National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment for Little River Canyon National Preserve, Alabama

Natural Resource Report NPS/CUPN/NRR—2011/446

ON THE COVER
Little River Canyon at the confluence of Little River and Bear Creek
Photograph by: Nathan Rinehart

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Acronyms

ACIP	Avian Conservation Implementation Plan
ADCNR	Alabama Department of Conservation and Natural Resources
ADECA	Alabama Department of Economic and Community Affairs
ADEM	Alabama Department of Environmental Management
ADWFF	Alabama Division of Wildlife and Freshwater Fisheries
AEMA	Alabama Emergency Management Agency
AFC	Alabama Forestry Commission
AMLIS	Abandoned Mine Land Inventory System
ANC	Acid Neutralizing Capacity
APHIS	Animal and Plant Health Inspection Service
ATN	Attainment
ATV	All-Terrain Vehicle
AQI	Air Quality Index
BHLR	Burnt House Ford
CAA	Clean Air Act
CAPS	Cooperative Agricultural Pest Survey
CASTNet	Clean Air Status and Trends Network
CBC	Christmas Bird Count
CCC	Civilian Conservation Corp
CEGL	Community Element GLobal
CESU	Cooperative Ecosystems Studies Unit
CFR	Code of Federal Regulations
cfs	cubic feet per second
CFU	Colony Forming Unit
CMLR	Canyon Mouth
CRMS	Center for Remote Sensing and Mapping Science
CSI	Cultural Sites Inventory
CSREES	Cooperative State Research, Education, and Extension Service
CUPN	Cumberland-Piedmont Network
CWA	Clean Water Act
DAT	Depression Analysis Threshold
DFLR	DeSoto Falls
DO	Dissolved Oxygen
DRG	Digital Raster Graphics
DSLR	DeSoto State Park
dv	Deciview
EBM	Environmental and Biotic Measures
EEA	Essential Ecological Attribute
EFLR	East Fork Little River
EPLR	Eberhart Point
ESA	Endangered Species Act
ESM	EcoSystem Measures
ESRI	Environmental Systems Research Institute
EXFOR	EXotic FORest Pest Information System

F & W	Fish and Wildlife
FHP	Forest Health Protection
FHM	Forest Health Monitoring
FIA	Forest Inventory and Analysis
FMP	Fire Management Plan
FMU	Fire Management Unit
GA EPD	Georgia Environmental Protection Division
GIS	Geographic Information System
GMP	General Management Plan
GOES	Geostationary Operational Environmental Satellite
GPRA	Government Performance and Results Act
HBLR	Highway 35 Bridge
HGM	HydroGeoMorphic
HUC	Hydrologic Unit Code
I&M	Inventory and Monitoring Program
IAB	Important Bird Areas
IDEA	Inventory Data Evaluation and Analysis
IMPROVE	Interagency Monitoring of PROtected Visual Environments
IND	Inadequate Data or no data
JCJC	Johnnie’s Creek
JSU	Jacksonville State University, Alabama
LCLR	Lookout Mountain Camp
LIRI	Little River Canyon National Preserve
MACA	Mammoth Cave National Park
MACT	Maximum Achievable Control Technology
MFLR	Middle Fork Little River
MRLC	Multi-Resolution Land Characteristics
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NABCI	North American Bird Conservation Initiative
NADP/NTN	National Atmospheric Deposition Program/National Trends Network
NAFC	North American Forestry Commission
NAPIS	National Agricultural Pest Information System
NAS	Nonindigenous Aquatic Species
MDN	Mercury Deposition Network
NHD	National Hydrography Dataset
NID	National Inventory of Dams
NLCD	National Land Cover Database (2001) or Dataset (1992)
NPCA	National Parks Conservation Association
NPDP	National Performance of Dams Program
NPS	National Park Service
NRC	Natural Resource Challenge
NRCS	National Resources Conservation Service
NTU	Nephelometric Turbidity Units
NVCS	National Vegetation Classification System
NWI	National Wetland Inventory

NWIS	National Water Information System
OMB	Office of Management and Budget
ONRW	Outstanding National Resource Water
OSM	Office of Surface Mining
OWR	Office of Water Resources
PIF	Partners In Flight
ppb	parts per billion
PRA	Pest Risk Assessment
PWS	Public Water Supply
QL	Quantifiable Limit
RPRS	Research Permit and Reporting System
RSS	Resource Stewardship Strategy
S	Swimming and other whole body water-contact sports
SAA	Southern Appalachian Assessment
SAB	Science Advisory Board
SAMAB	Southern Appalachian Man and the Biosphere
SEAC	Southeast Archeological Center
SERCC	Southeast Regional Climate Center
SpC	Specific Conductance
SSURGO	Soil SURvey GeOgraphic - database
STORET	STOrage and RETrieval
SU	Standard Unit
TDS	Total Dissolved Solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
VIEWS	Visibility Information Exchange Web System
VOC	Volatile Organic Compound
VSMP	Vital Signs Monitoring Plan
WED	Western Ecology Division
WCA	Watershed Condition Assessment
WRD	Water Resource Division
YCYC	Yellow Creek

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. xix) for more information.

Executive Summary

This natural resource assessment of Little River Canyon National preserve (LIRI) brings together existing scientific data and other information in order to determine the current condition of a selected suite of abiotic and biotic natural resources present within the park boundaries. The purpose of this assessment is to provide NPS scientists and managers with a complete and ready reference on the current state of knowledge about these natural resources with a special emphasis on graphical displays and spatial representations using a Geographic Information System and related databases.

Little River Canyon National Preserve (LIRI) is located atop Lookout Mountain in northeast Alabama within DeKalb and Cherokee counties. It currently encompasses more than 13,633 acres and there are plans to expand through land purchases. LIRI possesses a range of important natural resources which were identified for this study in consultation with NPS scientists, park personnel and external experts.

The assessment framework used herein was developed by grouping the selected natural resources with their related attributes and indicators into several hierarchical levels which were adapted from approaches in the *NPS Ecological Monitoring Framework* (NPS 2005) and the Essential Ecological Attribute (EEA) categories from the United States Environmental Protection Agency – Science Advisory Board (USEPA SAB 2002). 'Indicators' are the subset of physical, chemical, and biological elements that were selected to represent the overall health or condition of a natural resource or natural system. For some indicators in this study, a suitable data record had already been established through the Cumberland Piedmont Network's ongoing Inventory and Monitoring (I&M) Program, some indicators also may have had a record of legacy data and some, though deemed important, had a scant history of previous study. Therefore, another significant aspect of the natural resource assessment was to identify gaps in data and current knowledge both temporally and spatially.

In order to determine the current condition status of the study indicators, the data on each were compared against certain reference values such as existing legal and regulatory standards, any management-specified objectives, and expert opinions on the topic as appropriate. Reference values can be qualitative or quantitative by their nature and they generally represent the desirable resource condition. Our comparison of natural resource data to the appropriate reference conditions utilized a three-color, 'stoplight' approach.

The following chart summarizes the condition status and current state of knowledge for the selected indicators within the major natural resource groups examined in this assessment, namely Water, Landscape, Geology and Soils, Biota; Threats, Stressors and Disturbances; Air and Climate.

Condition status summary of natural resources and related issues for Little River Canyon National Preserve

LEVEL 1 CATEGORY Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
WATER					
Hydrology	Surface Water Dynamics	Daily Mean Discharge	TBD	NA	DeSoto (1997-2007): 0.01-4120 cfs, Canyon Mouth(1958-2007): 0.20-27100 cfs
		Gage Height	TBD	NA	DeSoto: 1.08-12.04 in, Canyon Mouth: 1.38-12.73 in
Water Quality	Water Chemistry	Acid Neutralizing Capacity (ANC)		≥0 mg/L $CaCO_3$	100% ATN at 11 sample locations
		Dissolved Oxygen		AL: >5.5 mg/L, GA: >5.0 mg/L	87% ATN at 11 sample locations
		pH		6.0-8.5 SU	85% ATN at 11 sample locations
		Specific Conductance		>10 µS/cm	100% ATN at 11 sample locations
		Sulfate		<250mg/L as SO_4	100% ATN at 11 sample locations
	Nutrient Dynamics	Nitrate		<90 mg/L as N	100% ATN at 11 sample locations
		Phosphate		<0.05 mg/L as total P	100% ATN at 11 sample locations
	Physical Parameters	Temperature		<32.2 C	100% ATN at 11 sample locations
		Turbidity		<05 NTU over background	100% ATN at 11 sample locations
	Microorganisms	*E. Coli*		<298 CFU/100mL	91% ATN at 11 sample locations
LANDSCAPE					
Landscape Dynamics	Land Cover and Use	Land Cover Change		NA	<2% Developed
		Impervious Surface		<10% Imperviousness	0.11% of LIRI has impervious surfaces
		Landscape Pattern and Fragmentation	TBD	NA	29 NVCS associations, 1802 patches
		Silviculture Impacts	TBD	NA	Evidence of past clear-cut activities adjacent to the Preserve
		Mining Impacts	TBD	NA	Mines within the LIRI watershed: 14 abandoned, 6 active, and 4 of unknown type
Viewscape	Viewscape	View Obstructions		NA	Noticeable structures from view points along the canyon rim

Condition status summary of natural resources and related issues for Little River Canyon National Preserve (continued)

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
GEOLOGY AND SOILS					
Soil Quality	Soil Function and Dynamics	Soil Type		NA	19 soil series types, mostly Hartsells and Rockland soil series, well-drained soils, high erosion hazard on steep slopes
THREATS, STRESSORS, AND DISTURBANCES					
Fire and Fuel Dynamics	Fire and Fuel Dynamics	Fire Location and Frequency, Fire Management Plan (FMP) Goals		NA	Adhering to FMP goals (reaction time and prescribed burns)
Invasive Species	Invasive/Exotic Plants	# Exotic Species		no exotics	95
		# Highly Ranked Species			6
	Invasive/Exotic Animals	# Exotic Species		no exotics	6
		# Highly Ranked Species			TBD
Infestation, Disease, and Trauma	Insect Pests	Southern Pine Beetle (SPB) Extent and Risk Factor		NA	SPB sightings decreasing in AL, 0.28% of LIRI considered High Hazard Class
	Plant Disease/Trauma	Risk Factor of Ozone Sensitive Plants	TBD	NA	Dogwood anthracnose (*Discula destructive*) intensifying in AL
Visitor and Recreation Use	Visitor Use	Population Density		NA	0-15 individuals per square mile
		ATV Use Trend (1991 to 2007)		NA	Nearly five-fold increase in ATV permits issued from 1998 to 2007 years. ATV use banned beginning September 2010.
		Rock Climbing Impact to Cliffs and Biota	TBD	NA	Information gap
		Impacts from Dams	TBD	NA	Limited dam safety regulations, 13 dams within LIRI watershed, evidence of structural damage to select dams
		Poaching Risk Factor	TBD	NA	Multiple poaching incidences including green pitcher plant, ginseng, and deer
BIOTA					
Flora					
Ecosystems and Communities	Community Extent	Floral Class Extent	TBD	NA	27 NVCS vegetation associations: 9 natural, 18 altered from natural state

Condition status summary of natural resources and related issues for Little River Canyon National Preserve (continued)

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
BIOTA					
Flora					
Ecosystems and Communities	Community Composition	Inventory of Species, Species Richness		NA	950 documented vascular plant species, 95 exotics, significant vegetation cover change in upstream sub-watersheds, several high quality wetlands
	Physical Structure	Successional State	TBD	NA	
Species and Populations	Population Size	Species of Concern Populations	TBD	NA	
	Habitat Suitability	Habitat Limitations	TBD	NA	Wetlands display relatively low ratings for provision of wildlife habitat and relatively moderate ratings for the support of wetland plants.
Fauna					
Ecosystems and Communities	Community Composition	Inventory of Species, Species Richness	TBD	NA	122 species aquatic insects, 147 species birds, 50 species fish, 74 species herps, 25 preliminary species mammals, 6 mollusks,
Species and Populations	Population Size	Species of Concern Populations	TBD	NA	
	Habitat Suitability	Habitat Limitations	TBD	NA	Possibly low habitat diversity for birds
Focal Species and Communities	Freshwater Invertebrates	Non-native Species, Species Richness		no exotics, detect at least 90% species	6 mollusk species, 1 exotic mollusk with high density in places and comprising 85% of specimens observed, low diversity and density, number of caddisfly species are similar to other drainage areas of similar size
	Birds	Non-native Species, Species Richness		no exotics, detect at least 90% species	147 species, 3 exotics, 90% species likely occurring not detected, rich species diversity but low species density, habitat limitations may affect species richness
	Herpetofauna	Non-native Species, Species Richness		no exotics, detect at least 90% species	74 documented species, no exotics, 90% species likely occurring detected
	Fishes	Non-native Species, Species Richness		no exotics, detect at least 90% species	50 documented species, 2 exotics,
	Mammals	Non-native Species, Species Richness	TBD	no exotics, detect at least 90% species	25 preliminary species, no exotics

Condition status summary of natural resources and related issues for Little River Canyon National Preserve (continued)

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
BIOTA					
At-Risk-Biota	Threatened & Endangered (T&E) Species and Communities	Presence, Populations	TBD	NA	6 T&E species, 5 highly ranked NVCS associations
AIR AND CLIMATE					
Air Quality	Ozone	Ozone Concentration	Red	<76 ppb	11% ATN
	Wet and Dry Deposition	Total deposition of Sulfur	Red	Class II: TBD Class I Parks: <0.010 kg/ha/yr	Class I: 0% ATN
		Total deposition of Nitrogen	Red	Class II: TBD Class I Parks: <0.010 kg/ha/yr	Class I: 0% ATN
	Visibility and Particulate Matter	Fine Particulate Matter (PM2.5) Levels	Green	<16.0 µg/m3	100% ATN
		Visibility in Deciviews (dv)	Red	Class II: TBD Class I Parks: <15.6 (<8 dv above background)	Class I: 0% ATN
	Air Contaminants	Mercury Levels	TBD	NA	NA
		Acid Rain (pH) Impacts	Yellow	Designated use waters: 6-8.5 SU	low pH values compared to WQ standard, but waters may be considered naturally low
Weather and Climate	Weather and Climate	Precipitation and Temperature Trends	TBD	NA	

NA = Not Available, TBD = To Be Determined, ATN = Attainment, Green = Good or Excellent (refer to text), Yellow = Caution, Red = Of Significant Concern.

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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.

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. xix) for more information.

1 - NRCA Background Information

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

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

- are multi-disciplinary in scope[1]
- employ hierarchical indicator frameworks[2]
- identify or develop logical reference conditions/values to compare current condition data against[3,4]
- emphasize spatial evaluation of conditions and GIS (map) products[5]
- summarize key findings by park areas[6]
- follow national NRCA guidelines and standards for study design and reporting products

NRCAs Strive to Provide…

Credible condition reporting for a subset of important park natural resources and indicators

Useful condition summaries by broader resource categories or topics, and by park areas

[1] However, the breadth of natural resources and number/type of indicators evaluated will vary by park

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

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions

[4] Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management "triggers")

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

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

Although current condition reporting relative to logical forms of reference conditions and values is the primary objective, NRCAs also report on trends for any study indicators where the underlying data and methods support it. Resource condition influences are also addressed. This can include past activities or conditions that provide a helpful context for understanding current park resource conditions. It also includes present-day condition influences (threats and stressors) that are best interpreted at park, watershed, or landscape scales, though NRCAs do not judge or report on condition status per se for land areas and natural resources beyond the park's boundaries. Intensive cause and effect analyses of threats and stressors or development of detailed treatment options is outside the project scope.

Credibility for study findings derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and describe level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject matter experts at critical points during the project timeline is also important: 1) to assist selection of study indicators; 2) to recommend study data sets, methods, and reference conditions and values to use; and 3) to help provide a multi-disciplinary review of draft study findings and products.

NRCAs provide a useful complement to more rigorous NPS science support programs such as the NPS Inventory and Monitoring Program. For example, NRCAs can provide current condition estimates and help establish reference conditions or baseline values for some of a park's "vital signs" monitoring indicators. They can also bring in relevant non-NPS data to help evaluate current conditions for those same vital signs. In some cases, NPS inventory data sets are also incorporated into NRCA analyses and reporting products.

Important NRCA Success Factors …

Obtaining good input from park and other NPS subjective matter experts at critical points in the project timeline

Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)

Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings

In-depth analysis of climate change effects on park natural resources is outside the project scope. However, existing condition analyses and data sets developed by a NRCA will be useful for subsequent park-level climate change studies and planning efforts.

NRCAs do not establish management targets for study indicators. Decisions about management targets must be made through sanctioned park planning and management processes. NRCAs do provide science-based information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[7] and help parks report to government accountability measures[8].

Due to their modest funding, relatively quick timeframe for completion and reliance on existing data and information, NRCAs are not intended to be exhaustive. Study methods typically involve an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in our present data and knowledge bases across these varied study components.

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

Over the next several years, the NPS plans to fund a NRCA project for each of the ~270 parks served by the NPS Inventory and Monitoring Program. Additional NRCA Program information is posted at: http://www.nature.nps.gov/water/NRCondition_Assessment_Program/Index.cfm

NRCA Reporting Products…

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

Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations
(near-term operational planning and management)

Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values
(longer-term strategic planning)

Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public
("resource condition status" reporting)

[7] NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy(RSS) but study scope can be tailored to also work well as a post-RSS project

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

2 - Park and Resources Context

2.1 Site Description

Little River Canyon National Preserve (LIRI) is located in northeast Alabama within DeKalb and Cherokee counties, approximately five miles east of the city of Fort Payne along Interstate Highway I-59 (Figure 1). The nearest major metropolitan area in the region is Chattanooga, Tennessee, which is located approximately 50 miles to the northeast. Atlanta, Georgia is approximately 90 miles to the southeast. LIRI is located atop Lookout Mountain, which rises between Wills Valley on the west and Shinbone and Broomtown Valleys on the east (Figure 1). The northern portion of LIRI is primarily uplands while the southern portion features a canyon area. The highest elevation within LIRI is in the north near DeSoto State Park at 1780 feet (USGS 1967) and the lowest elevation is in the south near the Canyon Mouth Day Use Area at 590 feet (USGS 1977). Estimates of acreage for lands owned and managed by LIRI vary depending on the source and official boundary lines have been disputed in the past. Current efforts are being made to expand the boundary of LIRI. *The National Parks: Index 2005-2007* (NPS 2005a) states that LIRI comprises 13,632.96 acres (~21.3 mi^2); 10,338.15 acres (~16.2 mi^2) of which is federally owned and 3,294.81 acres (~5.1 mi^2) of which is non-federally owned. The digital boundary layer provided by the National Park Service (NPS) state LIRI to be 13,798.12 acres (~21.5 mi^2). Boundaries of LIRI are shown in Figure 1, where the dark brown area of DeSoto State Park (state owned and managed) represents ~8.8 % of the total, and the light brown areas covering several Wildlife Management Areas (state owned and federally managed) represent ~14.4 % of the total. The green area identifies other lands within LIRI that are federally owned and managed (~76.8 % of the total).

2.2 Topography and Geologic Setting

The regional topography comprises a series of northeast and southwest trending sandstone and shale synclinal mountains such as Sand, Lookout, and Blount Mountains with intervening anticlinal limestone valleys such as Murphrees, Wills, and Sequatchie Valleys (Raymond *et al.* 1988) (Figure 2). The Paleozoic rocks dip southwestward into the Black Warrior Basin beneath the Coastal Plain overlap (*ibid*. 1988). Lookout Mountain is a major topographic and geologic structure whose eastern escarpment marks the eastern boundary of the Cumberland Plateau Physiographic Region of Alabama (Figure 2). It is separated from Sand Mountain to the west by the Wills Valley anticline and extends approximately 90 miles southwest from Chattanooga, Tennessee to Gadsden, Alabama. It is capped by erosion-resistant Pennsylvanian sandstones of the Pottsville Formation. Causey (1965) describes the Pottsville Formation as consisting of sandstone, sandy shale, thin bituminous coal beds, iron deposits, and conglomerates. Raymond and others (1988) describe the Pottsville Formation as consisting primarily of sandstone and shale along with lesser amounts of coal, underclay, and limestone. Smith (1979), Horsey (1981), and Rheams and Benson (1982) suggest the lower Pottsville was deposited in a prodelta/barrier/back-barrier system dominated by quartz sandstones while the superposed coal-bearing strata of the Pottsville were deposited in fluvial-dominated deltaic systems. Modern streams have deeply incised their valleys into the Pottsville Formation along zones of weakness (joints and faults) in the bedrock. The down-cutting process has exposed underlying Mississippian limestone, shale, and chert outcrops within the Little River Canyon. Table 1 provides descriptions of the geologic units underlying the Pottsville Formation as well as map symbols from the *Geologic map of Alabama* (Szabo *et al.* 1988) associated with each unit. The

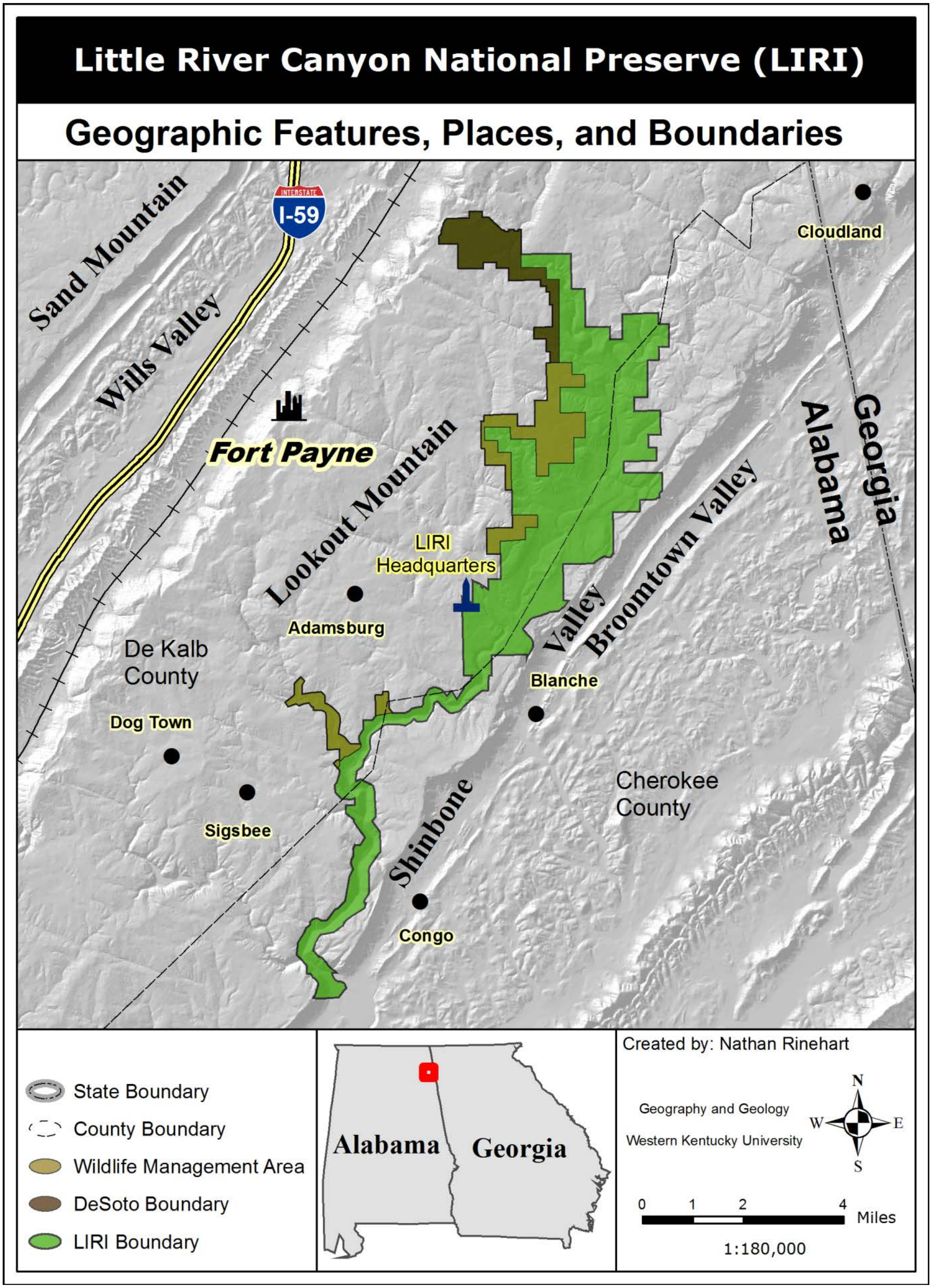


Figure 1. Location and boundary of Little River Canyon National Preserve. Source: (NPS 2006a).

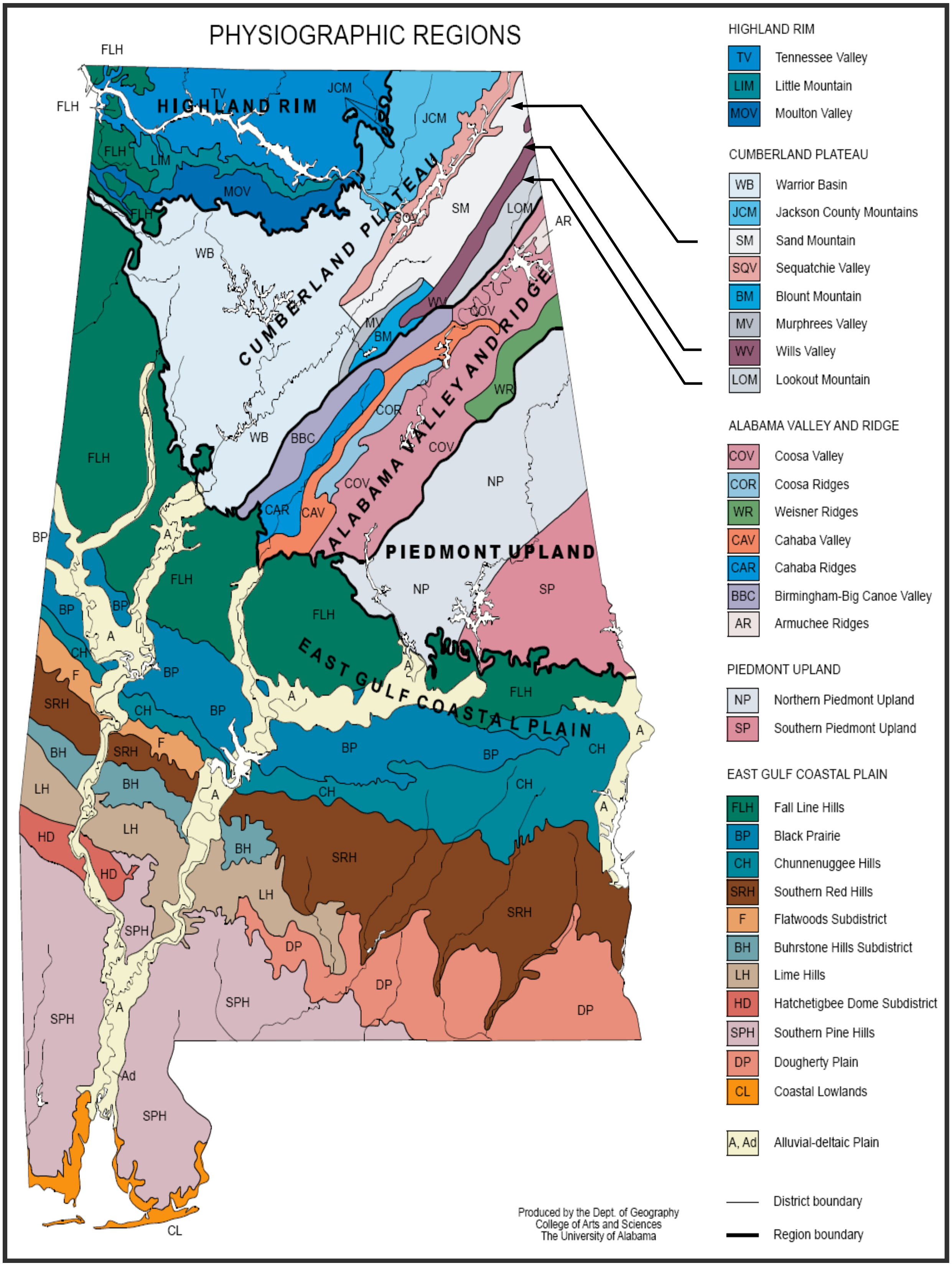


Figure 2. Physiographic Regions of Alabama. Source: (University of Alabama 2007).

