosa	Blue hosta	*Typha latifolia*	Cat tail
Houstonia caerulea	Azure bluet	*Ulmus americana*	American elm
Houstonia purpurea	Purple bluets	*Utricularia gibba*	Humped bladderwort
Houstonia purpurea var. *purpurea**	Summer bluet	*Utricularia radiata*	Little floating bladderwort
Hydrangea radiata	Silverleaf hydrangea	*Uvularia sessilifolia*	Sessileleaf bellwort
Hypericum calycinum	Aaron's beard	*Vaccinium*	Blueberry
Hypericum gentianoides	Orangegrass	*Vaccinium corymbosum*	Highbush blueberry
Hypericum hypericoides	St. Andrew's cross	*Vaccinium fuscatum*	Black highbush blueberry
Hypericum mutilum	Dwarf St. Johnswort	*Vaccinium pallidum*	Hillside blueberry
Hypericum prolificum	Shrubby St. Johnswort	*Vaccinium simulatum*	Upland highbush blueberry
Hypericum punctatum	Spotted St. Johnswort	*Vaccinium stamineum*	Deerberry
Hypericum virgatum	Sharp-leaf St. Johnswort	*Verbascum thapsus*	Mullein
Hypochaeris radicata	False dandelion	*Verbena urticifolia*	White vervain
Hypoxis hirsuta	Yellow star-grass	*Verbesina* sp.	Crownbeard
Ilex ambigua	Carolina holly	*Vernonia noveboracensis*	New York ironweed
Ilex crenata	Japanese holly	*Veronica hedaraefolia*	Ivyleaf speedwell
Ilex opaca	American holly	*Veronica officinalis*	Common gypsyweed
Ilex verticillata	Common winterberry	*Veronica peregrina*	Neckweed
Impatiens capensis	Jewelweed	*Veronica serpyllifolia*	Thymeleaf speedwell
Ipomoea coccinea	Red morningglory	*Viburnum acerifolium*	Mapleleaf viburnum
Ipomoea pandurata	Man-of-the-earth	*Viburnum nudum*	Possumhaw
Ipomoea purpurea	Common morningglory	*Viburnum prunifolium*	Blackhaw
Iris cristata	Dwarf crested iris	*Vicia carolina*	Carolina vetch
Iris verna var. *smalliana*	Dwarf violet iris	*Vicia sativa*	Garden vetch
Juglans nigra	Black walnut	*Vicia sativa* ssp. *nigra*	Garden vetch
Juncus acuminatus	Tapertip rush	*Vinca major*	Greater periwinkle
Juncus dichotomus	Forked rush	*Vinca minor*	Lesser periwinkle
Juncus effusus	Lamp rush	*Viola cucullata*	Marsh blue violet
Juncus platyphyllus	Forked rush	*Viola hastata*	Halberdleaf yellow violet
Juncus tenuis	Path rush	*Viola hirsutula*	Southern wood violet

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Species	Common name	Species	Common name
Juniperus virginiana var. *virginiana*	Red cedar	*Viola papilionacea* var. *priceana*	Common blue violet
Kalmia latifolia	Mountain laurel	*Viola pedata*	Birdfoot violet
Krigia virginica	Virginia dwarfdandelion	*Viola primulifolia*	Primrose-leaf violet
Kyllinga pumila	Low spikesedge	*Viola rotundifolia*	Roundleaf yellow violet
Lactuca canadensis	Florida blue lettuce	*Viola sagittata*	Triangle-leaved violet
Lathyrus latifolius	Everlasting peavine	*Viola sororia*	Confederate violet
Lechea minor	Thymeleaf pinweed	*Viola* X *primulifolia*	Primrose-leaf violet
Lechea racemulosa	Illinois pineweed	*Vitis aestivalis*	Summer grape
Leersia virginica	Rice cutgrass	*Vitis rotundifolia*	Muscadine
Lepidium virginicum	Peppergrass	*Wisteria floribunda*	Japanese wisteria
Lespedeza cuneata	Chinese lespedeza	*Woodsia obtusa*	Bluntlobe cliff fern
Leucanthemum vulgare	Oxeye daisy	*Woodwardia areolata*	Netted chainfern
Leucothoe fontanesiana	Highland doghobble	*Xanthium strumarium*	Cocklebur
Leucothoe recurva	Redtwig doghobble	*Xanthorhiza simplicissima*	Yellowroot
Liatris spicata	Dense gayfeather	*Xyris torta*	Common yellow-eyed Grass
Ligustrum sinense	Chinese privet	*Zizia aurea*	Golden alexanders
*Ligustrum vulgare**	Common privet hedge	*Zizia trifoliata*	Meadow alexanders
Lilium michauxii	Carolina lily		

Appendix C. Community types in KIMO, based on the vegetation map classified by the Center for Remote Sensing and Mapping Science (CRMS) at UGA (Jordan and Madden 2008).