Table 1. Description of geologic units in the vicinity of Lookout Mountain, Alabama.
Source: modified from (Szabo *et al.* 1988).

Map Symbol	Geologic Unit Name and Description
Ppv	POTTSVILLE FORMATION - Light-gray thin- to thick-bedded quartzose sandstone and conglomerate containing interbedded dark-gray shale, siltstone, and coal. Mapped on Lookout Mountain, Blount and Chandler Mountains, and Sand Mountain northeast of Blount County, and on the mountains of Jackson, Marshall, and Madison Counties north and west of the Tennessee River.
PMpwp	PARKWOOD AND PENNINGTON FORMATIONS UNDIFFERENTIATED - Interbedded medium- to dark-gray shale and light- to medium-gray sandstone, locally contains lithic conglomerate, dusky-red and grayish green mudstone, argillaceous limestone, and clayey coal.
Mb	BANGOR LIMESTONE - Medium-gray bioclastic and oolitic limestone, containing interbeds of dusky-red and olive-green mudstone in upper part.
Mbm	BANGOR AND MONTEAGLE LIMESTONE UNDIFFERENTIATED - (See individual descriptions).
Mm	MONTEAGLE LIMESTONE - Light-gray oolitic limestone containing interbedded argillaceous, bioclastic, or dolomitic limestone, dolomite, and medium-gray shale.
Mtfp	TUSCUMBIA LIMESTONE AND FORT PAYNE CHERT UNDIFFERENTIATED - TUSCUMBIA LIMESTONE--light- to dark-gray, fossiliferous and oolitic partly argillaceous and cherty limestone, absent locally and too thin to map separately. FORT PAYNE CHERT--dark-gray to light-gray limestone with abundant irregular light-gray chert nodules and beds. Commonly present below the Fort Payne is greenish-gray to grayish-red phosphatic shale (Maury Formation) which is mapped with the Tuscumbia Limestone and Fort Payne Chert undifferentiated.

Pottsville Formation overlies the Parkwood and Pennington Formations. The Parkwood Formation is roughly 150 feet thick at Fort Payne, Alabama, and is a succession of interbedded shales and sandstones (Thomas 1972). The combined Parkwood and Pennington Formations are more than 400 feet thick (*ibid*. 1972). The Pennington Formation is characterized by shale interbedded with maroon and olive colored mudstones (*ibid*. 1972). The Parkwood and Pennington Formation overlie the Bangor and Monteagle Limestone. Thomas (1972) explains that the Bangor limestone may be more than 600 feet thick, though it is hard to identify because of poor exposure. The Monteagle Limestone ranges from 200 to 300 feet thick (Raymond *et al.* 1988). The Bangor and Monteagle Limestone are primarily bioclastic and oolitic and are difficult to differentiate. Figure 3 is a geologic map with a cross section of Lookout Mountain showing the synclinal mountain and surrounding anticlinal valleys. At present, geologic maps of LIRI are only available at the state level of detail, though more detailed maps (~1:24000) are currently being generated for select portions of Alabama.

2.3 Hydrologic Setting

The main drainage feature through LIRI is the Little River. Over a distance of 27 miles the Little River falls 1250 feet to the mouth of Weiss Lake creating a scenic gorge, waterfalls, and a place for public swimming at the Canyon Mouth Day Use Area (NPS 1991). The Little River drains an area of approximately 200 square miles (~128,000 acres) of the Upper Coosa River Sub-basin of the Coosa River Basin in Georgia and Alabama before emptying into Weiss Lake (NPS 2005b). The major tributaries of Little River are the West Fork Little River, Middle Fork Little River, East Fork Little River, Bear Creek, Johnnies Creek, Yellow Creek, and Hurricane Creek (Figure 4). Stream flow patterns change from NE-SW in the north to strongly NW-SE in the south. Several tributaries of the Little River may cease to flow during periods of low water, leaving only intermittent pool zones, while flood events may raise stream levels as much as 15-20 feet (NPS 1991).

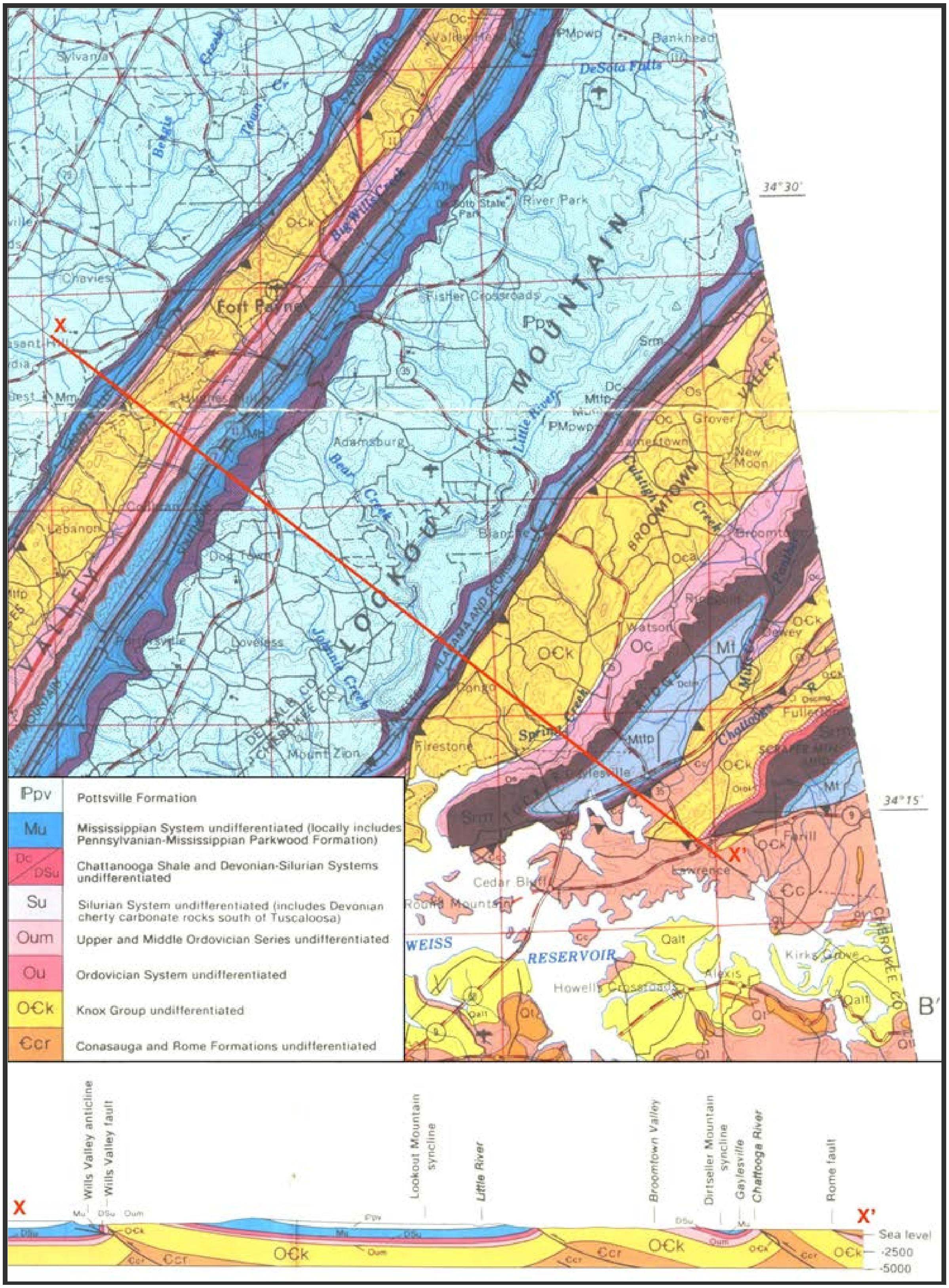


Figure 3. Geologic map of Lookout Mountain with structural cross section. Source: modified from (Szabo *et al.* 1988).

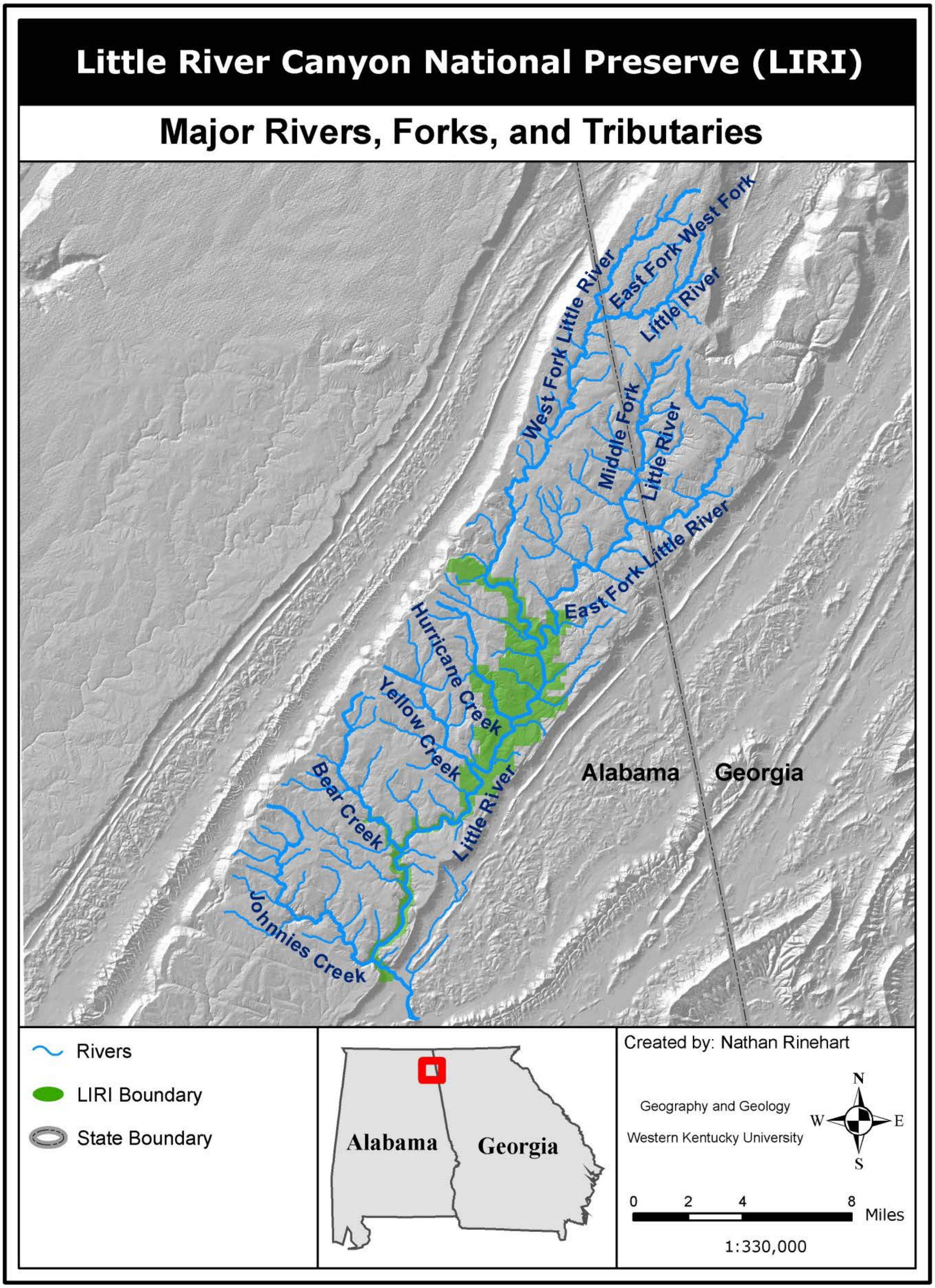


Figure 4. Rivers, forks, and tributaries influencing Little River Canyon National Preserve. Source: (USGS 2007a).

Georgia and Alabama have established “water use classifications” for the waters of Little River and its tributaries (ADEM 2008) (Table 2). Water use classifications in Alabama pertaining to the Little River include public water supply (PWS), swimming and other whole body water-contact sports (S), and fish and wildlife (F & W). Water use classifications in Georgia include recreation and fishing/aquatic life (Roy 2006). These classifications are assigned state or federally established limits for selected water quality parameters that will serve as benchmarks for water samples taken within the LIRI watershed. The Alabama Environmental Management Commission designated the Little River as an Outstanding National Resource Water (ONRW) on April 3, 1991, by amending the state's stream classification regulations (NPS 1991). Although the designation of ONRW implies a more pristine water body, no guidelines on specific limits for water quality parameters have been established for the ONRW designation, only restrictions as to activities that may pollute these waters. Since the ONRW is not defined as a separate water use classification, limits for water quality parameters associated with water use classifications such as PWS, S, and F & W still apply.

A watershed boundary defines an area of land that drains to a specific point. The United States Geological Survey (USGS) defines these boundaries at various scales using Hydrologic Unit Codes (HUCs) that can be accessed through the USGS National Hydrography Dataset (NHD) (USGS 2007a). Generally, six digit HUCs represent basin boundaries, eight digit HUCs represent sub-basin boundaries, ten digit HUCs represent watershed boundaries, and twelve digit HUCs represent sub-watershed boundaries. LIRI lies within the Coosa River Basin (HUC-031501), the Upper Coosa River Sub-basin (HUC-03150105), within two watersheds including the Upper Little River-Straight Creek Watershed (HUC-0315010507) and Lower Little River Watershed (HUC-0315010508), and is influenced by ten sub-watersheds such as the Bear Creek Sub-watershed (HUC-031501050803). Figure 5 displays the sub-basin boundaries as a thick red line, watershed boundaries as a medium thickness blue line, and sub-watershed boundaries as thin black line for LIRI. The ten sub-watersheds colored in gray represent boundaries whose water influences LIRI. Figure 6 shows the names of the ten USGS sub-watersheds influencing LIRI.

2.4 Climate, Soils, and Ecological Setting

2.4.1 Climate

LIRI is contained within the United States Department of Agriculture (USDA) Climate Zone seven. Zone seven is characterized by a probable lowest temperature in winter of 0-10 degrees Fahrenheit. The climate at LIRI is mild and has four distinct seasons with an average annual temperature of ~62 degrees Fahrenheit (SERCC 2008). The average annual precipitation for LIRI is ~ 54 inches and March is the wettest month (~5.8 inches), which has more than twice as much rain as the driest month of October (*ibid*. 2008). The summers are usually long and have moderately hot days and fairly cool nights. Snowfall averages ~1.4 inches per year and usually melts quickly but at times the ground can be covered for more than a week (*ibid*. 2008).

Table 2. Alabama water use classifications pertaining to Little River Canyon National Preserve. PWS – Public Water Supply, S – Swimming and other whole body water-contact sports, F&W – Fish and Wildlife. Source: (ADEM 2008).

Stream	From	To	Classification
COOSA RIVER (Lake Henry)	City of Gadsden's water supply intake	Weiss Dam powerhouse	PWS/F&W
COOSA RIVER	Weiss Dam powerhouse	Weiss Dam	F&W
COOSA RIVER (Weiss Lake)	Weiss Dam and Weiss Dam powerhouse	Spring Creek	PWS/S/F&W
COOSA RIVER (Weiss Lake)	Spring Creek	Alabama-Georgia state line	S/F&W
Bouldin Tailrace Canal (Callaway Creek)	COOSA RIVER	Bouldin Dam	F&W
Terrapin Creek	COOSA RIVER	U.S. Highway 278	F&W
Terrapin Creek	U.S. Highway 278	Calhoun County Road 70, east of Vigo	PWS/F&W
Terrapin Creek	Calhoun County Road 70, east of Vigo	Alabama-Georgia state line	F&W
Little River and tributaries	COOSA RIVER (Weiss Lake)	Junction of East Fork of Little River and West Fork of Little River	PWS/S/ F&W[3]
East Fork of Little River and tributaries	Little River	Alabama-Georgia state line	PWS/S/ F&W[3]
West Fork of Little River and tributaries	Little River	Alabama-Georgia state line	PWS/S/ F&W[3]
Chattooga River	COOSA RIVER (Weiss Lake)	Gaylesville	S/F&W
Chattooga River	Gaylesville	Alabama-Georgia state line	F&W

[3]The special designation of Outstanding National Resource Water applies to this segment.

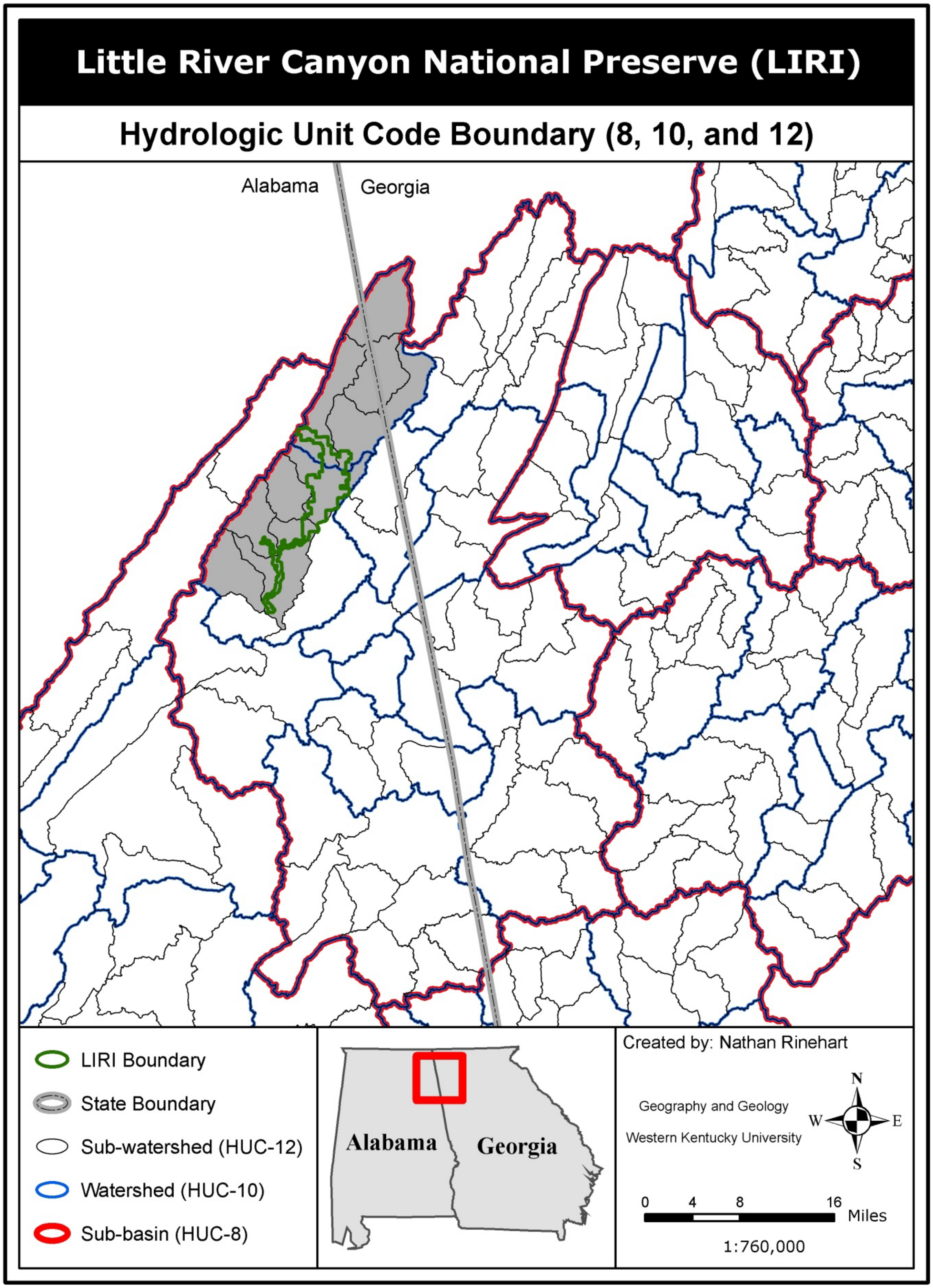


Figure 5. Hydrologic Unit Codes (8, 10, and 12) for Little River Canyon National Preserve. Gray sub-watersheds represent those influencing LIRI. Source: (USGS 2007a).

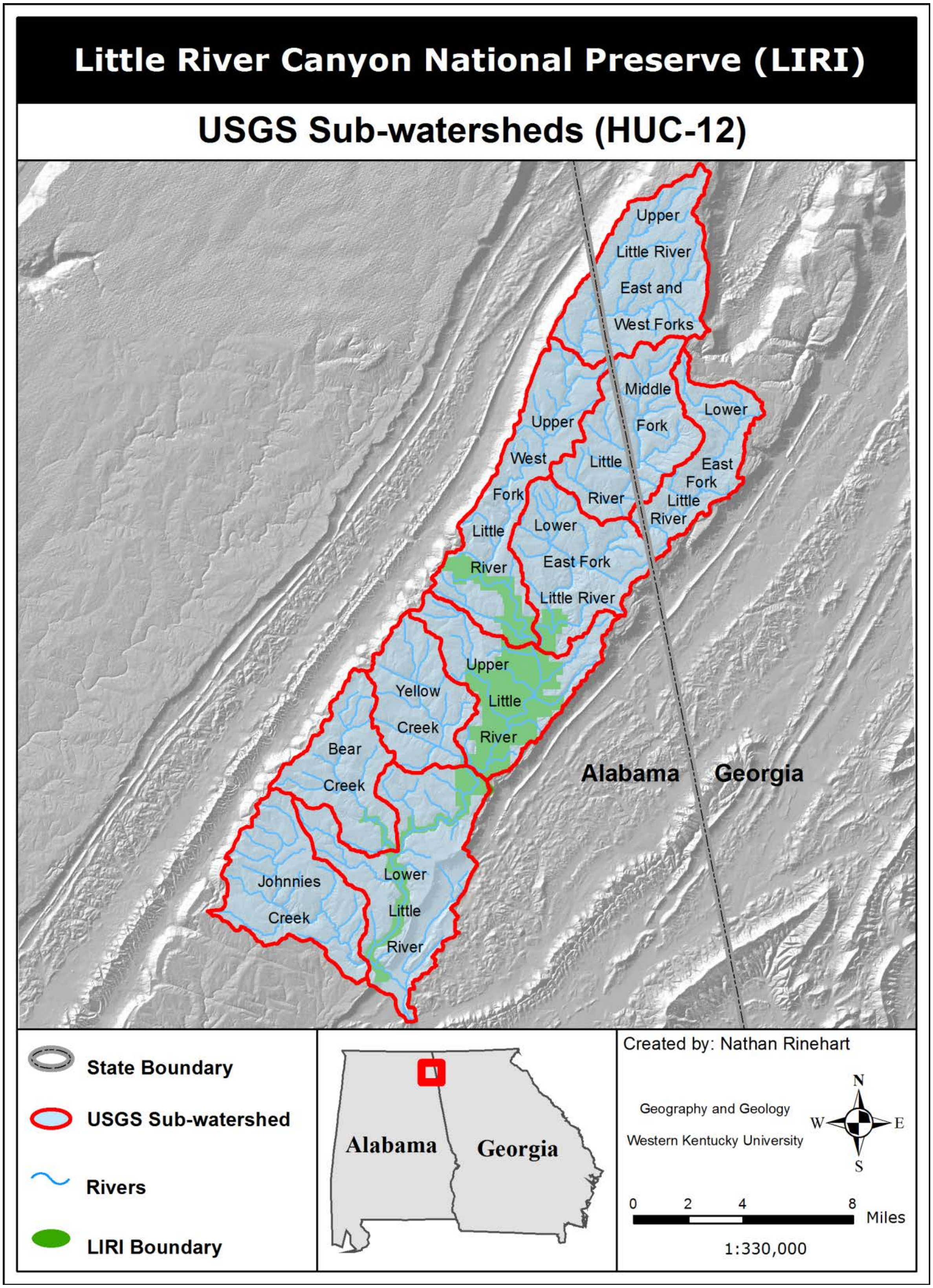


Figure 6. USGS sub-watersheds influencing Little River Canyon National Preserve. Source: (USGS 2007a).

2.4.2 Soils

The NPS provides geospatial data that show the distribution of soils at LIRI (NPS 2008a). Figure 7 shows soils at LIRI using general soil series descriptions. Soils can be classified as phases, types, series, or associations. Soil phases are descriptions characterized by features significant to land use and management. Soil type is the basic classification unit and may contain several phases. Soil series may contain several soil types that resemble each other in most of their characteristics. Soil associations are soils that occur together in a characteristic pattern, may consist of many soils, and may be similar or may be of many different soil types.

Figure 8 shows soil associations for DeKalb County, Alabama and is comprised mostly of the Hartsells-Muskingum and the Muskingum-Rockland-Hartsells soil associations. The Hartsells-Muskingum association surface is undulating to rolling for much of the area except for the narrow strips along the steeper drainage areas. This association provides well-drained soils, which Swenson and others (1958) describe as soils from which water is removed readily, but not rapidly, and has good drainage. The Hartsells soils within the Hartsells-Muskingum association occupy the undulating to rolling areas while Muskingum soils occupy the steeper slopes along the drainage areas. The Muskingum-Rockland-Hartsells soil association occupies the rougher part of the Lookout Mountain terrain. The Muskingum soils within this association are thin and, with the Rockland soils, occupy the steep mountain slopes. The Hartsells soils within the Muskingum-Rockland-Hartsells soil association are confined to the narrow ridge tops. Soils occupying the steep slopes have a high erosion hazard (Swenson *et al.* 1958). Soils series within DeKalb County are comprised mostly of the Hartsells and Muskingum soil series as well as the Rockland land type (NPS 2008a). Sandstones and shales from the Pottsville Formation have contributed parent material for the Hartsells, Linker, Crossville, Apison, Muskingum, and Pottsville soil series. The Bangor limestone influences development of extensive areas of land type called Rockland that occurs mostly on the lower slopes of Lookout Mountain. Other soils within LIRI include the Allen, Apison, Atkins, Barborsville, Cataco, Crossville, Hector, Linker, Pope, and Pottsville soil series (NPS 2005b).

Soils in Cherokee County are described in the *Soil Survey of Cherokee County, Alabama* (Montgomery 1978). Figure 9 shows soil associations for Cherokee County, Alabama. Dominant soil associations in Cherokee County, Alabama within the Preserve are the Hartsells-Rock Outcrop association and the Hartsells-Linker-Hector association. The Hartsells-Rock outcrop association is described in Montgomery (1978) as, “moderately deep, loamy soils formed in residuum weathered from sandstone, common sandstone boulders, and rock outcrop” and feature slopes ranging from 15 – 50%. This association is about 30% Hartsells soils, 30% rock outcrops, and 40% Allen, Hector, Linker, and Townley soils. The Hartsells-Linker- Hector association is described in Montgomery (1978) as, “moderately deep and shallow, well drained loamy soils formed in residuum weathered from sandstone” and feature slopes ranging from 2 – 10%. This association is about 75% Hartsells soils, 13% Linker soils, 7% Hector soils, and 5% mostly Townley soils.