CEGL#	Vegetation Type	Group	Area (ha)	Area (%)	Num. Patches	Mean Patch Size (ha)
8427	Appalachian Shortleaf Pine – Mesic Oak Forest[†]	Coniferous/Oak Forest	37	2	16	2.29
3765	Appalachian Shortleaf Pine – Post Oak Woodland[†]	Woodland	28	1	5	2.28
4732	Blackberry – Greenbrier Successional Shrubland Thicket*	Shrubland	31	2	8	3.82
4048	Cultivated Meadow*	Herbaceous	1	<1	2	0.31
7221	Interior Mid- to Late- Successional Tuliptree – Hardwood*	Successional Forest	133	8	44	3.02
4415	Piedmont Chestnut Oak – Heath Bluff[†]	Bluff	61	4	31	1.96
8475	Piedmont Dry-Mesic Oak – Hickory Forest[†]	Dry-Mesic Oak Forest	164	10	48	3.42
4426	Piedmont Low-Elevation Headwater Seepage Swamp[†]	Alluvial and Wetland Forest	1	<1	2	0.31
3949	Piedmont Mesic Basic Oak – Hickory Forest[†]	Mesic Oak Forest	<1	<1	1	0.35
3708	Piedmont Rock Chestnut Oak – Blackjack Oak Woodland[†]	Woodland	32	2	17	1.89
4418	Piedmont Small Stream Sweetgum – Tuliptree Forest[†]	Alluvial and Wetland Forest	39	2	9	4.34
7124	Red-cedar Successional Forest*	Successional Forest	11	1	5	2.14
6327	Shortleaf Pine Early Successional Forest*	Successional Forest	89	6	33	2.70
--	Bare Soil	Other	<1	<1	1	--
7493	Southern Blue Ridge Escarpment Shortleaf Pine – Oak Forest[†]	Coniferous/Oak Forest	86	5	37	2.33
7244	Southern Red Oak – White Oak Mixed Oak Forest[†]	Dry-Mesic Oak Forest	722	45	70	10.31
4044	Successional Broomsedge Vegetation*	Herbaceous	4	<1	7	0.24
7330	Successional Sweetgum Floodplain Forest*	Alluvial and Wetland Forest	20	<1	1	3.55
7340	Sycamore – Sweetgum Floodplain Forest*	Alluvial and Wetland Forest	30	1	4	5.09
2591	Virginia Pine Successional Forest*	Successional Forest	47	3	18	2.63
8431	Xeric Ridgetop Chestnut Oak Forest[†]	Xeric Oak Forest	108	7	29	3.72
--	Other/Developed	Other	5	1	23	--
	Total	**--**	**1649**	**100**	**411**	**2.83**

***Natural community type**
[†] **Non-natural communities, i.e. those which are semi-natural, human-modified, or dominated by exotic species**

Appendix D. Birds reported during 5-minute point count surveys in Kings Mountain National Military Park, March 2003-April 2005 (Rogers 2005).