2.4.3 Ecoregion

LIRI also can be described by ecoregion. Ecoregions are areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources they contain (Griffith *et al.* 2001). They serve as a spatial framework for research, assessment, management,

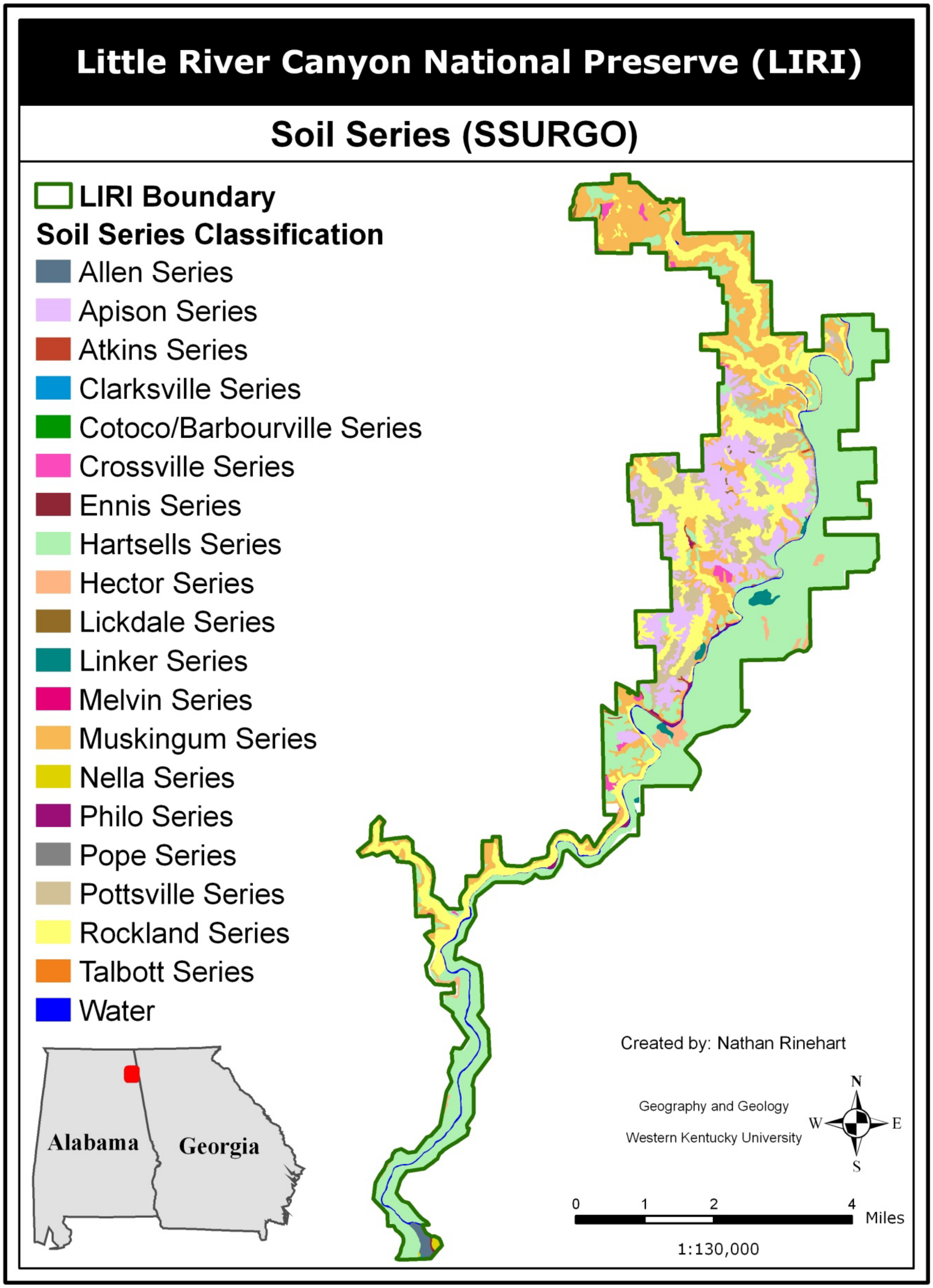


Figure 7. Little River Canyon National Preserve soil series from the Soil Survey Geographic (SSURGO) database. Source: modified from (NPS 2008a).

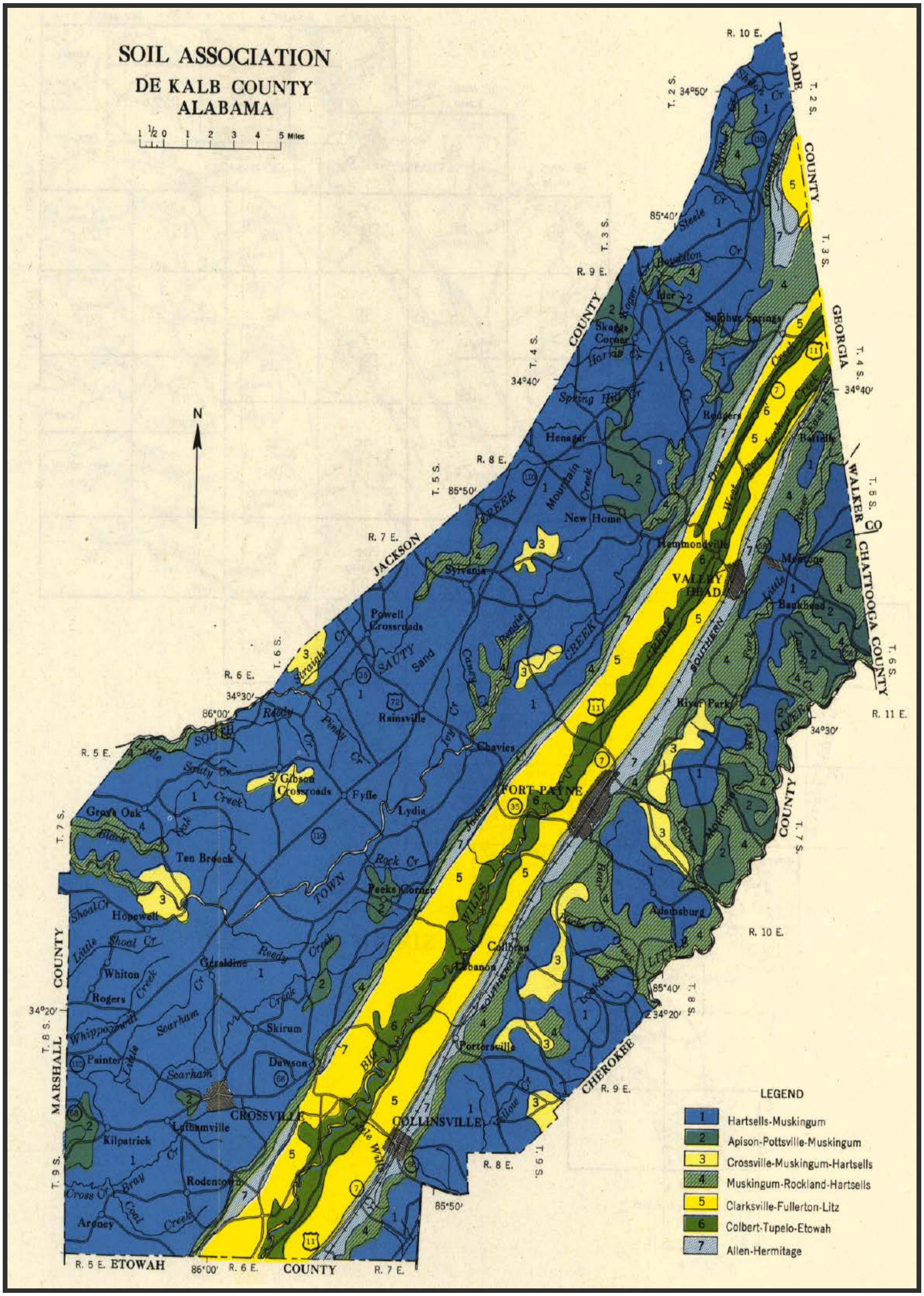


Figure 8. Soil Associations in DeKalb County, Alabama. Source: (Swenson *et al.* 1958).

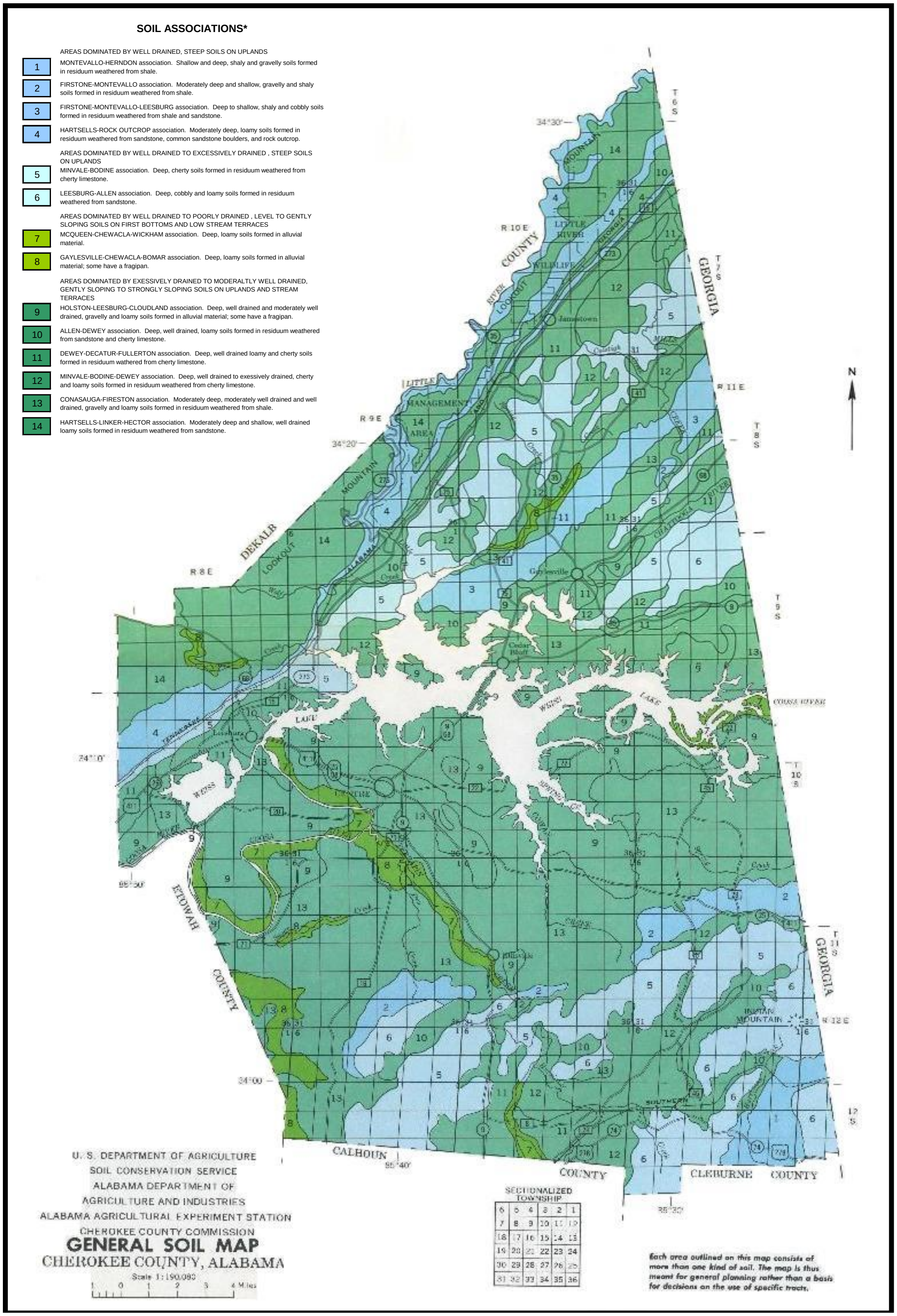


Figure 9. Soil Associations in Cherokee County, Alabama. Source: modified from (Montgomery 1978).

and monitoring of ecosystems and their components (Griffith *et al.* 2001). Ecoregions have utility to ecologists, but since their delineation is usually based on subjective criteria, several different definitions have been reported in the literature (Hargrove and Hoffman 2002).

The United States Environmental Protection Agency (USEPA) provides ecoregion maps (USEPA 2007a) for several states through its Western Ecology Division (WED). Different ecosystem levels are designated using a Roman numeral scheme. The approach used to compile these maps is based on analysis of spatial patterns and the composition of biotic and abiotic phenomena including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology that affect ecosystem quality (Wiken 1986; Omernik 1987, 1995). Omernik (1995), Omernik and others (2000), Griffith and others (1994), and Gallant and others (1989) provide descriptions of methods used to define the USEPA ecoregions. Ecoregion Level I involves the largest ecoregion polygons followed by Level II. Level III contains even smaller polygons and Level IV is a further subdivision of Level III ecoregions.

The LIRI watershed is situated within the Southwestern Appalachians Level III ecoregion and part of the Southern Table Plateaus Level IV Ecoregion (Figure 10). The Southwestern Appalachians (68) ecoregion stretches from Kentucky to Alabama and its low mountains contain a mosaic of forest and woodland with some cropland and pasture. The eastern boundary of the ecoregion is relatively smooth but is slightly notched by small eastward flowing stream drainages. The western boundary is more serrated with rough escarpments and deeply incised drainages defining it. Mixed mesophytic forest is found mostly in deep ravines and along escarpment slopes, while mixed oaks with shortleaf pine dominate the summit/tableland forests. The Southern Table Plateaus ecoregion (68d) includes Sand Mountain, Lookout Mountain, and Brindley Mountain. This ecoregion is similar to the Cumberland Plateau (68a) ecoregion with its Pennsylvanian-age sandstone caprock, shale layers, and coal-bearing strata. It is different in that it is lower in elevation, has a slightly warmer climate, and has more agriculture than the Cumberland Plateau (68a) ecoregion. It is at higher elevations and has more gentle topography with less dissection than the more forested ecoregions of 68e and 68f. The Georgia portion is mostly forested and the Alabama portion has more cropland and pasture. Elevations decrease to the southwest in Alabama and this region is one of Alabama's major poultry production areas (Griffith *et al.* 2001).

2.5 Land Use History

The Little River Wildlife Management Area, consisting of ~18,000 acres, was established in 1967 and was leased to the state of Alabama by the Alabama Power Company (NPS 1991). The Wildlife Management Area encompasses a majority of the land currently managed by LIRI, but includes additional areas just east of the Little River Canyon below Little River Falls. It does not include DeSoto State Park or the canyon area below Little River Falls near State Highway 35 Bridge. Upon the establishment of LIRI in 1992, this state-owned property fell under management of the NPS and today is used primarily for turkey and deer hunting. According to the Multi-Resolution Land Characteristics (MRLC) Consortium (MRLC Consortium 2007), the vast majority (~94%) of acreage within LIRI is in the "forest" category of land cover.

Land used for tourist activities in portions of the West Fork Little River area include private summer camps for children such as Comer Boy Scout Reservation, DeSoto Falls, DeSoto State

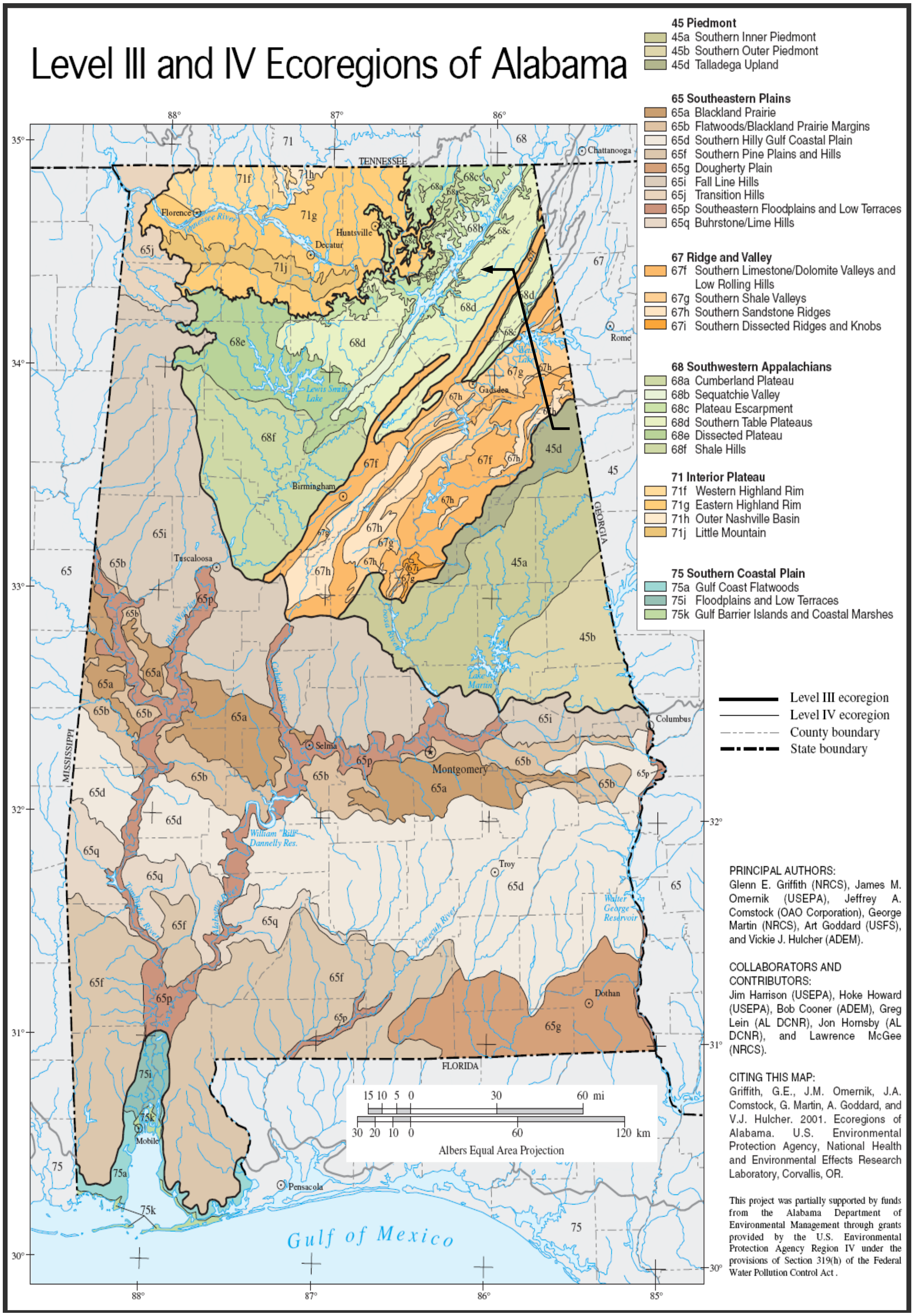


Figure 10. USEPA Level III and IV Ecoregions of Alabama. Source: modified from (Griffith *et al.* 2001).

Park, and various resorts in the city of Mentone, Alabama. A privately-owned resort, Canyonland Park, was operational on the west side of Little River Canyon and featured a chair lift to the canyon that provided recreation to members. This former resort and chair lift are no longer in operation, though the picnic areas, hiking trails such as Eberhart Trail, and restroom facilities nearby are federally maintained. Billy's ford, Hartline ford, and several other areas along the Little River provide sunbathing and picnicking opportunities for horseback riders and All-Terrain Vehicle (ATV) users. Canyon Mouth has been a recreational spot for decades. It was originally managed by Cherokee County, Alabama, but now maintained by the NPS as part of LIRI.

Land adjacent to LIRI has been used for various human activities such as cattle farming, poultry production, and coal mining. Old reclaimed strip mines can be found extensively along the East Fork Little River and along the edges of Yellow Creek. Land just east of the Little River Wildlife Management Area has been clear-cut in the past. Opportunities for land development have influenced the construction of summer homes and second homes along the outer ridges of Lookout Mountain as well as the edges of Little River Canyon.

2.6 Significant Park Resources

2.6.1 History, Purpose, and Significance

According to Public Law 102-427, LIRI was established in October 21, 1992 “in order to protect and preserve the natural, scenic, recreational, and cultural resources of the Little River Canyon area in DeKalb and Cherokee Counties, Alabama, and to provide for the protection and public enjoyment of the resources”. LIRI is the newest park unit in the CUPN (Leibfreid *et al*. 2005) and is the first major national park unit in Alabama (USGS 1996).

According to various NPS documents (NPS 1991, 2005b, 2005c), LIRI is significant because:

1) It has the only river in the United States that flows for almost its entire length atop a mountain (NPS 1991).
2) It has virtually pristine/unpolluted water (NPS 2005b).
3) It is the deepest/most extensive canyon and gorge system east of the Mississippi River (*ibid*. 2005b).
4) It offers sanctuary to a number of rare plants and animals such as the Green Pitcher Plant, the Kral’s water plantain, and the blue shiner fish (*ibid*. 2005b). The Preserve lies at the southern limits of the Cumberland Plateau, contributing to significant biological diversity including habitat for a unique assemblage of plants and animals unparalleled in the region (NPS 2005c).
5) The area offers exceptional opportunities for recreation and public use and enjoyment for biking, camping, horseback riding, world class whitewater boating, rock climbing, and natural and historical related activities (*ibid*. 2005c).
6) The Preserve contains some of the most rugged and outstanding canyon scenery in the southeastern United States (*ibid*. 2005c).
7) The area possesses exceptional value in illustrating and interpreting the theme of river systems in the Appalachian Plateaus (*ibid*. 2005c).

2.6.2 Natural Resources

LIRI contains a significant number of abiotic and biotic natural resources. Abiotic resources within LIRI include more than 12 miles of canyon lands with 10 scenic overlooks featuring an elevation change greater than 400 ft from bluff to canyon floor (NPS 2005b). Little River and its tributaries have carved a series of scenic waterfalls including DeSoto Falls, Little River Falls, Indian Falls, Lodge Falls, Grace's High Falls, Greggs Two Falls, and Johnnies Creek Falls. Although remote areas that limit human contact allow water to remain relatively pristine at LIRI, human influences from its watershed are an ongoing concern, specifically those resulting in the presence of coliform bacteria. Biotic resources within LIRI include habitats that offer sanctuary to a number of rare plants and animals. LIRI also provides outdoor opportunities such as bird watching, which is a favored activity in the area. These abiotic and biotic natural resources provide visitors with recreational opportunities such as hiking, rock climbing along the canyon bluffs, whitewater activities in the wilder portions of the river, swimming, bird watching, plant identification, and horseback riding. Portions of LIRI also include hunting and fishing opportunities through the Little River Wildlife Management Area.

2.6.3 Archeological, Historical, and Cultural Resources

Studies of historical and cultural resources are described by Marshal and Gregg (1997) within LIRI and existing studies have identified several historical and cultural sites adjacent to its boundaries. An archeological assessment conducted through the Southeast Archeological Center (SEAC) discovered approximately 165 archeological sites within and adjacent to the Preserve boundaries (Cornelison 1991). The SEAC maintains a current Cultural Sites Inventory (CSI) that lists 36 documented archeological sites for LIRI along with two prehistoric sites (NPS 2005b). Historic cultural resources include Civilian Conservation Corp (CCC) culverts and bridge abutments, historic roads and trails, and the locations of historical farmsteads (Cornelison 1991). Cultural resource surveys were conducted through the Alabama Power Company before the establishment of LIRI by the NPS (Lobdell 1994; Shaw 1994). These identified potential "bluff shelters" and provided recommendations for future research studies. Artifacts and sites found within LIRI are estimated to belong to the late Archaic/Gulf Formational and Early Woodland periods (B.C. 1200 to B.C. 500).

2.6.4 Natural Resource Management Zones

For management purposes, the LIRI has been subdivided into three resource units; namely a riverine unit, canyon unit, and an upland plateau forest unit.

The "riverine unit" includes the area delineated by the 100-year floodplain of Little River and its tributaries. The river above the falls features pool zones with sandy bottoms, riffles as rocks scour the stream, and is surrounded by wooded hills. The river in the canyon features high-energy environments, numerous rapids, and debris-laden floodplains as the river constricts and gradient increases. This unit provides kayakers and canoeists of all skill levels a place to recreate, however, the upper portion of the canyon is considered dangerous at all water levels as well as other portions as water rises during precipitation events. The more accessible portions of this unit provide other activities such as swimming and fishing.

The "canyon unit" encompasses the 12-mile length of the canyon, including the canyon rim but not the river and its associated floodplain. The canyon features incised valleys of mostly sandstone material that visitors use for rock climbing activities. Biological components within this unit are influenced by the steepness of the slopes.

The “upland plateau forest unit” comprises most of LIRI from the vicinity of Highway 35 northward, but does not include Little River and its 100-year floodplain. This unit is mostly gently sloping, with most of the variation in elevation associated with drainage slopes towards Little River.

As part of the NPS resource planning process, a General Management Plan (GMP) includes a section on management zones for the park units. Although final locations for these management zones have not been determined, the draft GMP for LIRI provides a description of its proposed management zones and is detailed below (NPS 2006c).

The “park support zone” will not typically allow visitors to enter and includes building such as maintenance buildings, administrative offices, and headquarters. Current facilities of this type include a preserve maintenance complex that consists of the main maintenance building, the roads and trails storage building, and two storage sheds.

The “visitor services zone” will provide facilities for collecting information, orientation, interpretation, education, and motor touring. This zone includes any facilities that provide for these activities as well as basic comforts to visitors.

The “sensitive resource zone” allows limited opportunities for access with education by guided tours. No development will occur in this zone other than what might be needed for resource protection.

The “recreation zone” provides hiking, picnicking, hunting, ATV use, motor touring, climbing, swimming, kayaking, bicycling, camping, and fishing activities. This zone includes facilities such as parking lots, trails/walkways, comfort stations, information kiosks, group program areas, overlooks, and wayside exhibits. Current facilities at LIRI include: 1) the Highway 35 parking lot that includes picnic tables and a restroom facility; 2) DeSoto State Park recreation, lodging, and dining facilities; 3) Canyon Mouth Day Use Area that contains a pavilion with a restroom facility and attached pump house and equipment storage, picnic tables, fire rings, a fee booth, and a USGS river level gauging station; and 4) 10 scenic overlooks along the canyon rim scenic drive.

The “semi-primitive recreation zone” provides visitors with similar activity access as the recreation zone, but includes facilities that allow access to resources with less impact to the environment such as natural surface trails, unpaved parking areas, primitive camping areas, and kiosk/waysides.

2.7 Biological Setting

Roughly 950 species of vascular plants have been documented throughout the Little River drainage (Schotz *et al.* 2008). Roughly 95 exotic vegetation species occupy LIRI (*ibid*. 2008). Upland areas of LIRI comprise primarily mixed oak-hickory/heath communities in deeper soils and pine/hardwood/heath communities in shallower soils (NPS 2005b). Canyon areas of LIRI comprise primarily hardwoods (*ibid*. 2005b). Wildlife species at the Preserve are typical of those inhabiting most southeastern United States hardwood forests (*ibid*. 2005b).

3 - Study Approach and Methodology

3.1 General Approach

The framework developed for the National Park Service (NPS) pilot program includes an analysis of biotic and abiotic natural resources as well as aquatic and terrestrial components of the Little River Canyon National Preserve (LIRI). Strategies for a “comprehensive” or a “focused” approach were considered for the NPS pilot program and each offers strengths and weaknesses (Shilling *et al*. 2005). A “comprehensive” approach assesses conditions for numerous components of the study area, which results in a broad overview of conditions. Benefits of this approach may include the exposure of unknown problems in the study area or identification of interconnections between resource components. A comprehensive approach may not be as useful in this study because comprehensive knowledge is not present for the park unit because of its relatively recent establishment in 1992. A “focused” approach identifies critical key resources and issues up front (of all those possible) and then focuses on these. The benefit to this approach is that it may be more useful for future decision making about specific resources or issues. With restrictions of time, money, and available data, the focused approach is more feasible, but it can become too narrow and miss critical issues or overlook broad connections. The NPS pilot program takes the comprehensive approach in that it assesses abiotic and biotic natural resources, but is focused in that it identifies natural resources of interest and related issues (from all those possible) to assess. The challenge was to select a limited, but inclusive, number of indicator/metrics that provide an encompassing representation of individual natural resource and watershed conditions.

The research steps used to organize the approach to accomplish the objectives defined for this study are modifications of those recommended by the *California Watershed Assessment Guide* (Shilling *et al.* 2005):

1) Define the purpose and objectives of the study and develop a plan for the assessment.
2) Collect data and information
3) Analyze the data
4) Integrate and report the data to inform resource management planning

The first step was largely determined in 2006 by the NPS through the development of the purpose and objectives of its pilot program. This step also involved identifying specific concerns and natural resources of interest to LIRI through management planning documents and workshops with personnel. The assessment framework for this study was developed through evaluating and compiling useful components from existing assessment frameworks along with suggestions from the NPS pilot program research team. The following sections in this chapter discuss the establishment of natural resources of interest and development of the assessment framework through results of the first step.

The second step involved gathering background information for LIRI and surrounding area including all existing scientific information such as quantitative, qualitative, and geospatial data pertaining to the natural resources of interest. Various strategies were used to gather and evaluate the information for relevancy and adequacy, which then were compiled in a data summary sheet. The data collection and evaluation process also provided valuable knowledge about information gaps concerning resources at LIRI. Information and data gathered through results of the second step are presented throughout this document and are specifically discussed at the end of this chapter.

The third step involved tabulating and preparing summary data and information through statistical measurements, spatial analysis tools, and data modeling tools. Methods for assessing current conditions involved comparing existing data, where available, to state and federal standards, quantifying variations from a defined reference condition, or defining reasonable criteria based on literature sources and judgment of third party experts. *The Five-S Framework for Site Conservation: A Practitioner's Handbook For Site Conservation Planning and Measuring Conservation Success* (The Nature Conservancy 2000) provided useful suggestions about using color schemes (dark green, green, yellow, red) and classification ranks (excellent, good, fair, poor) for displaying resource conditions.

The fourth step involved reporting the condition of the resources of interest and identifying the influences (threats, stressors, and disturbances) on those natural resources through data integration and synthesis. It is difficult to link causes and effects with high confidence because of the complexity of natural systems, but this study will attempt to identify and describe potential threats, stressors, and disturbances to the natural resources at LIRI that are present or emerging. A detailed analysis, condition assessment, and identification of threats, stressors, and disturbances to the natural resources of interest and related issues through results of the fourth step are presented in Sections 5-6.

3.2 Natural Resources of Interest

The Cumberland Piedmont Network (CUPN) Vital Signs Monitoring Plan (VSMP) (Leibfreid *et al*. 2005) is the primary source from which the natural resources of interest at LIRI were identified for this study. That document identified 12 high-priority vital signs to be monitored by the NPS within LIRI. The CUPN Inventory and Monitoring (I&M) Program has collected data about these vital signs. A list of these natural resources of interest and related issues was generated from these efforts. In a workshop, LIRI personnel reviewed these identified resources and issues to verify that they were still of concern and discussed other issues currently present at the Preserve. LIRI personnel then prioritized these resources and issues numerically (Appendix A). This helped to focus search efforts in this study toward those issues most important and useful to Park managers for resource planning and stewardship.

3.3 Developing the Assessment Framework

In order to build an assessment framework for this study, the various natural resources and related issues at LIRI were grouped into several category levels (Table 3) which were adopted and slightly modified from frameworks or approaches developed by the *NPS Ecological Monitoring Framework* (NPS 2005e) (Appendix B) and the Essential Ecological Attribute (EEA) categories from the United States Environmental Protection Agency – Science Advisory Board (USEPA-SAB) framework (USEPA SAB 2002) (Appendix C). Since data originate from several CUPN I&M Program data sources, it is logical to group natural resources according to the already integrated *NPS Ecological Monitoring Framework* (NPS 2005e). The USEPA-SAB framework approach (USEPA SAB 2002) contains a very comprehensive Essential Ecological Attribute (EEA) list, which was reviewed to capture any additional resource characteristics of interest. The *California Watershed Assessment Guide* (Shilling *et al.* 2005)

Table 3. Assessment framework for natural resources of interest and issues at Little River Canyon National Preserve. Source: Author, yellow categories originate from NPS2005e, green categories originate from USEPA SAB 2002.

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Status*
WATER			
Hydrology	Groundwater Dynamics		NA
	Surface Water Dynamics	Discharge	A
		Gage Height	A
Water Quality	Water Chemistry	Acid Neutralizing Capacity (ANC)	A
		Dissolved Oxygen	A
		PH	A
		Specific Conductance	A
		Sulfate	A
	Nutrient Dynamics	Nitrate	A
		Phosphate	A
	Physical Parameters	Temperature	A
		Turbidity	A
	Toxics		NA
	Microorganisms	*E. Coli*	A
	Aquatic Macroinvertebrates and Algae		NA
LANDSCAPE			
Landscape Dynamics	Land Cover and Use	Land Cover Change	A
		Impervious Surface	A
		Landscape Pattern and Fragmentation	A
		Silviculture	ND
		Mining	A
Soundscape	Soundscape		ND
Viewscape	Viewscape (e.g. building permits, distance from viewscape)		ND
Nutrient Dynamics	Nutrient Dynamics		NA
Energy Flow	Primary Production		NA
GEOLOGY AND SOILS			
Geomorphology	Windblown Features and Processes		NA
	Hillslope Features and Processes (e.g. falls, slides, flows)		NA
	Stream/river Channel Characteristics (e.g. sedimentation rate)		NA
	Lake Features and Processes		NA
Subsurface Geologic Processes	Cave/Karst Features and Processes		NA
	Seismic Activity		NA
Soil Quality	Soil Function and Dynamics	Soil Type	A
Paleontology	Paleontology		NA

Table 3. Assessment framework for natural resources of interest and issues at Little River Canyon National Preserve. Source: Author, yellow categories originate from NPS2005e, green categories originate from USEPA SAB 2002 (continued).

LEVEL 1 CATEGORY Level 2 Category	Level 3 Category	Selected Indicator	Status*
THREATS, STRESSORS, AND DISTURBANCES			
Fire and Fuel Dynamics	Fire and Fuel Dynamics	Fire Location and Frequency	A
Extreme Disturbance Events	Extreme Disturbance Events		ND
Invasive Species	Invasive/Exotic Plants (e.g. extent, risk factor, non-native species diversity)	# Exotic species # Highly ranked species	A
	Invasive/Exotic Animals (e.g. extent, risk factor, non-native species diversity)	# Exotic species # Highly ranked species	A
Infestation, Disease, and Trauma	Insect Pests (e.g. extent, risk factor)	Extent and risk factor	A
	Plant Disease/Trauma	Risk Factor of Ozone Sensitive Plants	A
	Animal Diseases		NA
Visitor and Recreation Use	Visitor Use	Population Density	A
		ATV Use Trend	A
		Swimming Impacts to Water Quality	NA
		Rock Climbing Impact to Cliffs and Biota	ND
		Poaching Risk Factor	ND
		Number of Visitors	NA
BIOTA			
Flora			
Ecosystems and Communities	Community Extent (e.g. floral class extent)		A
	Community Composition (e.g. inventory of species, native species diversity, species richness)		A
	Physical Structure (e.g. Vertical stand structure, tree canopy height, successional state)		NA
Species and Populations	Population Size (e.g. number of individuals in the population)		A
	Habitat Suitability (focal species) (e.g. Measures of habitat attributes important to focal species)		NA
Fauna			
Ecosystems and Communities	Community Extent		NA
	Community Composition (e.g. inventory of species, native species diversity, species richness)		A
Species and Populations	Population Size (e.g. number of individuals in the population, breeding population size, number of individuals per habitat area (density))		A
	Habitat Suitability (focal species) (e.g. Measures of habitat attributes important to focal species)		NA

Table 3. Assessment framework for natural resources of interest and issues at Little River Canyon National Preserve. Source: Author, yellow categories originate from NPS2005e, green categories originate from USEPA SAB 2002 (continued).

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Status*
BIOTA			
Fauna			
Focal Species and Communities	Freshwater Invertebrates (e.g. mussels)		A
	Terrestrial Invertebrates		NA
	Birds		A
	Herpetofauna (Amphibians & Reptiles)		A
	Fishes		A
	Mammals (e.g. deer, bats)		A
At-Risk-Biota	Threatened & Endangered (T&E) Species and Communities		A
AIR AND CLIMATE			
Air Quality	Ozone	Ozone Concentration	NA
	Wet and Dry Deposition		NA
	Visibility and Particulate Matter		NA
	Air Contaminants		NA
Weather and Climate	Weather and Climate (e.g. temperature trends, precipitation trends)		NA
*A = ASSESSED, NA = NOT ASSESSED, ND = NO DATA			

contains a detailed section on watershed issues that provided valuable information on potential natural resource indicators for this study. Items in Table 3 shaded green come from the USEPA-SAB framework and those shaded yellow come from the NPS Ecological Monitoring Framework. The “Selected Indicators” column represents items currently being monitored or that will be monitored through the I&M Program, those that have been identified as resources or issues of interest by NPS personnel, and those identified by the NPS pilot program team as significant for the assessment. The “Status” column identifies which items are assessed (A) and not assessed (NA) in this study and provides knowledge on information gaps (ND). The “Water” category mimics the NPS Ecological Monitoring Framework category with the addition of a “Physical Parameters” category from the USEPA-SAB framework and the removal of a “Marine Hydrology” category. The “Landscape” category name was slightly altered from the NPS Ecological Monitoring Framework and the "Fire and Fuel Dynamics" and "Extreme Disturbance Events" categories moved to the “Threats, Stressors, and Disturbances” category. The “Geology and Soils” category mimics the NPS Ecological Monitoring Framework category with the removal of the "Glacial features and processes", "Coastal/Oceanographic Features and Processes", "Marine Features and Processes", "Geothermal Features and Processes", and "Volcanic Features and Processes" categories. The “Threats, Stressors, and Disturbances” category combines the "Human Use" category from the NPS Ecological Monitoring Framework and the “Natural Disturbance Regimes” from USEPA-SAB framework. Several NPS Ecological Framework categories were brought in from the “Landscapes”, “Human Use”, and “Biological Integrity” categories namely: "Fire and Fuel Dynamics", "Extreme Disturbance Events", "Invasive Species", "Infections and Disease", and "Visitor and Recreation Use". Some items remained within their representative categories instead of being placed in the “Threats, Stressors, and Disturbances” category because these are often useful for describing both pristine and impacted resources depending on their condition. An example of this is land cover change; a low or high percent land cover change toward development suggests pristine or impacted conditions. The “Biota” category is subdivided into flora, fauna, and at-risk biota. It contains “Ecosystems and Communities” and “Species and Populations” category and selected subcategories from the USEPA SAB framework. It also contains the “At-risk Biota” and selected categories from the “Focal Species or Communities” category in the NPS Ecological Monitoring Framework. The “Air and Climate” category mimics the NPS Ecological Monitoring Framework category. This framework comprises what the NPS pilot program investigators deemed useful for assessment of natural resources and watershed conditions at LIRI.

3.4 Information Collection and Evaluation Process

The comprehensive literature search for spatial, qualitative, and quantitative data was conducted using guidelines from *Guidelines for Systematic Review in Conservation and Environmental Management* (Pullin and Stewart 2006). A list of general and specific search terms was developed to extract information on known resources and issues provided through the VSMP, CUPN I&M Program, and LIRI personnel. State and local agency information were also searched for information too localized to appear on various library databases. Data collection efforts focused primarily on numerical information but included useful qualitative information where numerical information was not available. The search strategy was to search various databases using key terms and combinations of key terms to extract relevant information.

4 - National Park Service Resource Planning and Stewardship at Little River Canyon National Preserve

The National Park Service (NPS) has initiated servicewide planning and performance reporting procedures for its park units including the General Management Plan (GMP), which defines and maps “desired conditions” and “Park management zones” for Park resources. The GMP also includes a “foundation statement” that established the park unit’s purpose, significance, and important resource values. Another planning procedure is the Resource Stewardship Strategy (RSS) that is a bridge between the desired conditions established in GMPs and the goals and actions determined through the Park strategic planning. It identifies and tracks indicators of desired conditions and reports accountability in attaining and maintaining desired conditions at the park unit.

Performance reporting for the NPS involve the Government Performance and Results Act of 1993 (GPRA) (United States Congress 1993) and the Office of Management and Budget (OMB) scorecard. The purpose of GPRA is to hold federal agencies accountable for achieving program results by setting goals, measuring performance, and publicly reporting progress. Under the Act, federal agencies are required to develop multiyear strategic plans, annual performance plans, and annual performance reports. The NPS has been limited in the GPRA process on setting goals for natural resources due to insufficient data. The Cumberland Piedmont Network (CUPN) Vital Signs Monitoring Plan (VSMP) and the CUPN Inventory and Monitoring (I&M) Program were organized to gather data on natural resources of interest. On January 25, 2006, the OMB introduced a scorecard for assessing productivity for various agencies including the NPS and covers five areas including strategic management of human capital, competitive sourcing, improved financial performance, expanded electronic government, and budget and performance integration. The scorecard uses a “stoplight” scoring system to track the progress of the NPS in implementing requirements in each area.

4.1 Resource Planning Efforts

The NPS has made several efforts for resource planning including the Resource Management Plan for Little River Canyon National Preserve (LIRI) in 1998 (NPS 1998). Objectives within this management plan were to: 1) maintain a level of water quality that will sustain the river’s assemblage of plants and animals, that will conform to the river’s status as Outstanding National Resource Water (ONRW), and that will continue to support traditional river-related recreation; 2) restore and maintain natural systems to assure the integrity of biological communities; 3) inventory and manage resident species identified as rare and relying on the Preserve for their continued existence; 4) inventory, evaluate and protect cultural resources; and 5) cooperate with the Alabama Division of Game and Fish in providing opportunities for hunting, trapping and fishing within appropriate areas of the Preserve (NPS 2005b).

A Baseline Water Quality Data Inventory and Analysis for LIRI was conducted in 1999 by the NPS Water Resource Division (WRD) to provide descriptive water quality information (NPS 1999). The document provides, “1) a complete inventory of all retrieved water quality parameter data, water quality stations, and the entities responsible for the data collection; 2) descriptive statistics and appropriate graphical plots of water quality data characterizing period of record, annual, and seasonal central tendencies and trends; 3) a comparison of the Park's water quality data to relevant EPA and WRD water quality screening criteria; and 4) an Inventory Data Evaluation and Analysis (IDEA) to determine what Servicewide Inventory and Monitoring Program "Level I" water quality parameters have been measured within the study area" (*ibid*. 1999). The results of the data retrievals for the study area identified 12 industrial/municipal dischargers, no drinking water intakes, one active and one inactive USGS stream gage, seven water impoundments, and water quality parameter values at 72 monitoring stations from 1928 to 1998, 14 of which were located within LIRI. A majority of the monitoring stations represent either one-time or intensive single-year sampling efforts. Nine stations within the study area yielded longer-term records consisting of multiple observations for several important water quality parameters, three of which were within LIRI (*ibid*. 1999).

The CUPN I&M Program was initiated in 2001 to inventory biotic species and examine the status and trends of ecosystem health within its Park units (Leibfreid *et al.* 2005). These inventories were designed to: 1) document at least 90% of the species estimated to occur in each park unit, along with their associated habitats; 2) describe the distribution and relative abundance of species of special concern; and 3) provide baseline information to develop a general monitoring strategy (Nichols *et al.* 2000). In order to accomplish this objective, the CUPN was required to prepare a monitoring plan to describe the design and implementation of their monitoring program as well as the process that led to the final selection of the Vital Signs to be monitored (Leibfreid *et al.* 2005). This monitoring plan was published as the Vital Signs Monitoring Plan for the Cumberland Piedmont Network and Mammoth Cave National Park Prototype Monitoring Program: July 2005 (*ibid*. 2005). The purpose for the VSMP is, "to provide information to detect, predict, and understand changes in major ecosystem resources of primary interest to the Parks that contain them" (*ibid*. 2005).

Objectives for the VSMP were accomplished in three phases: 1) identify significant natural resources, management issues, background information, and develop conceptual models; 2) prioritize and select the Vital Signs to be monitored; and 3) develop sampling designs, protocols, and data management procedures (*ibid*. 2005). During the early VSMP process, several workshops were conducted to identify vital signs for monitoring at the CUPN Park units. Eight high priority vital signs specific to LIRI were established including ozone and ozone impact, water quality and quantity, invasive plants, forest pests, vegetation communities, fish diversity, plant species of concern, and adjacent land use. Identified vital signs that will be monitored by agencies other than the NPS or for which monitoring will likely be done in the future include weather, benthic macro-invertebrates, deer, and fire. Data collection for these vital signs and other biotic species are accomplished through the CUPN I&M Program and are available at the CUPN headquarters at Mammoth Cave National Park (MACA). These stewardship efforts, the CUPN I&M Program and the VSMP, played a significant role in identifying significant natural resources and stressors for the implementation of this study.

A Fire Management Plan (FMP) was generated in 2004 in response to NPS policy Director's Order #18: Wildland Fire Management and serves as a comprehensive program of action to implement fire management policies and objectives in conjunction with resource management objectives (NPS 2005b). This fire management program strives to protect life, property, and natural and cultural resources at LIRI. This plan defined Fire Management Units (FMUs), established a long-term prescribed fire strategy, and described fire management objectives and protocols for LIRI.

A draft Climbing Management Plan for LIRI was generated in August 2005 in order to aid in providing an environment where visitors can safely engage in rock climbing activities while preserving and protecting the natural and cultural resources of LIRI (NPS 2005d). Regulations of climbing in LIRI: 1) allows climbing on any of the existing bolted routes in the west rim of the canyon; 2) allows replacement of existing bolts that are deemed a safety hazard for users either by permit or existing written memorandum of understanding; 3) allows rappelling and use of mechanical ascenders within the boundary of LIRI; 4) does not give permission to cross or climb on lands in private ownership; 5) prohibits installation of new routes or bolts except with permit; 6) may implement limitations on group size, permit systems, closures, and other management practices in order to mitigate or rehabilitate sensitive areas or areas affected by damage; 7) prohibits cutting or pruning of any trees, shrubs, or other vegetation; 8) requires padding of trees and other natural features and removal of padding after use; 9) prohibits killing or harassment of wildlife; and 10) restricts parking to pull outs and areas where parking can be safely accomplished completely off road and outside of tree line (*ibid*. 2005d). This plan details other regulations pertaining to climbing management through the Code of Federal Regulations (CFR) (Title 36 CFR Part 1 and 2, 1993 ed.).

In 2001, Mammoth Cave National Park Hydrogeologist Joe Meiman traveled to the Parks of the CUPN to perform hydrogeologic assessments relative to water resources. The Water Quality Monitoring Program for the Cumberland Piedmont Network (Meiman 2005) that resulted from this effort established sample locations and water parameters to be monitored for each park unit within the CUPN. Three test years were used to collect water data to determine essential water quality parameters for long term monitoring and to identify ideal monitoring locations within selected park units. LIRI was not included in this preliminary testing because extensive knowledge and data were already available from existing monitoring programs, which was used in selecting sample locations and a list of water quality parameters. The Water Quality Monitoring Program for the Cumberland Piedmont Network (*ibid*. 2005) also assigned LIRI a water resource ranking (Category One), which states, *"Water resources are central to Park establishment or mission. High amount of recreational use activities. Contains Federally or State Listed Threatened, Endangered or Rare aquatic or dependent species. Known exceedences of key water quality standards or 303d listed waters. High probability of water resource damage with little or no information of fundamental elements of hydrogeology or water quality.*" (*ibid*. 2005).

A recent water quality report (Meiman 2009) provides a summary of data collected from efforts made through the Water Quality Monitoring Program (Meiman 2005). This report describes water quality sample locations, parameters tested, and provides results in graphic form representing a 24-month testing period between October 2006 and September 2008. This report also provided a brief interpretation of results and recommendations for long-term monitoring. Overall conditions were “good” for water quality at locations sampled within LIRI. Conditions were “fairly good” at sample locations that recharge the Little River adjacent to LIRI.

The NPS Water Resources Division (WRD) received funds through the Natural Resource Challenge (NRC) to conduct Watershed Condition Assessments (NPS CESU 2006). A Watershed Condition Assessment (WCA) involves, “applying a set of descriptive and/or quantitative technical methods to describe ecosystem health at the watershed scale” (*ibid*. 2006). The initial round of NPS pilot program focused on natural resources within selected coastal and Great Lakes Park units. The purpose was to determine the status of, “water quality, habitat condition, invasive species, extractive uses, coastal development, and other issues affecting their condition; to identify knowledge gaps; and to make recommendations for further studies that address resource threats" (NPS 2006a). Inland Park units with their various natural, cultural, and historical resource settings were not included in the initial round of assessments. These assessments provided limited geospatial content, and generally did not show watershed conditions in a geospatial context. In 2006, another round of NPS pilot program assessments was initiated that incorporated inland Park units across the country. These assessments are intended to evaluate both natural resource and watershed conditions, while utilizing available geospatial content to display those conditions where possible. Results from these NPS pilot programs will be applied to a service-wide implementation, planned through 2014 (NPS CESU. 2006).

4.2 Review of Other Research Efforts

Sources of existing data potentially useful in this study were identified through initial discussions/surveys of NPS personnel, a literature search, and several workshops. Useful NPS information includes data collected from the Cumberland Piedmont Network (CUPN) Vital Signs Monitoring Plan (VSMP) (Leibfreid *et al*. 2005), CUPN Inventory and Monitoring (I&M) Program, Biological Inventories (Natural Resources Bibliography and NPSpecies database), existing management objectives including available General Management Plans (GMP), and other hosted research.

In 1989, the *Little River Canyon National Natural Landmark Site Evaluation* (Whetstone 1989) was generated to evaluate the area for nomination as a National Natural Landmark Site and provides background information on location, ecological descriptions, land use, significant resources, and comparative evaluation of the area.

In 1991, a *Special Resource Study Little River Canyon Area Cherokee, De Kalb, and Etowah Counties, Alabama* (NPS 1991) was developed prior to the Park unit establishment in fulfillment of a congressional mandate calling for a new area/special resource study to be conducted in these counties of Alabama. The major objective for this study was to determine if this area qualified in terms of national significance, suitability, and feasibility. This study describes resources, their significance, the area suitability, feasibility, alternatives for resource protection, and an environmental assessment for resources in this area.

In 1995, a *Bibliography of Little River Canyon National Preserve* (Gregg *et al*. 1995) was compiled to aid the development of a General Management Plan (GMP). A search for relevant data sources was accomplished through thirteen online databases, six regional libraries, and six state/corporate archives. The initial search revealed that very little work had been done within the boundaries of Little River Canyon National Preserve (LIRI), so the search was broadened to include northern Alabama, Lookout Mountain, and the southern Appalachian region.

The Natural Resources Bibliography (NRBib) provides as list of literature such as published papers, proceedings from meetings, government documents, research reports, hand-written notes, species lists, and information compiled by local volunteers (Nichols *et al.* 2000). This list, however, may not be useful in determining the current status of inventories due to the fact that it is often unverifiable.

NPS personnel at LIRI provided water quality information from an unpublished thesis study in

2001 (Belue 2001), which included bimonthly water sampling begun in Nov. 1996. Parameters include: temperature, pH, turbidity, dissolved oxygen, total dissolved solids, chloride and chlorine, nitrate, nitrite, ammonia, fecal coliform and enterococci, phosphorous, sulfate, and discharge. Main objectives were to characterize water quality in LIRI and provide management recommendations to protect water quality.

The *Upper Coosa Basin Watershed Management Plan* (ADEM 2004) includes information about the LIRI study area. The goal of this management plan is to improve, protect, and maintain the beneficial uses and water quality standards of the Upper Coosa River Basin through a basinwide public/private partnership. This document states the area sub-watersheds west of Little River have high potential for nonpoint source impairment and the area east of Little River have low potential for nonpoint source impairment. This plan highlighted several sample locations within the LIRI study area that yielded water quality values exceeding standards for pH and dissolved oxygen. Specifically, water quality values from the dam at Desoto Falls (DFLR) exceeded standards 65% for pH and 18% for dissolved oxygen. This plan also contained sedimentation rates detailed by Hydrologic Unit Code sub-watershed boundaries (HUC-11) defined by the Natural Resources Conservation Service (NRCS) within counties of the Upper Coosa Basin.

Several studies were conducted through the Top of Alabama Regional Council of Governments (Top of Alabama Regional Council of Governments 2005, 2006, 2007) that includes information on general location, geology, soils, climate, biology, cultural history, and current/potential issues for the East Fork Little River, West Fork Little River, and Little River watershed areas. Recommendations are given in response to issues presented in each area and several water sampling data results were included within these documents.

In 2008, the *Digital Vegetation Maps for the NPS Cumberland – Piedmont I&M Network Final Report* (Jordan and Madden 2008) became available, providing procedures for digitally mapping vegetation at NPS Park units in the CUPN. These digital vegetation layers are classified by the National Vegetation Classification System (NVCS).

The NPS provides a list of research permits pertaining to each Park unit through the Research Permit and Reporting System (RPRS) and provides access to contact information concerning previous and currently occurring research for LIRI (NPS 2007a). Many of the reports mentioned previously are listed within this database of research permits.

4.3 Management Planning Status

The status of LIRI's GMP and resource stewardship planning was evaluated to determine whether it had already defined its Park management zones and determined desired conditions and associated metrics for its resources. LIRI is currently developing a GMP that is anticipated to be available in 2011. The draft GMP provides proposed Park management zones with associated descriptions. Few desired conditions with associated measures have been developed for LIRI because a RSS is not generally developed until a GMP is in place.

The only natural resource oriented GPRA goal currently submitted from LIRI is service-wide goal Ia4A that addresses river miles meeting State and Federal water quality standards. The OMB scorecard is generated at the agency level, not park unit level, so there is no OMB scorecard specifically for LIRI.

5 - Condition Assessment

5.1 Assessment of Water Resources

5.1.1 Watershed

As previously discussed, Figure 6 shows ten United States Geological Survey (USGS) Hydrologic Unit Code (HUC) boundaries for Little River Canyon National Preserve (LIRI), but the points to which the streams within these HUCs drain do not correspond with the sample locations established by LIRI personnel for monitoring water quality. Fourteen sample locations are currently monitored for water quality in and around LIRI, 11 of which have been chosen for inclusion in this study (Figure 11). The three sample locations not used in this study are located in the headwaters of small tributaries and do not provide optimal locations or information. Five of these included sample sites are located within LIRI and six are outside its boundary. Each sample location has been assigned a four-letter code by the National Park Service (NPS) and these are explained in Table 4. Two USGS gage stations are operational within LIRI providing gage height and water discharge information (Figure 11).

The purposes for redefining the ten HUC-12 sub-watersheds is to provide a geospatial representation of the drainage area influencing water quality at these LIRI sample locations and to assess land cover change characteristics that will be discussed in a later section of this document. For this assessment, the term "LIRI watershed" refers to the 11 sub-watershed areas that collect and divert its water through LIRI. LIRI (~13,798 acres) comprises approximately 11% of the LIRI watershed (~127,158 acres) and Table 5 provides a summary of the area within each sub-watershed and its percentage of the LIRI watershed.

Table 4. Little River Canyon National Preserve sample location codes and descriptions. Source: modified from (Meiman 2005).

LIRI Code	Sample Location Description
BHLR	Burnt House Ford
CMLR	Canyon Mouth
DFLR	DeSoto Falls
DSLR	DeSoto State Park
EFLR	East Fork Little River
EPLR	Eberhart Point
HBLR	Highway 35 Bridge
JCJC	Johnnie's Creek
LCLR	Lookout Mountain Camp
MFLR	Middle Fork Little River
YCYC	Yellow Creek

Table 5. Sub-watershed area in acres and as a percent of the total Little River Canyon National Preserve watershed. Source: Author, (NPS 2006a).