Common Name	Scientific Name	Common Name	Scientific Name
Acadian Flycatcher	*Empidonax virescens*	Common Yellowthroat	*Geothlypis trichas*
American Crow	*Corvus brachyrhynchos*	Cooper's Hawk	*Accipiter cooperii*
American Goldfinch	*Carduelis tristis*	Dark-eyed Junco	*Junco hyemalis*
American Redstart	*Setophaga ruticilla*	Downy Woodpecker	*Picoides pubescens*
American Robin	*Turdus migratorius*	Eastern Bluebird	*Sialia sialis*
American Woodcock	*Scolopax minor*	Eastern Meadowlark	*Sturnella magna*
Bald Eagle	*Haliaeetus leucocephalus*	Eastern Phoebe	*Sayornis phoebe*
Barred Owl	*Strix varia*	Eastern Screech-Owl	*Otus asio*
Bay-breasted Warbler	*Dendroica castanea*	Eastern Towhee	*Pipilo erythrophthalmus*
Belted Kingfisher	*Ceryle alcyon*	Eastern Wood-Pewee	*Contopus virens*
Black Vulture	*Coragyps atratus*	Field Sparrow	*Spizella pusilla*
Black-and-white Warbler	*Mniotilta varia*	Golden-crowned Kinglet	*Regulus satrapa*
Black-billed Cuckoo	*Coccyzus erythropthalmus*	Gray Catbird	*Dumetella carolinensis*
Blackburnian Warbler	*Dendroica fusca*	Gray-cheeked Thrush	*Catharus minimus*
Blackpoll Warbler	*Dendroica striata*	Great Blue Heron	*Ardea herodias*
Black-throated. Green Warbler	*Dendroica virens*	Great Horned Owl	*Bubo virginianus*
Black-throated Blue Warbler	*Dendroica caerulescens*	Great Crested Flycatcher	*Myiarchus crinitus*
Blue Jay	*Cyanocitta cristata*	Hairy Woodpecker	*Picoides villosus*
Blue-gray Gnatcatcher	*Polioptila caerulea*	Hermit Thrush	*Catharus guttatus*
Blue-headed Vireo	*Vireo solitarius*	Hooded Warbler	*Wilsonia citrina*
Blue-winged Warbler	*Vermivora pinus*	House Finch	*Carpodacus mexicanus*
Broad-winged Hawk	*Buteo platypterus*	House Wren	*Troglodytes aedon*
Brown Creeper	*Certhia americana*	Indigo Bunting	*Passerina cyanea*
Brown Thrasher	*Toxostoma rufum*	Kentucky Warbler	*Oporornis formosus*
Brown-headed Cowbird	*Molothrus ater*	Killdeer	*Charadrius vociferus*
Brown-headed Nuthatch	*Sitta pusilla*	Louisiana Waterthrush	*Seiurus motacilla*
Canada Goose	*Branta canadensis*	Magnolia Warbler	*Dendroica magnolia*
Cape May Warbler	*Dendroica tigrina*	Mallard	*Anas platyrhynchos*
Carolina Chickadee	*Poecile carolinensis*	Mourning Dove	*Zenaida macroura*
Carolina Wren	*Thryothorus ludovicianus*	Mourning Warbler	*Oporornis philadelphia*
Cedar Waxwing	*Bombycilla cedrorum*	Nashville Warbler	*Vermivora ruficapilla*
Cerulean Warbler	*Dendroica cerulea*	Northern Cardinal	*Cardinalis cardinalis*
Chestnut-sided Warbler	*Dendroica pensylvanica*	Northern Flicker	*Colaptes auratus*
Chimney Swift	*Chaetura pelagica*	Northern Harrier	*Circus cyaneus*
Chipping Sparrow	*Spizella passerina*	Northern Mockingbird	*Mimus polyglottos*
Chuck-will's-widow	*Caprimulgus carolinensis*	Northern Parula	*Parula americana*
Common Grackle	*Quiscalus quiscula*	Northern Waterthrush	*Seiurus noveboracensis*
Common Nighthawk	*Chordeiles minor*	Osprey	*Pandion haliaetus*
Common Snipe	*Gallinago gallinago*	Ovenbird	*Seiurus aurocapillus*

Appendix D. Birds reported during 5-minute point count surveys in Kings Mountain National Military Park, March 2003-April 2005 (Rogers 2005) (continued).

Common Name	Scientific Name	Common Name	Scientific Name
Palm Warbler	*Dendroica palmarum*	Tennessee Warbler	*Vermivora peregrina*
Pileated Woodpecker	*Dryocopus pileatus*	Tufted Titmouse	*Baeolophus bicolor*
Pine Warbler	*Dendroica pinus*	Turkey Vulture	*Cathartes aura*
Prairie Warbler	*Dendroica discolor*	Warbling Vireo	*Vireo gilvus*
Prothonotary Warbler	*Protonotaria citrea*	Whip-poor-will	*Caprimulgus vociferus*
Purple Finch	*Carpodacus purpureus*	White-breasted Nuthatch	*Sitta carolinensis*
Red-bellied Woodpecker	*Melanerpes carolinus*	White-crowned Sparrow	*Zonotrichia leucophrys*
Red-breasted Nuthatch	*Sitta canadensis*	White-eyed Vireo	*Vireo griseus*
Red-eyed Vireo	*Vireo olivaceus*	White-throated Sparrow	*Zonotrichia albicollis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Wild Turkey	*Meleagris gallopavo*
Red-shouldered Hawk	*Buteo lineatus*	Winter Wren	*Troglodytes troglodytes*
Red-tailed Hawk	*Buteo jamaicensis*	Wood Duck	*Aix sponsa*
Rock Dove	*Columba livia*	Wood Thrush	*Hylocichla mustelina*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Worm-eating Warbler	*Helmitheros vermivorus*
Ruby-crowned Kinglet	*Regulus calendula*	Yellow Warbler	*Dendroica petechia*
Ruby-throated Hummingbird	*Archilochus colubris*	Yellow-bellied Sapsucker	*Sphyrapicus varius*
Scarlet Tanager	*Piranga olivacea*	Yellow-billed Cuckoo	*Coccyzus americanus*
Sharp-shinned Hawk	*Accipiter striatus*	Yellow-rumped Warbler	*Dendroica coronata*
Song Sparrow	*Melospiza melodia*	Yellow-throated Vireo	*Vireo flavifrons*
Summer Tanager	*Piranga rubra*	Yellow-throated Warbler	*Dendroica dominica*

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