Sub-watershed	Area (acres)	% of LIRI Watershed
BHLR	72052	56.66%
CMLR	127158	100.00%
DFLR	22717	17.87%
DSLR	27237	21.42%
EFLR	7956	6.26%
EPLR	106647	83.87%
HBLR	90023	70.80%
JCJC	12413	9.76%
LCLR	23329	18.35%
MFLR	10974	8.63%
YCYC	9302	7.32%

Note that a 'cumulative' approach is used to represent the sub-watershed areas with regard to water quality. For each sample location, the cumulative subwatershed represents all upstream area from that point. For example, in Figure 12 the Lookout Mountain Camp (LCLR)

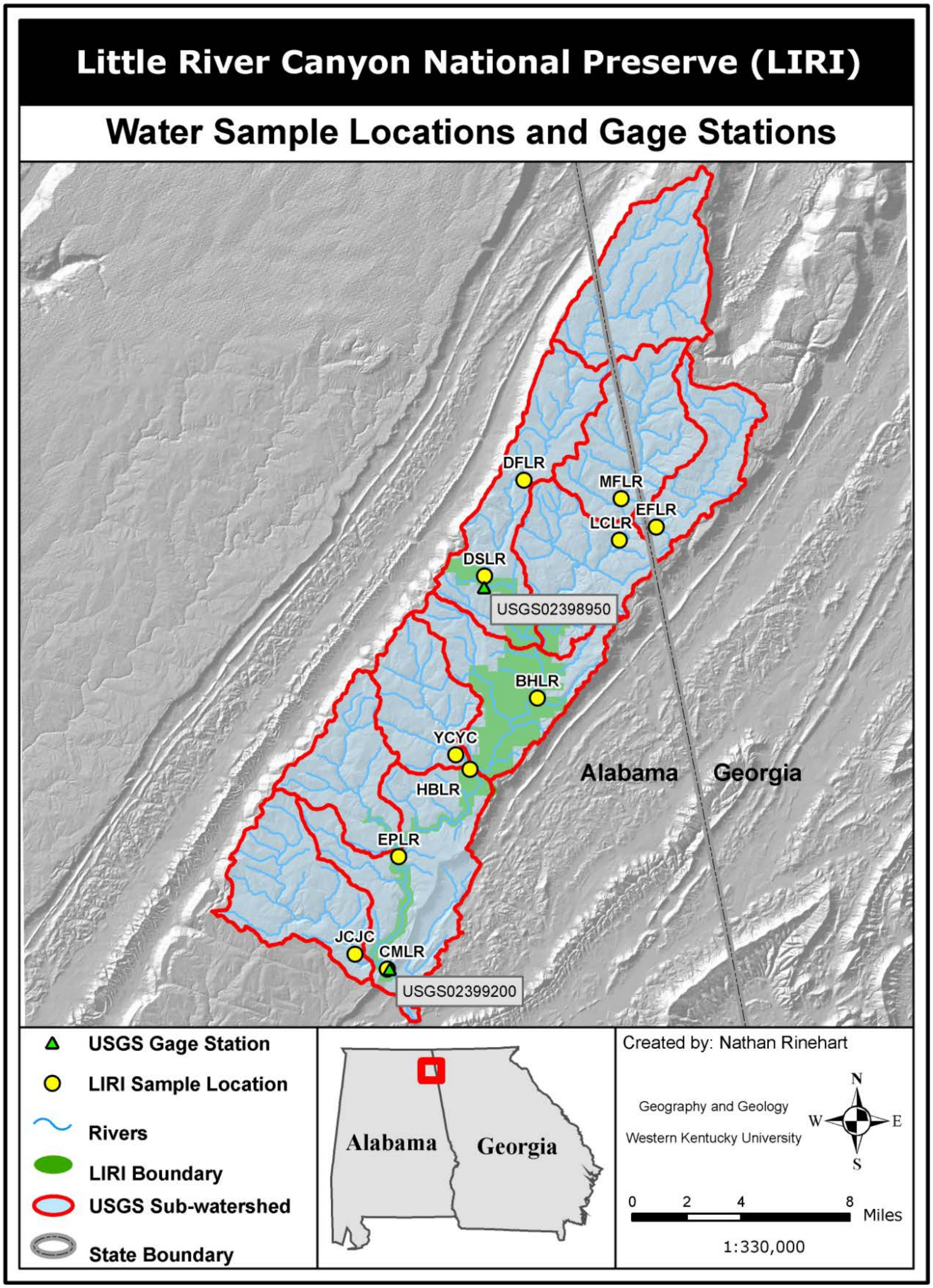


Figure 11. Little River Canyon National Preserve sample locations and gage stations. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie's Creek, CMLR – Canyon Mouth. Source: (USGS 2008; USGS 2007a; NPS 2007b).

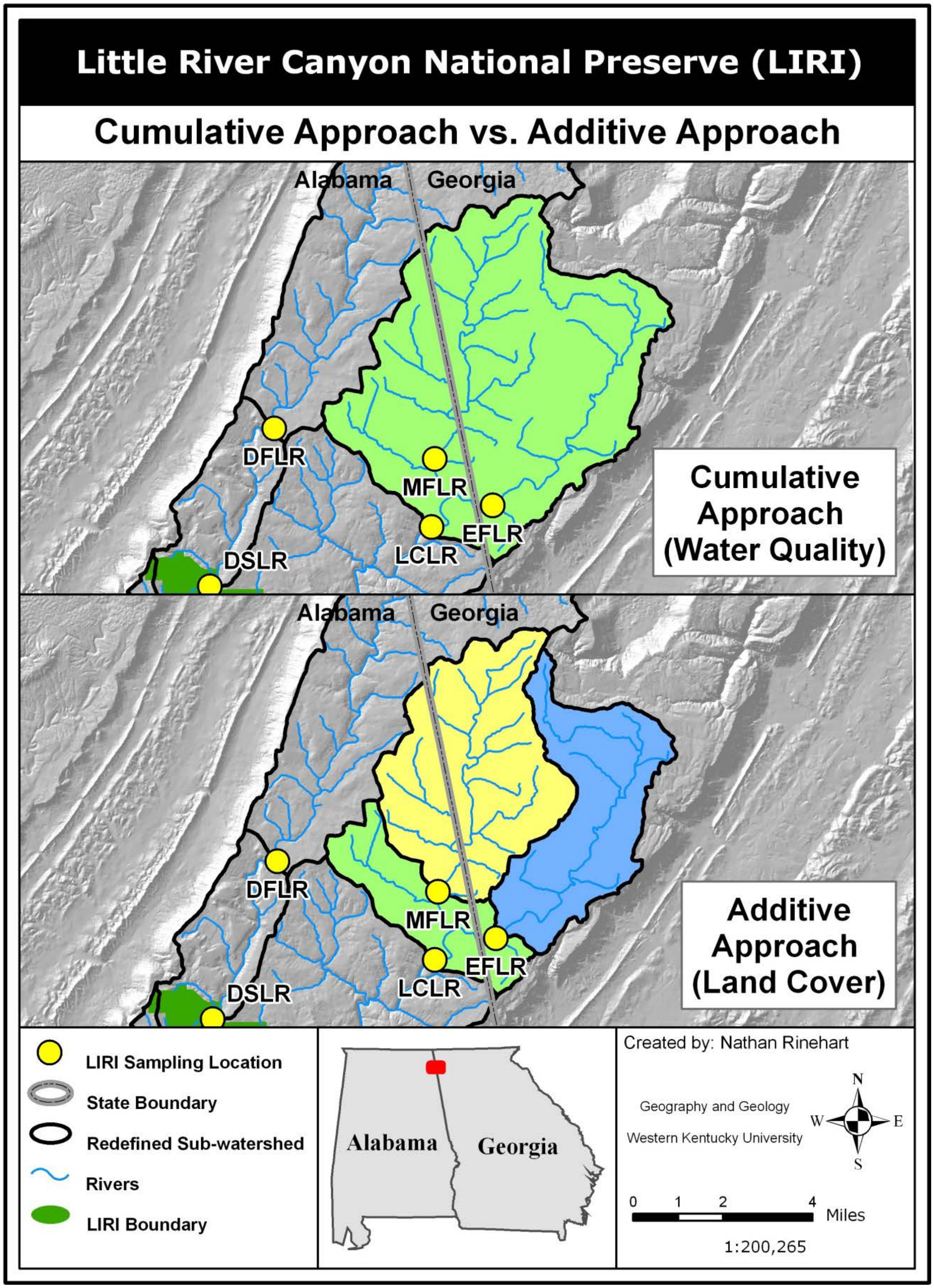


Figure 12. Cumulative approach vs. additive approach for defining sub-watersheds at Little River Canyon National Preserve. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park. Source: Author, (USGS 2007a).

‘cumulative’ sub-watershed includes the Middle Fork Little River (MFLR) and East Fork Little River (EFLR) sub-watersheds plus the additional area draining to the LCLR sample location.

An ‘additive’ approach as shown in Figure 12 is used in the discussion of land cover characteristics. In this case, each sub-watershed is considered separately and added together will total 127,158 acres or 100% of the LIRI watershed.

The USGS sub-watershed polygons were adjusted using the Environmental Systems Research Institute (ESRI®) software ArcMap™ Editor toolbar, LIRI sample locations, and georeferenced digital topographic relief maps at a 1:24,000 scale. Adjustments were made to the HUC-12 boundaries by starting at the sample locations and editing the original boundary following perpendicular to the elevation contours, until the adjusted polygon boundary overlapped with the original HUC boundary. Figure 13 shows the 11 redefined sub-watershed boundaries (black outline) compared to the ten USGS HUC-12 boundaries (red outline).

5.1.2 Water Quantity

Two USGS gage stations currently monitor stream discharge and gage height within LIRI. Data from these locations were downloaded from the USGS National Water Information System (NWIS) website (USGS 2008). Gage station USGS 02398950 (at DeSoto State Park) provides data ranging from 1997 to the present and gage station USGS 02399200 (at Canyon Mouth) provides data ranging from 1958 to the present. Data are collected at gage stations by automatic recorders and manual field measurements. Data provided by the USGS NWIS include: 1) real-time data; 2) daily data; 3) statistics data providing daily, monthly, and yearly summaries; 4) peak-flow data; and 5) field measurements. Real-time data are time-series data from automated equipment, commonly recorded at 5-60 minute intervals, and then transmitted to the NWIS database every 1-4 hours. Data relayed through the Geostationary Operational Environmental Satellite (GOES) system are processed automatically in near real time, may be available online within minutes, and are available online for 31 days. Daily data values are summarized from time-series data for each day and provide the daily mean, median, maximum, minimum, and/or other derived values. Daily values include approved, quality-assured data that may be published, and more recent provisional data, whose accuracy has not been verified. Statistics are computed from approved daily mean time-series data at each site and provide summaries of historical daily values for daily, monthly, and annual (water year or calendar year) time periods. A water year is defined as October 1 through September 30. A calendar year is defined as April 1 through March 31. The hydrologic seasons for LIRI are: June 1 to October 31, November 1 to February 28, and March 1 to May 31 (NPS 1999). Peak-flow data consist of annual maximum instantaneous flow values. Manual field measurements of stream flow and gage height are periodically taken and used to supplement or verify the accuracy of the time-series measurements.

Annual statistics for these USGS gage stations are summarized in Table 6 for USGS 02398950 (at DeSoto State Park) and Table 7 for USGS 02399200 (at Canyon Mouth) according to water year (October 1 through September 30). Annual mean discharge values are expressed in cubic feet per second (cfs) and range from 42.1 cfs to 119.2 cfs for station USGS 02398950 and from

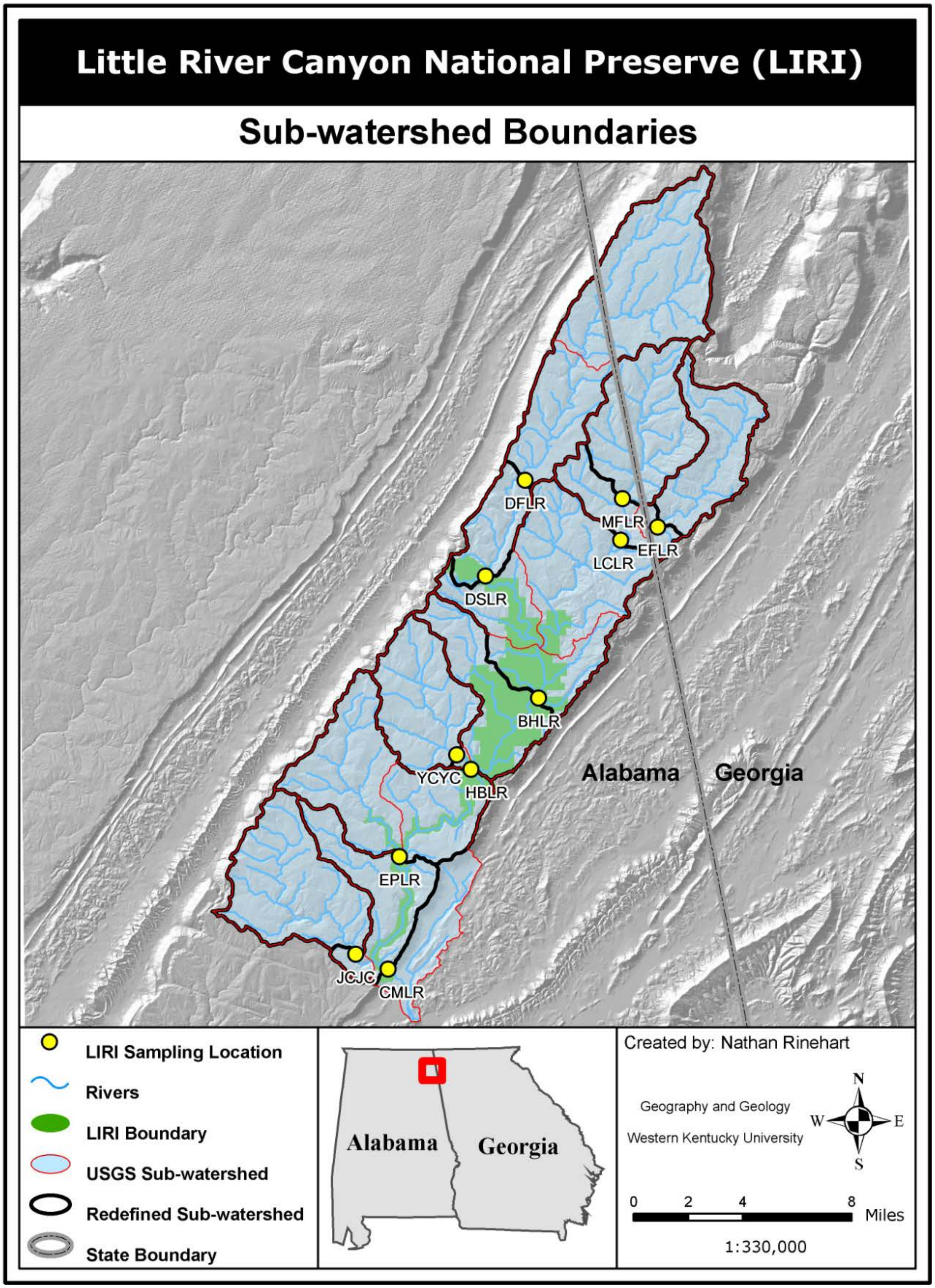


Figure 13. Redefined sub-watersheds at Little River Canyon National Preserve modified from the USGS sub-watersheds. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie’s Creek, CMLR – Canyon Mouth. Source: Author, (USGS 2007a).

Table 6. Mean annual statistics for gage station USGS 02398950. cfs = Cubic feet per second, ft = feet, ND = No Data. Source: (USGS 2008).

Water Year	Gage Height (ft)	Discharge (cfs)
1998	ND	83.7
1999	ND	67.6
2000	2.783	54.7
2001	3.102	63.9
2002	ND	71.8
2003	3.761	119.2
2004	ND	78.1
2005	ND	90.8
2006	ND	44.2
2007	ND	42.1

Table 7. Mean annual statistics for gage station USGS 02399200. cfs = Cubic feet per second, ft = feet, ND = No Data. Source: (USGS 2008).

Water Year	Gage Height (ft)	Discharge (cfs)	Water Year	Gage Height (ft)	Discharge (cfs)	Water Year	Gage Height (ft)	Discharge (cfs)
1959	ND	267.8	**1976**	3.764	555.3	**1993**	3.546	559.2
1960	ND	412.9	**1977**	ND	465.5	**1994**	ND	495.6
1961	ND	498.6	**1978**	ND	557.8	**1995**	ND	445.2
1962	ND	566.2	**1979**	ND	643.9	**1996**	4.071	640
1963	ND	485.1	**1980**	ND	547.6	**1997**	ND	547
1964	ND	562.7	**1981**	ND	557.8	**1998**	ND	484.5
1965	ND	421.9	**1982**	ND	536.7	**1999**	ND	353.4
1966	ND	357.7	**1983**	ND	593.1	**2000**	3.223	251
1967	ND	438.4	**1984**	ND	633	**2001**	3.607	372.5
1968	ND	ND	**1985**	3.352	428.3	**2002**	3.353	373.7
1969	ND	ND	**1986**	3.077	191.7	**2003**	4.04	626.6
1970	ND	ND	**1987**	ND	492	**2004**	ND	379.4
1971	ND	458.4	**1988**	3.268	237.4	**2005**	ND	463.4
1972	ND	459.7	**1989**	ND	584.2	**2006**	3.894	200.6
1973	ND	695.9	**1990**	ND	783.7	**2007**	ND	172.9
1974	ND	550.2	**1991**	ND	457.7			
1975	ND	575.7	**1992**	3.591	438.6			

172.9 cfs to 783.7 cfs for station USGS 02399200. The highest discharge rates (mean of monthly means for the period of record) appear in February at station USGS 02398950, in March at station USGS 02399200, and the lowest for both stations appear in August. The top five highest and lowest mean daily discharge and gage height events for the period of record appear in Table 8 for USGS 02398950 and Table 9 for USGS 02399200. For gage station USGS 02398950, discharge ranges from 0.01 – 4120 cfs and gage height ranges from 1.08 – 12.04 inches. For USGS 02399200, discharge ranges from 0.2 – 27100 cfs and gage height ranges from 1.38 – 12.73 inches. Notice for gage station USGS 02398950 that the three highest discharge and gage height values are on the same dates as well as the highest values for USGS 02399200. For gage station USGS 02398950, there are several consecutive days in 1999 where the lowest discharge values occurred.

Table 8. Top five highest and lowest mean daily discharge and gage height events for USGS 02398950 (10/23/1997 to 9/30/2007). cfs = Cubic feet per second, ft = feet. Source: (USGS 2008).

Rank	Mean Daily Discharge (cfs)	Date	Mean Daily Gage Height (ft)	Date
HIGHEST	4120.00	9/17/2004	12.04	9/17/2004
2nd Highest	2520.00	5/6/2003	10.15	5/6/2003
3rd Highest	1880.00	4/3/2000	9.35	4/3/2000
4th Highest	1700.00	4/4/2000	9.12	11/4/2004
5th Highest	1700.00	1/25/2002	8.99	5/7/2003
LOWEST	0.01	9/15/1999	1.08	9/17/2000
2nd Lowest	0.01	9/16/1999	1.13	9/16/2000
3rd Lowest	0.01	9/17/1999	1.18	8/21/2000
4th Lowest	0.01	9/19/1999	1.25	9/8/2007
5th Lowest	0.01	9/20/1999	1.25	9/10/2007

Table 9. Top five highest and lowest mean daily discharge and gage height events for USGS 02399200 (10/1/1958 to 9/30/2007). cfs = Cubic feet per second, ft = feet. Source: (USGS 2008).

Rank	Mean Daily Discharge (cfs)	Date	Mean Daily Gage Height (ft)	Date
HIGHEST	27100.00	2/16/1990	12.73	2/16/1990
2nd Highest	23000.00	4/13/1979	12.09	3/4/1979
3rd Highest	20900.00	9/17/2004	12.00	7/17/1983
4th Highest	19800.00	3/4/1979	11.43	9/17/2004
5th Highest	18900.00	7/24/1985	11.00	7/18/1983
LOWEST	0.20	7/20/1960	1.38	10/22/1976
2nd Lowest	0.20	7/21/1960	1.39	10/15/1974
3rd Lowest	0.27	9/20/1999	1.39	10/21/1976
4th Lowest	0.27	9/28/1999	1.40	10/14/1974
5th Lowest	0.28	9/27/1999	1.40	10/31/1974

5.1.3 Water Quality

The sample locations depicted in Table 4 and the water quality parameters adopted for this study come from the *Water Quality Monitoring Program for the Cumberland Piedmont Network* (Meiman 2005). The ten water quality parameters are acid neutralizing capacity (ANC), dissolved oxygen (DO), *E. coli*, nitrate (NO_3), pH, phosphate (PO_4), specific conductance (SpC), sulfate (SO_4), turbidity, and water temperature. The following definitions of water quality parameters are summarized from *USGS Techniques of Water-Resources Investigations Book 9, Chapters A1-A9* (USGS 2001).

Acid Neutralizing Capacity (ANC) is the capacity of unfiltered water to neutralize an acid to a specified pH endpoint. ANC differs from alkalinity since ANC also includes the neutralization capacity of the suspended solids and dissolved solids (alkalinity). ANC is equivalent to alkalinity for samples without titratable particulate matter. ANC can be quite low in places that lack exposure to carbonate strata and these places are susceptible to lowered pH values possibly caused by acidic precipitation or human influences that may introduce acids into the waters.

Dissolved oxygen (DO) is a measure of the amount of oxygen in solution, which is influenced by photosynthetic and microbiologic activity and can be subject to significant daily variation. Adequate DO is necessary to maintain diverse aquatic communities and fisheries and also documents change to the environment caused by natural phenomena and human activities. Many chemical and biological reactions in ground water and surface water depend directly or indirectly on the amount of oxygen present.

E. coli bacteria are found in wastes of warm-blooded animals. Fecal indicator bacteria are used to assess the quality of water not because they are typically disease causing, but are correlated to the presence of several waterborne disease causing organisms (pathogens). The concentration of fecal indicator bacteria is a measure of water safety for body-contact recreation or for human consumption. The most widely used indicator bacteria are total coliform, fecal coliform, enterococci, fecal streptococci groups, and *E. coli*. *E. coli* is common to the waters of LIRI and in cases fecal bacteria exceed state water quality limits for its water use classification.

Nitrate (NO_3) is a highly soluble anion found in many waters throughout Park units of the Cumberland Piedmont Network (CUPN). LIRI waters are highly oxygenated, therefore, the oxidation state of nitrogen is found as nitrate. Nitrate is likely the limiting nutrient (controls growth) in LIRI waters. The *Water Quality Monitoring Program for the Cumberland Piedmont Network* (Meiman 2005) notes that several water bodies within the network have elevated or slightly elevated nitrate levels that are high enough to warrant long-term monitoring.

Values of pH represent the negative logarithm of the hydrogen ion (H^+) activity in water. The pH of water is an important indicator of water system health because it directly affects physiological functions of plants and animal systems. Values of pH are naturally low in LIRI waters.

Phosphate (PO_4) is an anion associated with agricultural land use, especially fertilizers and is a contributor to non-point source pollution. Sulfate (SO_4) and phosphate levels found at LIRI suggest the necessity to include these anions for long-term monitoring (*ibid*. 2005).

Specific conductance (SpC) is the ability of a solution to carry an electric current and can be useful in estimating the concentration of total dissolved solids (TDS) in water, but there is no universal linear relation between total dissolved substances and conductivity.

Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. While turbidity alone does not address the key questions, as turbidity is not necessarily directly correlative to suspended solid loads, it remains the most cost-effective measure. Turbidity has long been a parameter sampled at LIRI, which has an extensive watershed beyond its boundaries, and various land use practices typically introduce fine sediments into LIRI waters.

Water temperature is an important parameter because: 1) it may indicate thermal pollution; 2) it may help in identifying mixing of surface water through surface runoff and groundwater through groundwater drainage; 3) it influences most physical, chemical, and biological processes; and 4) for the determination of dissolved-oxygen concentration, specific conductance, pH, rate and equilibrium of chemical reactions, biological activity, and fluid properties rely on accurate temperature measurements.

5.1.3.1 Data Preparation: Three major databases for water quality were used for this study: the historical United States Environmental Protection Agency (USEPA) STOrage and RETrieval (STORET) database (USEPA 2007b), Vital Signs Monitoring Plan (VSMP) CUPN Water Quality Program database (NPS 2008b), and results of water quality studies done through Jacksonville State University (JSU) (Belue 2001).

Several modifications were made to the JSU database in order to create a master database for analysis. A date column was added and filled as well as a column to represent each location's four-letter Park unit code established by the National Park Service (NPS). A column for *E. coli* was added and values were brought in from a corresponding microorganism database.

The CUPN water quality program database was sorted by parameters and those not part of the ten used for this study were removed. Two columns were added in the master database for "specific conductance" (SpC) and "acid neutralizing capacity" (ANC). The appropriate information associated with sample locations, dates, and parameters were brought into the master database from the CUPN water quality program database.

The USEPA STORET database was sorted by sample location and these locations were geospatially compared to the 11 NPS sample locations used in this study. Assumptions were made concerning the locations of these various USEPA STORET and NPS sample locations such as: 1) the sample locations all had to be in the river or stream; 2) the method used for establishing latitude and longitude coordinate by the NPS is likely more accurate than historical methods used by the USEPA STORET sources; and 3) the parameter value would not be drastically different between the represented location differences (difference of ~ 500 ft) unless tributaries came into the main channel between the locations. Using these assumptions, locations from the USEPA STORET database shown to be comparable to the NPS sample locations were used while the others were removed (Table 10). It should be noted that most of the USEPA STORET locations within the study area matched the NPS locations, partially due to accessibility constraints to the rivers and tributaries. The USEPA STORET database date column was reformatted to match the format of the master database (e.g. 650107 became 1-7-1965). The USEPA STORET database was sorted by parameter and those not associated with the ten parameters used in this study were removed. Note that the historical USEPA STORET database contains data that may have been collected using different methods/protocols depending on date, operator, or agency. Five-digit parameter codes were developed (USGS 2007b) to describe these methods/protocols and were included for each parameter value in this database. Parameter information was brought into the master database that was comparable with methods/protocols employed by the other databases. Table 11 shows the selected parameter codes used in the master database and their descriptions. During merger process, several issues were addressed including removal of duplicate records, selection of values closest to exceeding water quality limits where duplicate records show different values, and correction of data entry errors. Compatibility of phosphate values could not be determined between the JSU database and the other databases, so the JSU phosphate values were not included in this analysis.

Table 10. USEPA STORET Station IDs comparable to Little River Canyon National Preserve sample locations. Source: Author.

LIRI Code	USEPA STORET Station ID
BHLR	NONE
CMLR	LIRI0007, LIRI0008, LIRI0009, LIRI0010
DFLR	LIRI0060, LIRI0061, LIRI0062
DSLR	LIRI0027, LIRI0042
EFLR	LIRI0048
EPLR	LIRI0023
HBLR	LIRI0028, LIRI0029, LIRI0032
JCJC	LIRI0015, LIRI0016
LCLR	LIRI0047, LIRI0050
MFLR	LIRI0055
YCYC	NONE

Table 11. USGS water quality parameter codes used from the USEPA STORET database. Source: (USGS 2007b).

Code Description	Parameter Code
Temperature, water (degrees Celsius)	00010
Specific conductance (UMHOS/CM @ 25C)	00095
Dissolved oxygen, unfiltered (mg/L)	00300
pH, unfiltered, field (standard units)	00400
Nitrate nitrogen, total (mg/L as N)	00620
Phosphate, Ortho (mg/L as PO_4)	00660
Sulfate (mg/L as SO_4)	00945
Turbidity, field nephelometric turbidity units (NTU)	82078

5.1.3.2 Data Analysis: Once the water quality data were combined, values were compared to water quality limits assigned to the ten parameters chosen for this assessment. Table 12 shows each parameter with its measurement unit and parameter limit or range. Parameter limits for dissolved oxygen, pH, water temperature, and turbidity come from state-designated criteria (ADEM 2008; GA EPD 2008). Neither Alabama nor Georgia has assigned limits for *E. coli*, nitrate, phosphate, and sulfate; so USEPA federal guidelines were used in these cases (USEPA 1986, 1999). Specific conductance and acid neutralizing capacity limits were established from professional judgment by LIRI and CUPN personnel and past water quality monitoring efforts.

All water flowing through LIRI ends up at the Canyon Mouth (CMLR), the farthest downstream sample location (Figure 13). Making an assumption that water quality values at this sample location represent the cumulative water quality at LIRI, Table 13 was generated to provide a summary of the combined database for the Canyon Mouth (CMLR) sample location including count, minimum, median, maximum, mean, standard deviation, and percent attainment (% ATN) values. Within the combined database, ~3% of the observations were "*Non-detect", ~1% were "*Present <QL", and ~0.1% were ">QL". "Non-detect" refers to instances when an analysis is done and nothing was detected in the sample. "Present <QL" refers to when an analysis is done

Table 12. Water quality parameters with respective units and limit values for Little River Canyon National Preserve. Source: CUPN, ADEM 2008, GA EPD 2008, (USEPA 1986, 1999).

Water Quality Parameter	Reference Condition	Reference Source
Acid Neutralizing Capacity (ANC) (mg/L)	≥ 0 mg/L $CaCO_3$	CUPN
Dissolved Oxygen (DO) (mg/L)	> 5.5 mg/L >5.0mg/L	ADEM 2008 GA EPD 2008
E. coli (Colony Forming Units-CFU/100 mL)	< 298 CFU/100 mL	USEPA 1986
Nitrate (NO_3) (mg/L as N)	< 90 mg/L as N	USEPA 1986
pH (Standard Unit-SU)	6.0 - 8.5 SU	ADEM 2008 GA EPD 2008
Phosphate (PO_4) (mg/L as total P)	< 0.05 mg/L as total P	USEPA 1986
Specific Conductance (SpC) (microsiemens-µS/cm)	> 10 µS/cm	CUPN
Sulfate (SO_4) (mg/L as SO_4)	< 250 mg/L as SO_4	USEPA 1999
Water Temperature (degrees Celsius)	< 32.2 C	ADEM 2008 GA EPD 2008
Turbidity (Nephelometric Turbidity Units-NTU)	< 50 NTU over background	ADEM 2008

Table 13. Water quality summary for Canyon Mouth (CMLR) sample location. Source: Author.

Parameter (CMLR)	Count	Min	Median^	Max	Mean^	Std Dev^	% ATN
ANC (mg/L)	15	2.10	7.20	13.20	7.18	3.40	**100%**
DO (mg/L)	207	3.40	8.96	14.40	9.23	1.98	**99%**
***E. coli* (CFU/100mL)**	92	*Present <QL	8.45	>2419.20	74.21	261.09	**96%**
NO_3 (mg/L as N)	123	*Non-detect	0.13	0.92	0.18	0.15	**100%**
pH (SU)	225	4.50	6.58	8.77	6.53	0.59	**84%**
PO_4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	**100%**
SpC (µS/cm)	256	1.00	32.00	240.00	33.75	16.92	**100%**
SO_4 (mg/L as SO_4)	148	0.84	7.00	330.41	18.75	35.89	**99%**
Turbidity (NTU)	125	0.34	1.21	33.96	2.52	4.70	**100%**
Water Temp. (^{o}C)	343	1.00	16.70	31.00	16.57	7.59	**100%**

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor, ATN = Attainment, QL = Quantity Limit.

and something is found, but it is below the measurement method's quantifiable limit (QL). ">QL" is when an analysis is done and something is found, but it is larger than the measurement method's quantifiable limit (QL). The mean, standard deviation, and median for parameters were calculated using the remaining ~96 % of the data. "Non-detect", "*Present <QL", and ">QL" were used in observation counts and to calculate percent attainment as well as represent minimum and maximum values where appropriate. The *E. coli* values are the only values that exceed a quantifiable limit (>2419.2 CFU/100mL). In this case, this quantifiable limit is much higher than the established limit of 298 CFU/100mL, so it should not make much difference in terms of knowledge gained because it would be apparent that these values were largely outside the determined limit. Histograms were generated for water parameters at the CMLR sample location as well as parameter values from an accumulation of all sample locations (Appendix D). The approach taken for calculating percent attainment was to divide the number of attainment values by the number of observations for the period of record. The question then became: How does one assign a condition to these water quality parameters? A "stoplight" approach was used by assigning a color to predefined percentages for water quality attainment to represent its condition over the period of record. Water quality parameters were classified into one of four possible resource conditions based on their percent attainment of a state or federal standard. These four conditions are based on the model of a normal (bell-shaped) distribution for the data. In this model, 95% of data are within two standard deviations of the mean parameter value, and approximately 99.7% of data are within three standard deviations. Another attribute of this distribution is that the mean and median values are equal such that 50% of data will lie below the mean and 50% will lie above it. Each level of attainment is associated with a color and a resource condition term. Thus, water quality is considered to be 'Excellent' (green) for a given parameter when at least 99% of the data values demonstrate attainment. Water quality is considered 'Good' (light green) at a 95-98% attainment level. A condition of 'Fair' (yellow) is assigned to a 50-94% attainment level and 'Poor' (red) to cases where less than 50% of the data values demonstrate attainment.

A similar summary table was created for all the sample locations (Appendix E) and a majority of the condition values from these summary tables were designated green or light green, though many of the conditions for dissolved oxygen, pH, and *E. coli* were designated yellow. A summary of water quality conditions was assessed using all sample location data (Table 14) to provide a way in which to capture a holistic view of water quality in the LIRI watershed.

Table 14. Water quality summary for all sample locations within the Little River Canyon National Preserve watershed. Source: Author.

Parameter (All)	Count	Min	Median^	Max	Mean^	Std Dev^	% ATN
ANC (mg/L)	161	0.00	7.20	34.30	8.02	5.91	**100%**
DO (mg/L)	1133	0.00	8.60	19.50	8.66	2.25	**87%**
***E. coli* (CFU/100mL)**	894	*Present <QL	13.4	>2419.20	95.51	271.65	**91%**
NO_3 (mg/L as N)	859	*Non-detect	0.1	2.46	0.17	0.20	**100%**
pH (SU)	1117	3.3	6.62	8.86	6.59	0.66	**85%**
PO_4 (mg/L as P)	168	*Non-detect	--	*Present <QL	--	--	**100%**
SpC (µS/cm)	915	1.00	37.60	240.00	40.12	17.02	**100%**
SO_4 (mg/L as SO_4)	760	*Non-detect	21.70	330.41	27.09	34.42	**100%**
Turbidity (NTU)	1089	0.08	1.39	69.90	2.67	4.73	**100%**
Water Temp. (^{o}C)	1346	1.00	16.05	32.00	16.22	7.19	**100%**

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor, ATN = Attainment, QL = Quantity Limit.

The parameters pH and *E. coli* were analyzed in more detail for the CMLR sample location because these parameters achieved only a yellow or light green condition. Figure 14 displays a frequency chart that was generated for pH at the CMLR sample location using the combined water quality database to evaluate pH values compared to state parameter limits. A total of 225 samples were taken over the period of record with 37 sample values being outside the state parameter limit of between pH 6 (SU) and pH 8.5 (SU). A closer look at the last decade of pH data for Canyon Mouth (CMLR) sample location shows that 110 of the total 222 samples for the period of record occur during this time period (Table 15) and 16 of the total 37 lie outside the parameter limit; 1996 being a particular significant year for non-attainment. Table 16 provides summary statistics for pH values by month for the period of record. The months of February, April, and December have higher non-attainment counts than the other months and January and September have the lowest non-attainment counts compared to the other months for the period of

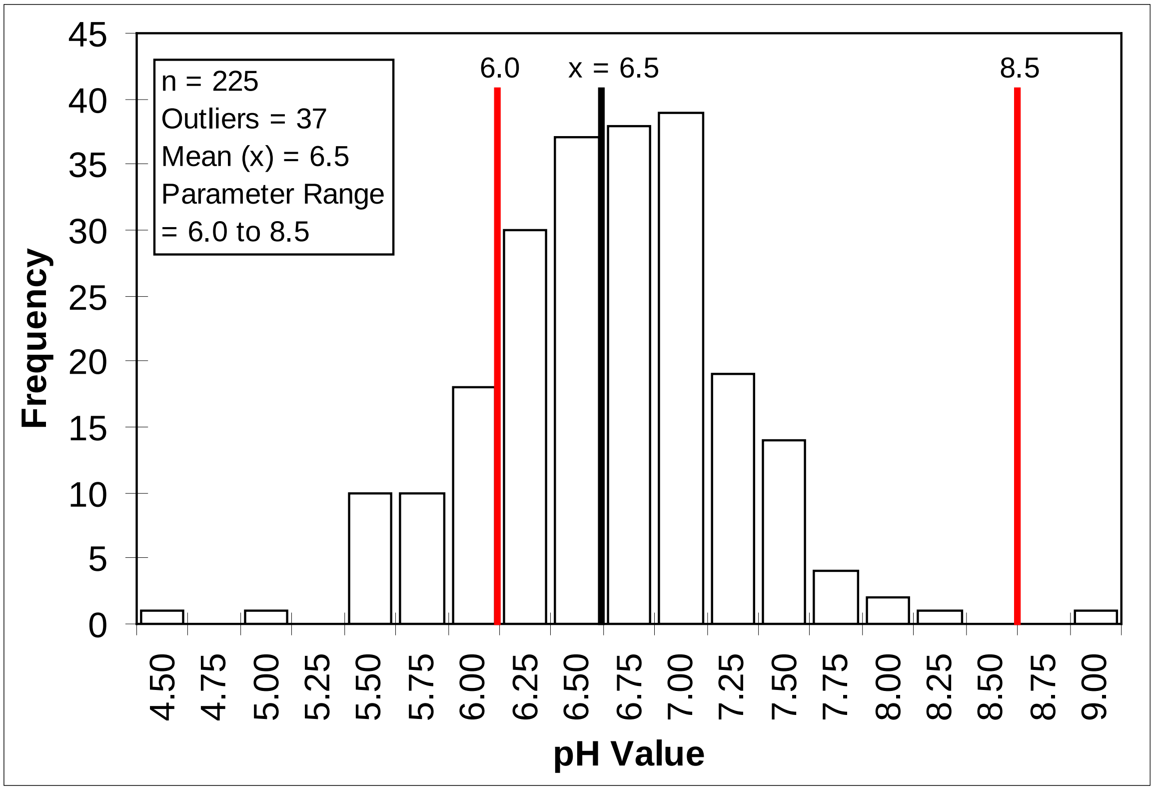


Figure 14. Histogram for pH at Canyon Mouth (CMLR) sample location. Source: Author.

Table 15. Summary table for pH at Canyon Mouth (CMLR) sample location by month for the period of record. (ATN = Attainment). Source: Author.

Month (CMLR)	Count	Mean	Non-ATN	% ATN
January	19	6.6	1	95%
February	20	6.4	6	70%
March	17	6.5	2	88%
April	15	6.2	6	60%
May	22	6.6	3	86%
June	16	6.5	2	87%
July	14	6.7	2	86%
August	19	6.6	3	84%
September	19	6.7	1	95%
October	24	6.7	2	92%
November	20	6.5	3	85%
December	20	6.4	6	70%

Table 16. Summary table for pH values at Canyon Mouth (CMLR) sample location from 1997-2007. (ATN = Attainment). Source: Author.

Year (CMLR)	Count	Non-ATN	% ATN
1997	20	9	55%
1998	13	1	92%
1999	14	0	100%
2000	22	2	91%
2001	11	0	100%
2002	5	0	100%
2003	3	1	67%
2004	4	1	75%
2005	0	0	100%
2006	6	0	100%
2007	12	2	83%
Total	**110**	**16**	

record. Values of pH collected during the month of April had the lowest mean value and percent attainment for the period of record. Although parameter values exceed state pH limits in the LIRI watershed, this does not necessarily denote violations of state water quality standards. According to Section 2 of 335-6-10-.05 (General Conditions Applicable to All Water Quality Criteria), "natural waters may, on occasion, have characteristics outside of the limits established by these criteria." Rainfall is naturally acidic (about 5.6 to 5.8 SU) and can be lowered further when combined with natural humic acids from soils and decaying plant material. The pH tends to remain low unless the water contacts carbonate strata, which provides means for the streams to buffer acids. Carbonate rocks such as limestones are virtually non-existent in the LIRI watershed, so LIRI waters may be naturally acidic (<7.0 SU).

A summary table (Table 17) was generated to show any *E. coli* anomalies by month for the CMLR sample location. High mean values occur in January, February, March, and October due to the four potential outliers that occurred during these months. To examine how *E. coli* values compare throughout the study area, Table 18 was generated showing summary statistics of each of the 11 sample locations. Yellow Creek (YCYC) sample location has the lowest number of attainment values (ATN) with the lowest number of observations (Count) besides Burnt House Ford (BHLR) sample location. Notice in Table 18 that there are several maximum values represented by >2419.2 CFU/100mL. The upper detectable limit for the method used to calculate *E. coli* is 2419.2 CFU/100mL and the lower detectable limit of this method is 1 CFU/100mL.

Table 17. Summary statistics by month for the period of record pertaining to *E. coli* at the Canyon Mouth (CMLR) sample location. (ATN = Attainment). Source: Author.

Month (CMLR)	Count	Mean^	Non-ATN	% ATN
January	9	226.8	1	89%
February	9	353.7	1	89%
March	6	163.8	1	83%
April	6	19.5	0	100%
May	9	30.8	0	100%
June	8	40.8	0	100%
July	7	13.2	0	100%
August	7	18.5	0	100%
September	7	21.1	0	100%
October	10	204.7	1	80%
November	7	31.0	0	100%
December	7	28.6	0	100%

^Values representing "*Non-detect" and "*Present <QL" were not included in calculations.

This may suggest that *E. coli* values could have exceeded the maximum limit, but were not shown properly due to method limitations. One hypothesis for several high value readings of *E. coli* is that these reading might have been taken just after large rain events that flush high concentrations of contaminants into streams. To see if there was any correlation between *E. coli* values and discharge rates, a scatter plot was generated (Figure 15) with *E. coli* values plotted on a logarithmic scale compared to discharge rates at the CMLR sample location. The R^2 value (0.1955) for Figure 15, which measures how well a regression line approximates real data points, suggest that there is little relationship between *E. coli* and discharge directly, however, there could be a time lag between the discharge of water through the watershed and the settling out of contaminants. A visual scan of *E. coli* and precipitation events suggest another plausible hypothesis. Several days without rain (5 days or more) may allow *E. coli* to accumulate and when sampling is done after a rain event, observed values may be higher as opposed to when consistent rain events occur, but further evaluation would be needed to test this.

Table 18. Summary table comparing all sample locations pertaining to *E. coli* within the study area. Source: Author.

Location	Parameter	Count	Min	Median^	Max	Mean^	Std Dev^	ATN	% ATN
BHLR	*E. coli*	15	1	8.5	461.10	72.41	158.30	13	87%
CMLR	*E. coli*	92	*Present <QL	8.45	>2419.2	74.21	261.09	88	96%
DFLR	*E. coli*	92	*Present <QL	9.80	1986.28	86.80	280.88	88	96%
DSLR	*E. coli*	91	*Present <QL	8.40	1299.65	55.10	157.27	87	96%
EFLR	*E. coli*	78	*Present <QL	21.60	1986.28	89.53	250.90	73	94%
EPLR	*E. coli*	89	*Present <QL	12.10	>2419.2	99.66	290.53	80	90%
HBLR	*E. coli*	93	*Present <QL	8.60	1413.60	67.99	208.94	89	96%
JCJC	*E. coli*	93	*Present <QL	18.50	>2419.2	81.33	196.31	85	91%
LCLR	*E. coli*	93	*Present <QL	9.10	>2419.2	81.70	291.79	88	95%
MFLR	*E. coli*	81	*Present <QL	16.00	2419.17	105.72	316.95	74	91%
YCYC	*E. coli*	77	*Present <QL	39.90	2419.17	187.95	415.41	66	86%

^Values representing "*Non-detect", "*Present <QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor, ATN = Attainment, QL = Quantifiable Limit.

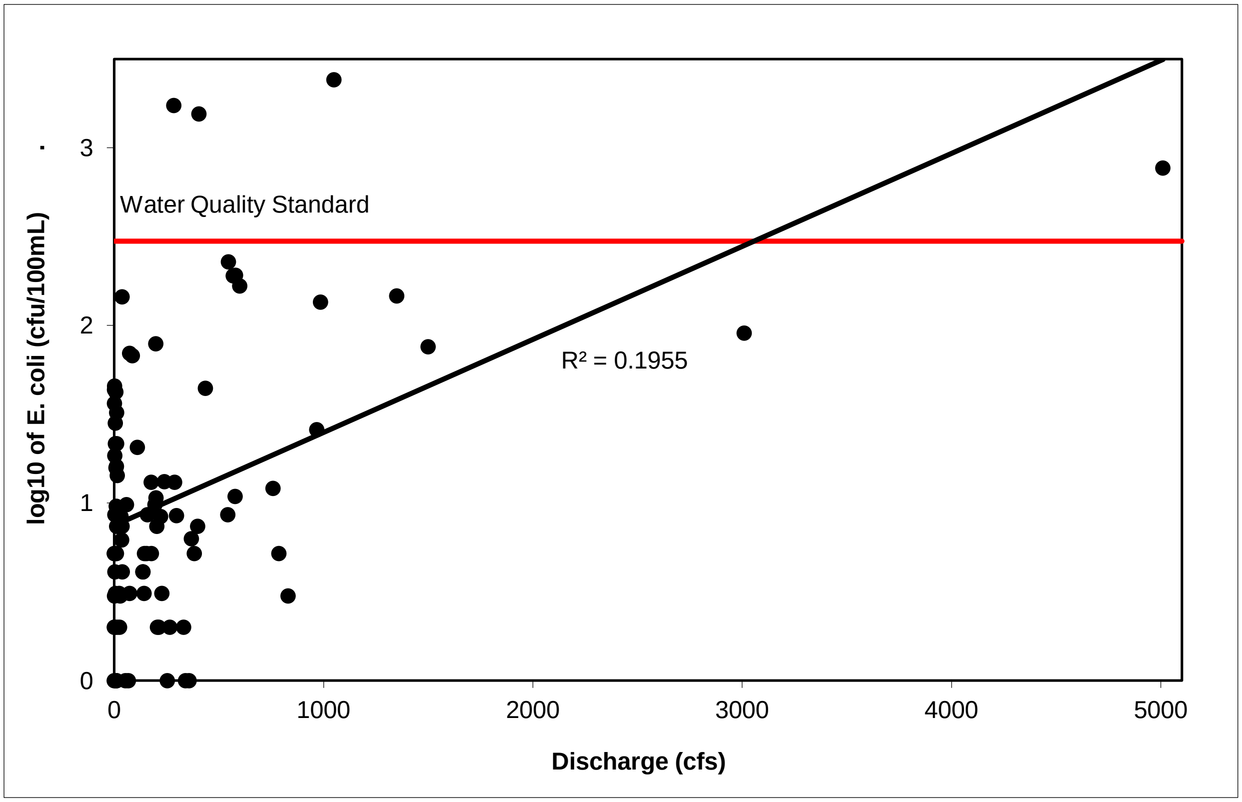


Figure 15. Scatter plot graph of *E. coli* and discharge values for the Canyon Mouth (CMLR) sample location. Source: Author, (USGS 2008).

5.1.4 Summary and Discussion

Table 19 provides a number of ways to summarize water quality conditions in the LIRI watershed. The "condition" column shows the eleven sample stations distributed by condition level that are associated with a water quality parameter. The "Total" for these columns show the

Table 19. Sample location counts by condition level with overall results of water quality conditions. Source: Author.

Parameter	Condition				Count (All)	ATN (All)	% ATN (All)	% ATN (CMLR)
ANC	11	0	0	0	164	164	100%	100%
Dissolved Oxygen	2	3	6	0	1133	985	87%	99%
E. coli	0	5	6	0	894	818	91%	96%
Nitrate	11	0	0	0	859	859	100%	100%
pH	0	1	10	0	1117	945	85%	84%
Phosphate	11	0	0	0	168	168	100%	100%
SpC	11	0	0	0	915	914	100%	100%
Sulfate	11	0	0	0	760	757	100%	99%
Turbidity	11	0	0	0	1089	1087	100%	100%
Water Temperature	11	0	0	0	1346	1346	100%	100%
Total	79	8	23	0	8445	8043		
Weighted Result (total attainment over total observed)							95%	97%
Normalized Result (all parameters weighted equally)							96%	98%

Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor, ATN = Attainment.

total number of sample stations that fall within each condition level. Column "Count (All)" represents the total number of observations from all the sample locations for each parameter. Column "ATN (All)" represents the total number of values in attainment from all sample locations for each parameter. Table 19 also shows an overall look at the percent attainment values over the entire LIRI watershed ("% ATN (All)") from Table 14 and how they compare with the Canyon Mouth (CMLR) sample location ("% ATN (CMLR)") from Table 13. Percent attainment is calculated as "ATN (All)"/ "Count (All)". To roll up these parameter conditions into an overall result of water quality, a weighted result and normalized result was calculated for the CMLR sample site and the entire LIRI watershed. The weighted result was calculated by dividing the total number of attainment values by the total number observations for all parameters. This approach does not allow each parameter to be treated equally; for instance, a parameter with a higher number of observations will receive a higher weight than parameters with lower number of observations. In an attempt to treat each parameter equally, a normalized result was calculated by taking the sum of the percent attainment for the parameters and dividing that by the number of parameters ($\sum$ [(ATN/$Count_x$] / P where ATN = number of parameter values in attainment, $Count_x$ = total number of values observed for the parameter x, and P = total number of parameters).

One goal for this study is to provide NPS managers a quick look at water conditions at LIRI. To accomplish this goal, the color status values featured in Table 13 and Appendix E were displayed geospatially in a summary map for water quality (Figure 16). Each sample location on this map features a colored pie chart and each equally sized segment represents a specific water quality parameter. Several general trends can be seen from this map, which can help managers assess water quality conditions at a glance. No red conditions are seen at any of the sample locations, suggesting that the water quality in this area is not poor. Yellow conditions for pH appear throughout the LIRI watershed except for Johnnie's Creek (JCJC) sample location. Light green

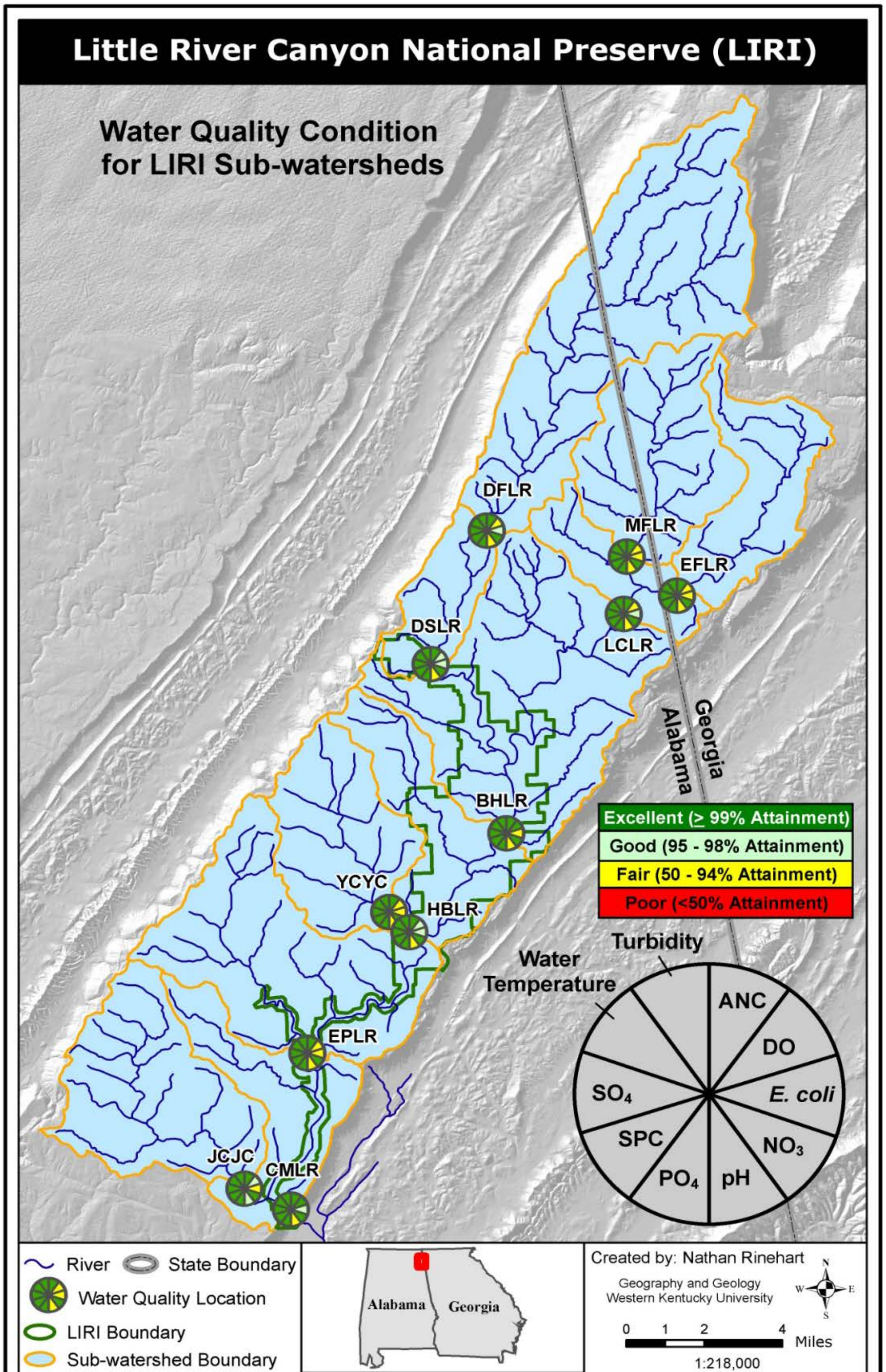


Figure 16. Water quality summary map of the Little River Canyon National Preserve watershed. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie's Creek, CMLR – Canyon Mouth.

condition counts for *E. coli* appear almost equal to yellow condition counts throughout the watershed with no apparent pattern. Dissolved oxygen conditions are yellow in the upper reaches of the LIRI watershed and in two portions of Little River Canyon, as tributaries bring water into the main river, but are not in the central and southern portions of the LIRI watershed.

5.2 Assessment of Landscape Resources

5.2.1 Land Cover

The landscape is under constant change owing to the influence of human activities and natural processes. Human land uses such as commercial and residential development, mining, and converting one vegetation type to another can affect many components of the hydrology of natural systems. The proportion of altered watershed is an indicator of the impacts to natural systems. There are several methods used to evaluate land cover change including image algebra, post classification comparison, multi-date composites, spectral change vector analysis, binary change mask, and change detection by image display (Campbell 1996). Post classification comparison was used to assess the land cover change at Little River Canyon National Preserve (LIRI) and involves classification of land by similar methods for two time slices and then comparing one to another using a "from-to" matrix analysis. An advantage of this method is that one can assess whether land is changing toward development (such as forest to urban) or whether it is changing the other way (such as barren to forest).

5.2.1.1 Data Preparation: Land cover for 2001 and land cover change from1992-2001 were downloaded and unzipped from the Multi-Resolution Land Characteristics (MRLC) Consortium website (MRLC Consortium 2007). These National Land Cover Database (NLCD) datasets use the Anderson Level I and Level II Classification System for land cover (Anderson *et al*. 1976). Both datasets were re-projected into the "NAD_1983_UTM_ Zone_16N" projection using ESRI ArcToolbox™, and then both were clipped to the LIRI watershed boundary and the LIRI boundary. A 400-meter buffer layer was then created around the LIRI boundary and land cover change layer was clipped to this layer to help understand land cover changes to adjacent areas. To assess the proportion of land altered within the 11 sub-watersheds used in this assessment, the land cover change dataset was clipped to each 'additive' sub-watershed boundary as discussed previously and illustrated in Figure 12.

5.2.1.2 Data Analysis: For the LIRI watershed, LIRI boundary, and 400-meter LIRI buffer layers, the area covered by each land cover classification for the NLCD 2001 dataset was calculated using grid cell size, grid cell count, and an equation for converting square meters to acres. The percentage of land covered by each classification was assessed by dividing land cover classification area by the total coverage area. As of 2001, LIRI primarily consists of forest (~95%) followed by urban development (~1.9%) and wetlands (~1.6%) (Figure 17). Land cover percentage for the LIRI watershed is presented in Table 20 and primarily consists of forest (~69%) followed by pasture/hay (~16%), shrub/scrub (~4%), and developed, open space (~3%). Land cover percentage for the 400-meter LIRI buffer layer is also presented in Table 20 and primarily consists of forest (~74%) followed by pasture/hay (~11%), shrub/scrub (~4%), and grassland/herbaceous (~4%).

Recent products from the MRLC Consortium have allowed the comparison between 1992 and 2001 NLCD layers using a "from-to" matrix analysis. Figure 18 shows the land cover change

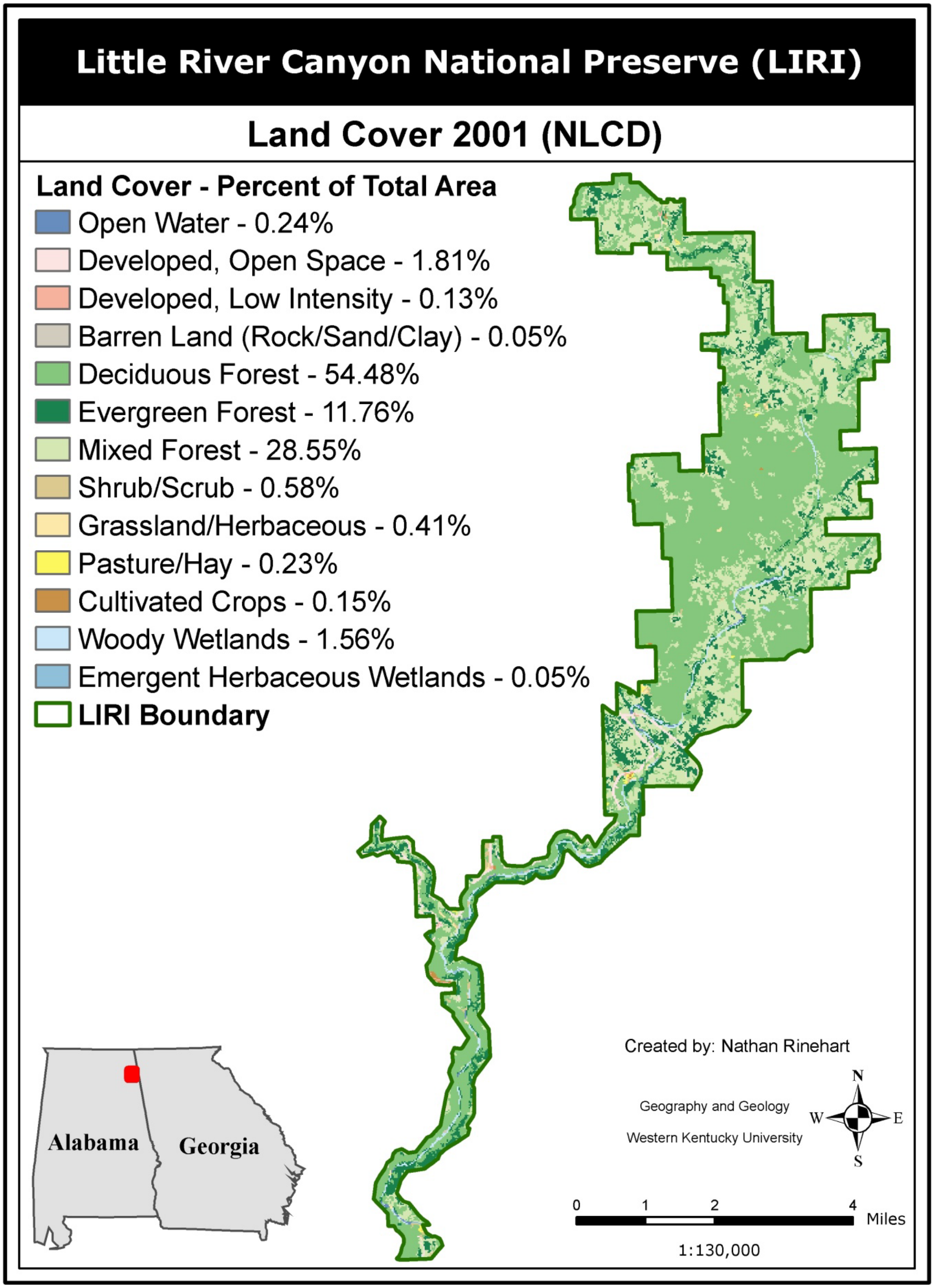


Figure 17. Land cover for the 2001 National Land Cover Database (NLCD) at Little River Canyon National Preserve. Source: (MRLC Consortium 2007).

Table 20. Percentage of land cover for 2001 within the Little River Canyon National Preserve watershed and the 400-meter buffer. Source: (MRLC Consortium 2007).

Land Cover Description	Cell Value	% of Total Area for 400-meter Buffer	% of Total Area for LIRI Watershed
Open Water	11	0.53%	0.48%
Developed, Open Space	21	2.38%	3.26%
Developed, Low Intensity	22	0.24%	0.36%
Developed, Medium Intensity	23	0.02%	0.03%
Developed, High Intensity	24	0.04%	0.01%
Barren Land (Rock/Sand/Clay)	31	0.21%	0.08%
Deciduous Forest	41	41.33%	41.85%
Evergreen Forest	42	12.17%	8.47%
Mixed Forest	43	20.48%	18.92%
Shrub/Scrub	52	4.27%	4.13%
Grassland/Herbaceous	71	4.31%	2.92%
Pasture/Hay	81	11.37%	16.44%
Cultivated Crops	82	2.32%	2.57%
Woody Wetlands	90	0.32%	0.47%
Emergent Herbaceous Wetlands	95	0.01%	0.01%

between 1992 and 2001 for the LIRI boundary and the LIRI buffer layer. Land cover classifications "open water" through "wetlands" represent areas where no change in land cover occurred between the two time slices. A light pink color represents change from forest to other land cover classifications. A dark pink color represents change from agriculture to forest cover. In general, the land cover change between these two time slices was not significant within the LIRI boundary (~0.71%). The land cover change within the LIRI watershed boundary was 6.94% and change within the 400-meter LIRI buffer layer was 9.21%. Table 21 summarizes the land cover change within each of the 11 'additive' sub-watersheds influencing LIRI. The total change within each sub-watershed is expressed in acres and as a percentage of the LIRI watershed. Table 21 also provides the land change to "Urban" in acres and as a percentage of the sub-watershed area. Net changes in "Forest" and "Agricultural Land" are also shown. On a percentage basis, the Middle Fork Little River (MFLR) sub-watershed shows the greatest total land cover change (15.28%) followed by Canyon Mouth (CMLR) sub-watershed (10.35%). On an acre basis, the greatest total land cover change is Middle Fork Little River (MFLR) sub-watershed (1676.86 acres) followed by Burnt House Ford (BHLR) sub-watershed (1399.09 acres). By summing the rows in Table 21, one can determine that the greatest change in acres occurs in the "Forest to Grassland/Shrub" category (4844.65 acres) followed by "Forest to Agricultural Land" category (2805.52 acres).

Assessment of land cover is often expressed in terms of human impacts such as urban development or impervious surfaces. According to the data in Figure 17, "Developed" areas represent 1.94% of LIRI and from Table 20, "Developed" areas represent 3.66% of the entire LIRI watershed. According to the Center for Watershed Protection (Schueler 2000), less than 10% impervious surface indicates minimal impacts to the environment, greater than 10% and less than 25% indicates moderate impacts, and greater than 25% indicates potentially severe impacts. The data from the MRLC Consortium (2007) show that every individual sub-watershed

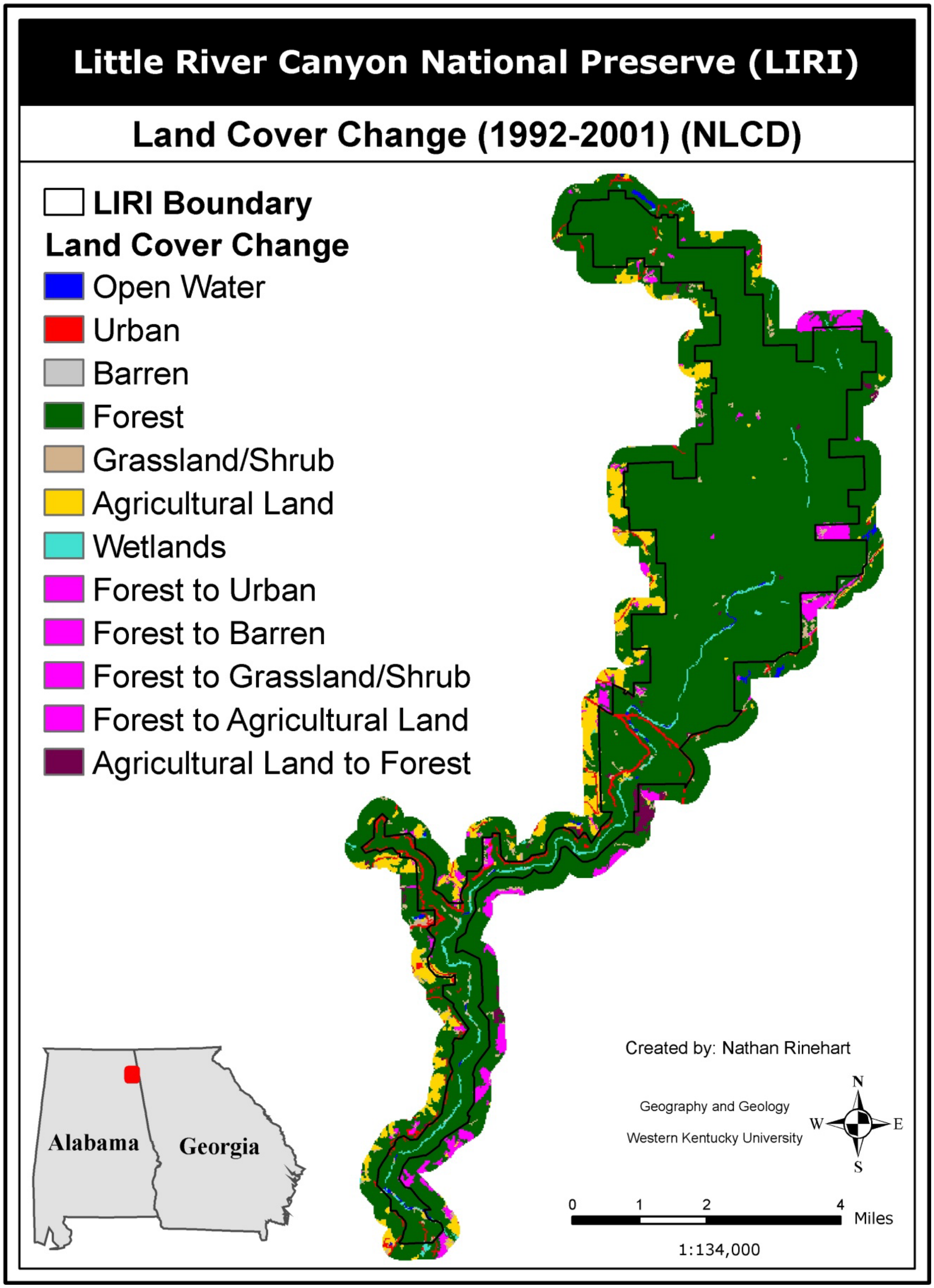


Figure 18. Land cover change between the 1992 and 2001 National Land Cover Database (NLCD) for Little River Canyon National Preserve and 400-meter buffer surrounding the Preserve. Source: (MRLC Consortium 2007).

Table 21. Land cover change summary (1992-2001) showing changes represented in acres for each of the sub-watershed segments within the Little River Canyon National Preserve watershed. (DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie's Creek, CMLR – Canyon Mouth). Source: (MRLC Consortium 2007).

Land Cover Change Description	BHLR	DFLR	DSLR	EFLR	EPLR	HBLR	JCJC	LCLR	MFLR	YCYC	CMLR
Forest to Open Water	9.56	None	None	None	None	None	3.56	None	None	None	None
Forest to Urban	36.70	37.36	2.00	18.24	29.13	12.01	23.13	14.68	79.17	22.68	8.90
Forest to Barren	41.59	3.11	None	None	None	None	3.56	None	32.91	None	None
Forest to Grassland/Shrub	932.72	514.84	62.72	100.08	582.45	138.33	488.82	127.43	1175.58	194.60	527.08
Forest to Agricultural Land	284.22	711.66	36.03	68.28	356.50	103.19	406.54	109.20	330.03	265.54	134.33
Forest to Wetlands	None	None	None	None	None	None	1.56	1.33	None	None	None
Agricultural Land to Open Water	1.11	None	None	1.33	None	None	6.00	None	None	None	None
Agricultural Land to Urban	2.00	None	None	None	1.33	None	None	None	None	2.00	None
Agricultural Land to Forest	84.29	14.90	1.11	34.03	225.29	17.35	102.52	23.35	59.16	46.93	167.69
Agricultural Land to Grassland/Shrub	6.89	1.56	None	2.22	1.56	None	None	None	None	None	None
Total Change (acres)	**1399.09**	**1283.44**	**101.86**	**224.17**	**1196.26**	**270.88**	**1035.69**	**275.99**	**1676.86**	**531.75**	**837.98**
Total Change (% of total area)	**6.51%**	**5.65%**	**2.25%**	**2.82%**	**7.19%**	**3.12%**	**8.34%**	**6.27%**	**15.28%**	**5.72%**	**10.35%**
Change to Urban (acres)	38.70	37.36	2.00	18.24	30.47	12.01	23.13	14.68	79.17	24.69	8.90
Change to Urban (% of total area)	0.18%	0.16%	0.04%	0.23%	0.18%	0.14%	0.19%	0.33%	0.72%	0.27%	0.11%
Net Change in Forest (acres)	1304.79	1266.98	100.74	186.59	968.08	253.53	927.16	252.64	1617.70	482.82	670.30
Net Change in Agriculture (acres)	94.30	16.46	1.11	37.58	228.18	17.35	108.53	23.35	59.16	48.93	167.69

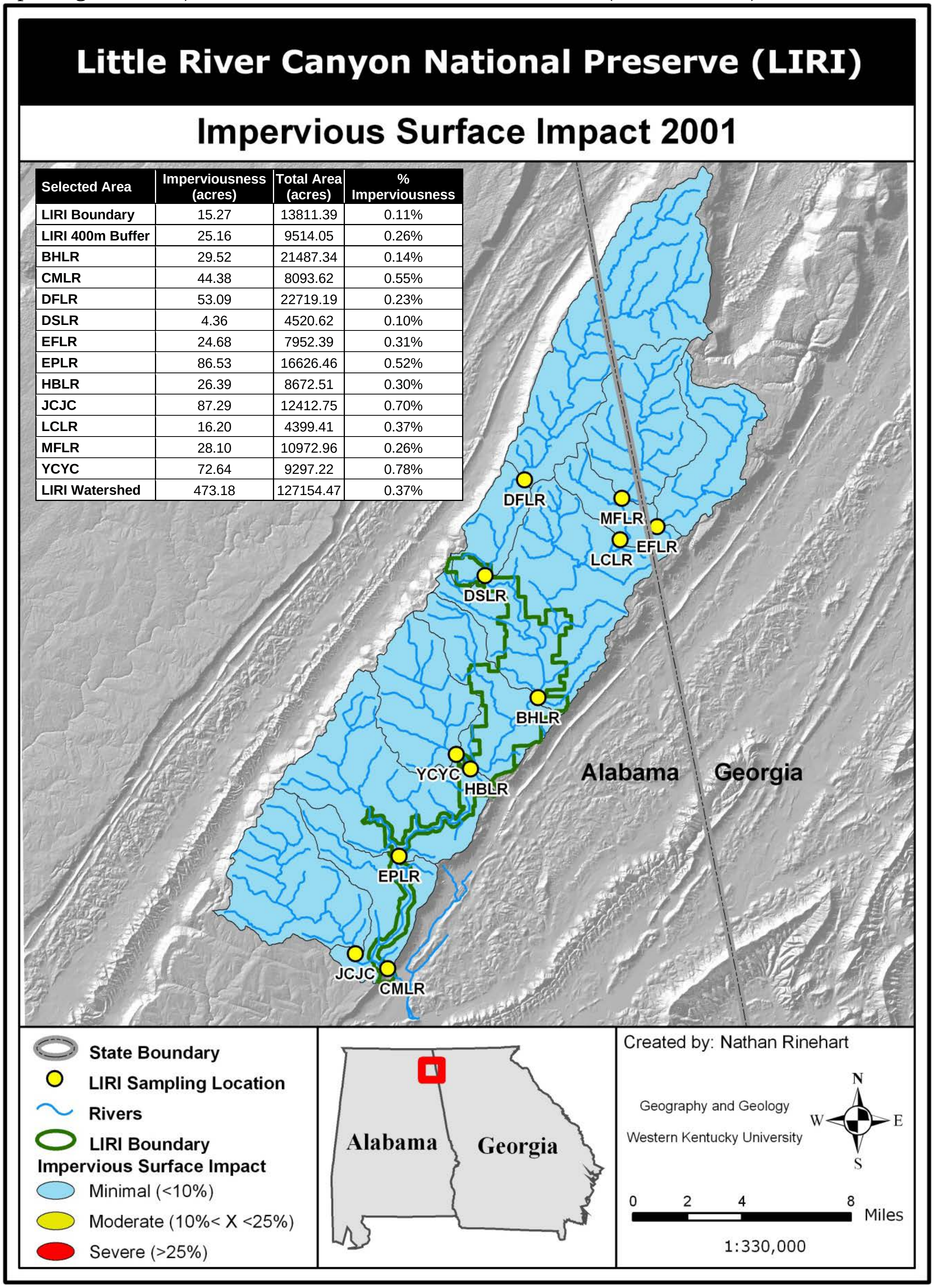
influencing LIRI suggest minimal impact (<1% impervious surface) to the environment (Figure 19).

5.2.2 Vegetation Cover

Another way of looking at landscape resources is by analyzing vegetation cover. Recent digital vegetation maps were produced for LIRI by the Center for Remote Sensing and Mapping Science (CRMS) at the University of Georgia. This vegetation layer is more detailed than the NLCD layers and is represented by polygons rather than grid cells of land cover. These polygons represent dominant vegetation types distributed throughout the study area and are often referred to as vegetation "patches". This dataset uses the National Vegetation Classification System (NVCS) developed by NatureServe (Grossman *et al*. 1998), along with additional classes and modifiers, to classify vegetation communities from color-infrared, aerial, stereophotographs. With this vegetation layer, one can view distribution of patches and patch sizes to help in understating fragmentation of vegetation.

5.2.2.1 Data Analysis: Table 22 summarizes the dominant vegetation within LIRI including the number of polygons (count), area, percent of the total area, and average patch size for each classification. There are 29 NVCS association-level classes listed as Community Element Global (CEGL) numbers with modifiers that show detailed variations of these classes and 19 other categories that provide information on successional stages of vegetation communities, damage conditions, and types of management and land uses. The four vegetation classes that cover the most area within LIRI are shaded light gray in Table 22 and include: 1) CEGL-8427 classified as

"Shortleaf Pine – Mesic Oak (White Oak –Southern Red Oak – Post Oak – Black Oak) Forest" comprising 14.7%; 2) CEGL-8430 classified as "White Oak – (Chestnut Oak)/ Oakleaf



Selected Area	Imperviousness (acres)	Total Area (acres)	% Imperviousness
LIRI Boundary	15.27	13811.39	0.11%
LIRI 400m Buffer	25.16	9514.05	0.26%
BHLR	29.52	21487.34	0.14%
CMLR	44.38	8093.62	0.55%
DFLR	53.09	22719.19	0.23%
DSLR	4.36	4520.62	0.10%
EFLR	24.68	7952.39	0.31%
EPLR	86.53	16626.46	0.52%
HBLR	26.39	8672.51	0.30%
JCJC	87.29	12412.75	0.70%
LCLR	16.20	4399.41	0.37%
MFLR	28.10	10972.96	0.26%
YCYC	72.64	9297.22	0.78%
LIRI Watershed	473.18	127154.47	0.37%

Figure 19. Impervious surface impact for 11 sub-watersheds influencing Little River Canyon National Preserve. Source: Author, (MRLC Consortium 2007), (Schueler, 2000).

Hydrangea – Mapleleaf Viburnum Forest" comprising 12.04%; 3) CEGL-7244 classified as "White Oak – (Southern Red Oak –Mixed Oak) – Pignut Hickory Forest" comprising 10.28%; and 4) CEGL-6327 classified as "Shortleaf Pine Early-Successional Forest" comprising 9.4%. CEGL-8430 features the most patches followed by CEGL-7244. The category Water (W) features the largest average patch size followed by CEGL-7493 classified as "Shortleaf Pine – Dry Oak (Chestnut Oak – Southern Red Oak) Forest".

Table 22. Summary of dominant vegetation at Little River Canyon National Preserve. Source: modified from (Jordan and Madden 2008).

Dominant Vegetation (CEGL)	Patch Count	Area (acres)	% of Total Area	Average Patch Size (acres)
Shortleaf Pine - White Oak / Hillside Blueberry / Arrowleaf Heartleaf - Striped Pipsissewa Forest **(8427)**	155	2014.66	14.70%	13.00
White Oak - (Chestnut Oak) / (Oakleaf Hydrangea) - Mapleleaf Viburnum / Painted Sedge - Eastern Speargrass Forest **(8430)**	163	1650.45	12.04%	10.13
Southern Red Oak - White Oak - Mockernut Hickory / Sourwood / Deerberry Forest **(7244)**	162	1409.17	10.28%	8.70
Shortleaf Pine Early-Successional Forest **(6327)**	145	1287.96	9.40%	8.88
Virginia Pine Successional Forest **(2591)**	42	173.87	1.27%	4.14
Loblolly Pine - (Shortleaf Pine) / Little Bluestem Woodland **(3618)**	1	0.82	0.01%	0.82
Smooth Alder - Yellowroot Shrubland **(3895)**	33	55.84	0.41%	1.69
Smooth Alder - Smooth Azalea / Green Pitcherplant - Few-flower Beaksedge Shrubland **(3914)**	3	1.85	0.01%	0.62
Broomsedge Bluestem Herbaceous Vegetation **(4044)**	13	13.82	0.10%	1.06
Cultivated meadow dominated by Fescue (*Lolium* spp.) and other exotic and native grasses and forbs **(4048)**	6	30.77	0.22%	5.13
(White Oak, Scarlet Oak, Southern Red Oak, Black Oak) / Mountain Laurel Temporarily Flooded Forest **(4098)**	28	145.15	1.06%	5.18
American Beech - White Oak / Mountain Laurel - (Horsesugar, Catawba Rhododendron) / Galax Forest **(4539)**	10	55.19	0.40%	5.52
Nuttall's Rayless-goldenrod - Woodland Tickseed - Small-head Blazingstar Herbaceous Vegetation **(4622)**	21	15.94	0.12%	0.76
Alabama Cumberland Sandstone Glade and Barrens Complex, with Virginia Pine and shrubs **(4622x)**	11	14.36	0.10%	1.31
Loblolly Pine Early to Mid-Successional Forest **(6011)**	45	159.99	1.17%	3.56
Virginia Pine - (Pitch Pine, Shortleaf Pine) - (Chestnut Oak) / Hillside Blueberry Forest **(7119)**	138	728.65	5.32%	5.28
Silktree Forest **(7192)**	1	1.15	0.01%	1.15
Sweetgum - (Tuliptree) Temporarily Flooded Forest **(7330)**	6	14.99	0.11%	2.50
Sweetgum - Red Maple / Sedge species - Peatmoss species Forest **(7388)**	4	5.46	0.04%	1.36
Carolina Red Maple - Blackgum / Cinnamon Fern - Slender Spikegrass - Greater Bladder Sedge / Yellow Peatmoss Forest **(7443)**	19	82.58	0.60%	4.35
Shortleaf Pine - (Chestnut Oak, Southern Red Oak) / Sourwood / Hillside Blueberry Forest **(7493)**	56	1209.43	8.83%	21.60
Shortleaf Pine - Post Oak - Chestnut Oak - Pignut Hickory / (Poverty Oatgrass, Eastern Speargrass) Forest **(7500)**	13	202.25	1.48%	15.56
Loblolly Pine - Tuliptree / Northern Spicebush / Fringed Sedge Forest **(7546)**	43	139.95	1.02%	3.25
White Oak - (Tuliptree, Sweetgum) / Sweet-shrub / Common Ladyfern Forest **(8428)**	119	754.05	5.50%	6.34
Chestnut Oak - (Scarlet Oak) / Sand Hickory / Farkleberry - Hillside Blueberry Forest **(8431)**	67	1158.16	8.45%	17.29

Table 22. Summary of dominant vegetation at Little River Canyon National Preserve. Source: modified from (Jordan and Madden 2008) (continued).

Dominant Vegetation (CEGL)	Patch Count	Area (acres)	% of Total Area	Average Patch Size (acres)
Loblolly Pine - Sweetgum Semi-natural Forest (8462)	60	631.65	4.61%	10.53
Northern Red Oak - Appalachian Basswood - Carolina Shagbark Hickory / (Southern Sugar Maple, Chalk Maple) / Oakleaf Hydrangea Forest **(8488)**	21	219.74	1.60%	10.46
Bushy St. John's-wort - Smooth Alder / Eastern Gammagrass Shrubland **(8495)**	34	53.77	0.39%	1.58
Wisteria Vine Shrubland (Exotic) **(8568)**	1	0.81	0.01%	0.81
Agriculture	8	29.86	0.22%	3.73
Beaver Pond	2	4.71	0.03%	2.35
Clear Cut	3	50.12	0.37%	16.71
Dead	13	29.01	0.21%	2.23
Hardwoods	7	24.42	0.18%	3.49
Human Influence	36	59.99	0.44%	1.67
Pines	126	508.84	3.71%	4.04
Loblolly Pine	1	1.01	0.01%	1.01
Loblolly Pine/Om	1	0.55	0.00%	0.55
Virginia Pine	2	2.90	0.02%	1.45
Mixed Pines	6	38.13	0.28%	6.35
Mixed Oaks	24	181.11	1.32%	7.55
Road	39	169.74	1.24%	4.35
Rock	63	56.26	0.41%	0.89
Right-of-Way	6	11.22	0.08%	1.87
Railroad	1	0.89	0.01%	0.89
Shrub, Woody Shrub	12	15.34	0.11%	1.28
Water	6	267.28	1.95%	44.55
Wildlife Food Plot	26	20.41	0.15%	0.78
Total	**1802**	**13704.28**		

5.2.3 Wetlands

Wetlands are of particular interest to LIRI as they provide habitat for specific biota of concern including the Green Pitcher Plant (*Sarracenia oreophila*). Wetlands are defined as, "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." (U. S. Army Corps of Engineers 1987).

A recent study was conducted for the NPS during 2006-2008 and objectives were to: 1) identify and delineate all wetlands subject to jurisdiction under Sections 404 and 401 of the Clean Water Act (CWA), and all wetlands subject to National Park Service procedures for implementing Director's order #77-1; 2) produce a database that includes the location and description of all wetlands present including their Cowardin and Hygrogeomorphic (HGM) classifications; and 3) assess the biotic and abiotic functions and values of these wetlands (Roberts and Morgan 2008). This study reviewed available information including the National Wetland Inventory (NWI), which indicated 18 wetlands using the Cowardin classification system. Limitations of the NWI and Cowardin system were discussed and wetlands found within LIRI were classified using both the HGM system and the Cowardin system. DeSoto State Park and the wildlife management areas were not included in this study. Eight specific "functions/values" were described as well as a description for assigning ratings to these various wetland functions/values. This study located 127 wetlands, totaling an estimated 71.1 acres (28.7 ha) (Figure 20). These 127 wetlands were assigned ratings for surface water storage, groundwater discharge to streams, carbon/nutrient export, provision of wildlife habitat, support of wetland plants, cultural importance, research and scientific value, economic value, and presence of exotic plant species. The authors concluded that several wetlands were of high quality and are in relatively good hydrologic condition, though most of the vegetation likely has been altered.

5.2.4 Summary and Discussion
The land cover within LIRI is ~94% forested showing little land cover change (~0.71%) between 1992 and 2001. "Developed" cover is ~1.94% within LIRI and an analysis of imperviousness suggests that minimal impacts to the environment (<10% impervious surfaces) are occurring within LIRI. Land cover change adjacent to the Preserve (9.21% change within a 400 meter buffer) may become a source of stress to resources within LIRI as more land is converted to different land cover types. On a watershed scale, the Middle Fork Little River (MFLR) 'additive' sub-watershed had the highest land cover change (1676.86 acres, being 15.28% of the area) of the 11 sub-watersheds. With this amount of change taking place over a 10-year period, the Middle Fork Little River sub-watershed may need closer monitoring or analysis.

Oaks and Pines comprise the majority of vegetation within LIRI. If a theoretical vegetation cover layer were available, spatial analysis could compare it to the current vegetation. A search of the literature did not provide information on what the unaltered vegetation should be like or information on standard patch sizes and counts. What is available is the current status of the vegetation community resource.

Several wetlands within LIRI are of high quality and are in relatively good hydrologic condition. Wetland analysis suggests relatively low ratings for provision of wildlife habitat and relatively moderate ratings for the support of wetland plants. Of the 127 wetlands located within LIRI, 14 contained exotic plants such as Japanese honeysuckle (*Lonicera japonica*), Privet (*Ligustrum*), and Nepalese browntop (*Micostegium vimineum*).

5.3 Assessment of Biota
Knowledge of plants and animals within LIRI can help direct conservation efforts and other management initiatives. Compiling an inventory is a necessary first step in developing a monitoring plan and ultimately managing these natural resources effectively. An inventory is a process by which one determines the location or condition of a resource, including the presence, class, distribution, and status of target species in a given area. A good inventory is able to provide data about threatened, endangered, rare, and state protected species as well as exotic and invasive species. In contrast, monitoring is a process by which one evaluates the status of a resource over time to detect changes or trends. Data from baseline inventories, when combined with subsequent monitoring, can be used to detect and evaluate temporal trends in species richness and abundance (Tuberville *et al.* 2005).

Biologic inventories selected for detailed discussion in this assessment appear in Table 23 with a summary of relevant data from each. A list of additional reference documents along with the

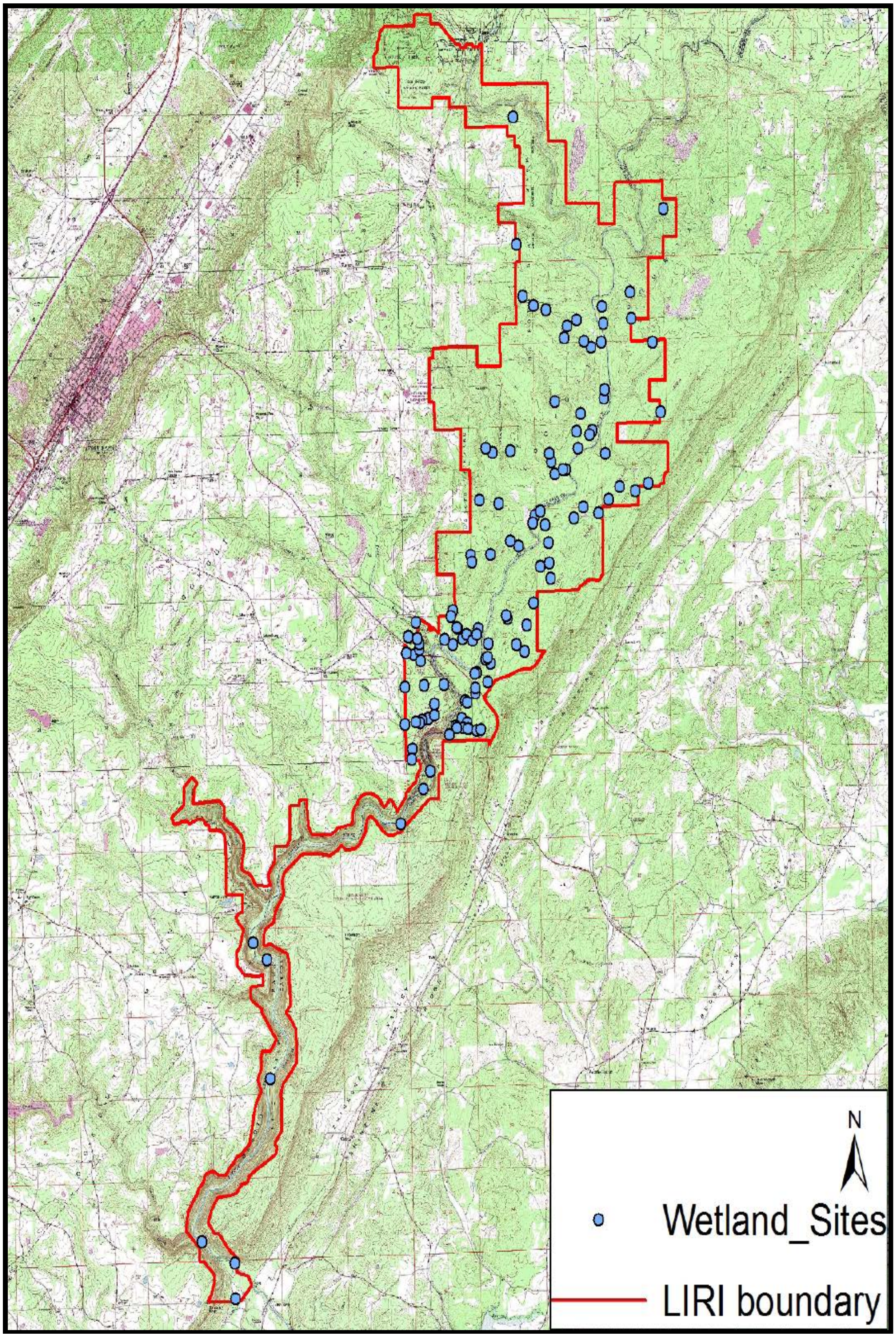


Figure 20. Locations of wetlands at Little River Canyon National Preserve from 2006-2008. Source: modified from (Roberts and Morgan 2008).

agencies or entities involved, and a resource summary appear in the appropriate section below for each taxonomic group of interest.

Table 23. Inventories selected for detailed discussion or analysis of the biologic resources at Little River Canyon National Preserve.

Taxonomic Group	Survey Year	Author	# Species	# Individuals	# Exotic
Aquatic Insects	2006-2008	Chuck Parker (NPS)-in progress	NA	NA	NA
	1988-1989	Frazer *et al.* (University of Michigan)	122	23720	NA
Birds	2003-2005	Stedman and Stedman (Tennessee Tech University)	147	NA	3
Fish	1992-1993	Ballard and Pierson (Jacksonville State University)	46	6269	1
Herpetofauna	2003-2005	Accipiter Biological Consultant	74	418	0
Mammals	2007-2009	Michael Kennedy (NPS)-in progress	NA	NA	NA
	2006-2007	Michael Kennedy (NPS)-preliminary	25	NA	0
Mollusks	1998-1999	Godwin and Shelton (Alabama Natural Heritage Program)	6	3218	1
Vascular Plants	2002-2004	Schotz (NatureServe)	569	NA	95
	1997	Whetstone (Jacksonville State University)	687	NA	17
NA = Not Available.					

The current condition status of each taxonomic group has been assessed where possible. Two numeric indicators used in the condition assessment are the Jaccard Index of Similarity (S_j) and whether or not the inventory was able to document at least 90% of the species expected to be present within LIRI. The Jaccard Index is a simple method for comparing two different datasets in regard to their total number of species (Krebs 1999). It is calculated by dividing the number of species in common between both datasets (a) by the sum of (a) plus the number of species found only in the first dataset (b), plus the number of species found only in the second dataset (c):

$$S_j = a/(a + b + c)$$

This index relies solely on the number of species within the datasets, not the actual abundance of each species (count data). Where species-specific count data are available, other indices such as the Shannon-Weiner Index (H') (Allaby 2004) can be determined for the condition assessment, but such information is rare within the inventories for LIRI. Typical uses for the Jaccard Index of Similarity are comparing repeated field inventories conducted during different time periods or comparing a field inventory to a theoretical list derived from the literature or other sources. In any case, S_j values can range from 0.0 to 1.0 indicating a condition that ranges from complete disagreement to complete agreement between datasets. Each of the following summaries contains a discussion of species of concern, non-native (exotic) species, and existing recommendations for future management efforts.

5.3.1. At-risk-Biota

Six observed species at LIRI are federally listed as endangered or threatened by the U.S. Fish and Wildlife Service per the U.S. Endangered Species Act of 1973, as amended. The Coosa moccasinshell (*Medionidus parvulus*), the blue shiner fish (*Cyprinella caerulea*), the gray bat (*Myotis grisescens*), the green pitcherplant (*Sarracenia oreophila*), harperella (*Ptilimnium nodosum*), and Kral's water plantain (*Sagittaria secundifolia*) have all been observed at LIRI and recovery plans have been developed by the U.S. Fish and Wildlife Service for each of them (http://ecos.fws.gov/tess_public/TESSWebpageRecovery). Additional literature providing background information for these species include Carter *et al*. (2006), Emanuel (1998), Higginbotham *et al*. (1996), Alabama Natural Heritage Program (2008), Pierson and Krotzer 1987 and Dobson (1994). In general, management recommendations from these studies include maintaining high water quality and developing programs for prescribed burns at appropriate time intervals and severity to sustain the necessary species habitats. Unfortunately, there is insufficient information to determine a current condition status for the at-risk species within LIRI.

Table 24 is a 2008 list of organisms derived from the NPSpecies database (including rank data obtained from NatureServe) provided by Bill Moore (NPS Cumberland Piedmont Network). The list contains 84 organisms known to occur at LIRI, which are designated as protected within the state of Alabama (SP), and/or federally threatened or endangered (T or E), and/or imperiled on a state (S1, S2) or global (G1, G2) level. The table also provides a column describing the short-term global trend in population size and/or spatial extent of the species according to additional information provided by NatureServe.

Agencies that track the at-risk biota listed in Table 24 include the Alabama Natural Heritage Program, Alabama Department of Conservation and Natural Resources, U.S. Forest Service, U.S. Fish and Wildlife Service, and NPS.

5.3.2 Aquatic Insects

Frazer *et al*. (1991) identified 122 species from 23,720 collected specimens of Trichoptera (caddisfly), which included four previously undescribed species later discussed in Frazer and Harris (1991). Their survey included the entire Little River drainage basin, which extends well beyond LIRI boundaries, though 10 of their 25 sample sites were located within the Preserve.

According to Frazer *et al*. (1991), nine caddisfly species seem to be endemic to the Little River drainage basin. The authors also state that the number of caddisfly species occurring in the Little River drainage basin is close to those reported in other southeastern drainage systems of similar size, though the overall species richness is low. No exotic species were detected during this survey.

A new survey of aquatic insects is ongoing by Chuck Parker, an aquatic biologist with the USGS Biological Resources Division who reported verbally that the investigation to date suggests the waters at LIRI are in good condition.

5.3.3 Birds

A number of agencies and programs provide information about birds including Partners in Flight (PIF), the U.S. Geological Survey (Breeding Bird Surveys), Southern Appalachian Assessment (SAA) sponsored by The Southern Appalachian Man and the Biosphere (SAMAB), USFS forest inventory and analysis (FIA) concerning bird habitats, Flight STAR involving the Partners in Flight Bird Education Center Program, North American Bird Conservation Initiative (NABCI),

Table 24. Species found at Little River Canyon National Preserve that are designated rare, threatened, endangered, or otherwise protected within Alabama. Includes short-term global trend. Source: Bill Moore pers. com. 2009.

Taxonomic Group	Scientific Name	Common Name	State Protection Status[1]	Rounded State Rank[2]	Rounded Global Rank[3]	ESA Status (Federal)[4]	Short-term Trend[5]
Aquatic Insects (30)	Agapetus spinosus	caddisfly		S1	G2		
	Agrypnia vestita	large caddisfly		S2	G5		
	Ceraclea alabamae	caddisfly		S1	G2		
	Ceraclea alces	caddisfly		S1	G4		
	Ceraclea neffi	caddisfly		S1	G5		
	Ceraclea resurgens	caddisfly		S1	G5		
	Cheumatopsyche harwoodi	caddisfly		S2	G5		
	Cheumatopsyche helma	Helma's net-spinning caddisfly		S1	G3		
	Dibusa angata	caddisfly		S2	G5		
	Hydroptila chattanooga	caddisfly		SNR	G2		
	Hydroptila licina	caddisfly		S1	G1		
	Hydroptila micropotamis	caddisfly		S1	G1		
	Hydroptila oneili	caddisfly		SNR	G2		
	Hydroptila paramoena	caddisfly		SNR	G2		
	Hydroptila talladega	caddisfly		S1	G4		
	Ironoquia punctatissima	caddisfly		S2	G5		
	Lepidostoma griseum	caddisfly		S1	G5		
	Lepidostoma weaveri	caddisfly		S1	G1		
	Macrostemum zebratum	caddisfly		S1	G5		
	Molanna blenda	caddisfly		S2	G5		
	Neureclipsis piersoni	caddisfly		SNR	G2		
	Nyctiophylax barrorum	caddisfly		SNR	G1		U
	Ochrotrichia riesi	purse casmaker caddisfly		S1	G3		
	Phryganea sayi	caddisfly		S1	G5		
	Polycentropus nascotius	caddisfly		S1	G5		
	Pycnopsyche scabripennis	caddisfly		S2	G5		
	Rhyacophila glaberrima	rhyacophilan caddisfly		S2	G5		
	Theliopsyche melas	caddisfly		S1	G4		
	Triaenodes cumberlandensis	Cumberland triaenodes caddisfly		S2	G3		
	Wormaldia shawnee	caddisfly		S1	G4		
Birds (5)	*Accipiter cooperii*	Cooper's Hawk	SP	S3B,S4N	G5		E
	Aquila chrysaetos	Golden Eagle	SP	SNA	G5		
	Falco columbarius	Merlin	SP	SNA	G5		
	Haliaeetus leucocephalus	Bald Eagle	SP	S3B	G5		E/F
	Pandion haliaetus	Osprey	SP	S5	G5		F
Fish (1)	*Cyprinella caerulea*	blue shiner	SP	S1	G2	T	D
Herpetofauna (2)	*Aneides aeneus*	green salamander	SP	S3	G3		D
	Desmognathus ocoee	Ocoee salamander		S2	G5		D/E
Mammals (3)	*Myotis grisescens*	gray myotis	SP	S2	G3	E	E
	Myotis septentrionalis	northern myotis		S2	G4		E
	Ursus americanus	American black bear		S2	G5		
Mollusks (2)	*Elliptio arctata*	delicate spike		S2	G2		D
	Medionidus parvulus	Coosa moccasinshell	SP	SX	G1	E	A
Vascular Plants (41)	Allium speculae	Little River Canyon onion		S2	G2		
	*Amelanchier arborea	Downy serviceberry		S1	G5		
	Asplenium bradleyi	Bradley's spleenwort		S2	G4		D
	Asplenium trichomanes	maidenhair spleenwort		S2	G5		

Table 24. Species found at Little River Canyon National Preserve that are designated rare, threatened, endangered, or otherwise protected within Alabama. Includes short-term global trend. Source: Bill Moore pers. com. 2009 (continued).

Taxonomic Group	Scientific Name	Common Name	State Protection Status[1]	Rounded State Rank[2]	Rounded Global Rank[3]	ESA Status (Federal)[4]	Short-term Trend[5]
Vascular Plants (41)	*Castanea pumila	Allegheny chinquapin		S1	G5		
	Castilleja coccinea	scarlet Indian-paintbrush		S1	G5		
	Celastrus scandens	climbing bittersweet		S2	G5		
	Coreopsis pulchra	woodland tickseed		S2	G2		
	Cuscuta harperi	Harper's dodder		S2	G2		D
	Diervilla rivularis	mountain bush-honeysuckle		S2	G3		
	*Diervilla sessilifolia	southern bush-honeysuckle		S2	G4		
	Eurybia surculosa	creeping aster		S1	G4		
	Fothergilla major	mountain witch-alder		S2	G3		
	*Helianthus longifolius	longleaf sunflower		S1	G3		
	Lathyrus venosus	smooth veiny peavine		S1	G5		
	Lygodium palmatum	climbing fern		S2	G4		
	Lysimachia graminea	grass-leaf loosestrife		S1	G1		
	Melanthium parviflorum	small-flowered false-helleborne		S1	G4		
	Monarda clinopodia	basil beebalm		S2	G5		
	*Monotropa hypopithys	American pinesap		S2	G5		
	Nestronia umbellula	nestronia		S2	G4		
	Oxalis grandis	great yellow woodsorrel		S1	G4		
	Pachysandra procumbens	Allegheny-spurge		S2	G4		
	*Polygonella americana	southern jointweed		S1	G5		
	Ptilimnium nodosum	harperella		S1	G2	E	
	Pyrularia pubera	buffalo nut		S2	G5		
	Quercus georgiana	Georgia oak		S2	G3		
	Ribes curvatum	granite gooseberry		S2	G4		
	Ribes cynosbati	prickly gooseberry		S1	G5		
	Rudbeckia heliopsidis	sun-facing coneflower		S2	G2		D
	Sabatia capitata	Appalachian rose-gentian		S2	G2		B
	Sagittaria secundifolia	Kral's water plantain		S1	G1	T	
	Sarracenia oreophila	green pitcherplant		S2	G2	E	B
	Schoenolirion croceum	yellow sunnybell		S2	G4		
	Schoenolirion wrightii	Texas sunnybell		S1	G3		
	*Selaginella rupestris	ledge spike-moss		S2	G5		
	Silene caroliniana ssp. Wherryi	Wherry's catchfly		S1	T3		
	Silene rotundifolia	roundleaf catchfly		S1	G4		
	Stewartia malacodendron	silky camellia		S2	G4		E
	Stewartia ovata	mountain camellia		S2	G4		
	Talinum mengesii	Menges' fameflower		S2	G3		

***** These plants are not currently being tracked by the Alabama Natural Heritage Program.
1 Nongame Species Regulation 220-2-92: SP=state protected.
2 The rounded NatureServe conservation status, developed by NatureServe and its network of member (state) programs, of a species from a state/province perspective, characterizing the relative imperilment of the species. S1=Critically Imperiled, S2=Imperiled, S3=Vulnerable, S4=Apparently Secure, S5=Secure, SNR=Unranked, SNA=Not Applicable, SX=Presumed Extirpated, B=Breeding population, N=Non-breeding population. Refer to http://www.natureserve.org/explorer/nsranks.htm for additional information on ranks.
3 The rounded NatureServe conservation status, developed by NatureServe and its network of member programs, of a species from a global (i.e., rangewide) perspective, characterizing the relative imperilment of the species. G1=Critically Imperiled, G2=Imperiled, G3=Vulnerable, G4=Apparently Secure, G5=Secure. Refer to http://www.natureserve.org/explorer/ranking.htm for additional information on ranks.
4 U.S. Endangered Species Act (ESA): Current Status of the taxon as designated or proposed by the U.S. Fish and Wildlife Service (USFWS) or the U.S. National Marine Fisheries Service, and as reported in the U.S. Federal Register in accordance with the U.S. Endangered Species Act of 1973, as amended. E=Listed endangered, T=Listed threatened.
5 Code that best describes the observed, estimated, inferred, or suspected short-term trend in population size, extent of occurrence, area of occupancy, number of occurrences, and/or viability/ecological integrity of occurrences (whichever most significantly affects the NatureServe global conservation status). A=Severely declining (decline of >70% in population size, range, area occupied, and/or number or condition of occurrences, B=Very rapidly declining (decline of 50-70%), C=Rapidly declining (decline of 30-50%), D=Declining (decline of 10-30%), E=Stable (unchanged or remaining within ±10% fluctuation), F=Increasing (increase of >10%), U=Unknown (short-term trend unknown), ND (rank factor not assessed).

Waterbird Conservation for the Americas (WCA), Important Bird Areas (IBAs) sponsored by the National Audubon Society, Christmas Bird Count Circle (CBC) through National Audubon Society, Alabama Division of Wildlife and Freshwater Fisheries (ADWFF), Alabama Ornithological Society, and Alabama Breeding Bird Atlas project.

Studies pertaining to birds within LIRI include the draft Avian Conservation Implementation Plan (ACIP) (Watson 2004) and an inventory conducted by Stedman and Stedman (2006) who surveyed for 60 days during all seasons from 2003-2005. The latter study had two goals: 1) to inventory the bird species occurring at LIRI; and 2) to indicate the status and relative seasonal abundance of documented species. Several survey methods were used to collect data including point count plots, migration walk, raptor survey, night survey, and general inventory. The authors documented 147 species against a potential list of 275 species known or expected to occur throughout the diverse habitats of northern Alabama. Ninety of these were breeding species and 57 were migratory species. Three exotic species, the Rock Pigeon (*Columba livia*), European Starling (*Sturnus vulgaris*), and House Finch (*Carpodacus mexicanus*), were counted among the 147 observed species. Comparing the list of observed species to the potential list, the Jaccard Index of Similarity is 0.53 (147/275). Stedman and Stedman (2006) explain that frequent storms could have adversely affected the number of species they observed. Moreover, the natural habitats present within LIRI are limited in comparison to the larger geographic region from where the reference list of 275 species was compiled.

No federally listed threatened or endangered bird species are known to occur in LIRI. The American Peregrine Falcon (*Falco peregrinus*), now de-listed, may occur within LIRI among the cliff ledges, but no nesting surveys have been conducted. Several state protected species occur within the Preserve including the Osprey (*Pandion haliaetus*), Bald Eagle (*Haliaeetus leucocephalus*), Cooper’s Hawk (*Accipiter cooperii*), Golden Eagle (*Aquila chrysaetos*), and Merlin (*Falco columbarius*) (Table 24). All are considered migratory. However, the presence of an immature Bald Eagle at Eberhart Point on several dates during winter and spring and a nesting pair at nearby Weiss Lake suggests that one day they may nest in the Preserve (Stedman and Stedman 2006).

High priority PIF species that regularly occur within LIRI include the Chuck-will’s-widow (*Caprimulgus carolinensis*), Swainson’s Warbler (*Limnothlypis swainsonii*), Worm-eating Warbler (*Helmitheros vermivorus*), Louisiana Waterthrush (*Seiurus motacilla*), Kentucky Warbler (*Oporornis formosus*), Yellow-throated Warbler (*Dendroica dominica*), Prairie Warbler (*Dendroica discolor*), Wood Thrush (*Hylocichla mustelina*), Brown Thrasher (*Toxostoma rufum*), Acadian Flycatcher (*Empidonax virescens*), Summer Tanager (*Piranga rubra*), and Field Sparrow (*Spizella pusilla*). Other high priority PIF species present in the Preserve in low numbers are the Brown-headed Nuthatch (*Sitta pusilla*), Cerulean Warbler (*Dendroica cerulea*), Bachman’ Sparrow (*Aimophila aestivalis*), and Orchard Oriole (*Icterus spurius*) (Watson 2004).

Stedman and Stedman (2006) recommend continuing prescribed burns to promote nesting of a wider range of bird species, increasing the size of wildlife openings (game food plots) where possible for migratory and winter birds, and continuing efforts in bird monitoring.

5.3.4 Fish

Fish inventories related specifically to LIRI include Taylor (2009 draft), Ballard and Pierson (1996), and Dobson (1994). The latter two publications were based on the same prior inventory. Additional supporting reference documents that provide inventories at a statewide level but include sample locations within the boundaries of LIRI are Ramsey (1976), Smith-Vaniz (1968), Boschung (1961), and Fowler (1945). The Alabama Division of Wildlife and Freshwater Fisheries track information about fish in the state.

The most recent review (Taylor 2009 draft) gathered existing data from the NPS I&M program, including the earlier study by Ballard and Pierson (1996) and listed 49 fish species occurring at LIRI.

Ballard and Pierson (1996) conducted 123 collection events, documenting 6,269 fish across 46 species between September 1992 and November 1993. They also included some unpublished data by Robert A. Stiles of Samford University and miscellaneous data from the University of Alabama and Auburn University. Taylor (2009 draft) documented four species not documented by Ballard and Pierson (1996), who found one species not listed by Taylor, making a grand total of 50 fish species observed at LIRI between the two studies. It should be noted that data contributed from these authors were not confined within LIRI boundaries, thus some species they detected may or may not occur within the Preserve. Taylor (2009 draft) listed 78 fish species known to occur in the surrounding (and much larger) USGS HUC-8 sub-basin (Figure 5). This could suggest that additional species may yet be discovered within LIRI or that perhaps the limited habitats within LIRI may not be wholly representative of the larger sub-basin.

Only one of these 50 species, the blue shiner (*Cyprinella caerulea*), is listed as federally threatened under the Endangered Species Act (Table 24). Two documented species, the redbreast sunfish (*Lepomis auritus*) and the rainbow trout (*Oncorhynchus mykiss)*, are considered to be native transplants according to the USGS Nonindigenous Aquatic Species (NAS) database (http://nas.er.usgs.gov/taxgroup/fish).

Although there are no impaired waters at LIRI as set forth in Section 303(d) of the Clean Water Act, fish are specifically sensitive to low levels of dissolved oxygen (DO) and/or high water temperatures. Dobson (1994) made monthly water temperature and DO measurements at five locations for a period of one year, totaling 60 observations. From November through March, average measurements at all locations remained approximately the same and ranged from 8.0-11.5 mg/L DO and 5.5-11.0 ^{o}C (NPS Cumberland Piedmont Network,. By April, temperatures began to increase while DO decreased until October when water temperatures began decreasing again. The database summary developed in the water quality section of this natural resource assessment document (Table 14) contains 1,133 measurements on dissolved oxygen concentrations and 1,346 measurements on water temperature from 11 sample locations through 2007. The grand average of dissolved oxygen is 8.66 mg/L with a standard deviation of 2.25 mg/L. The grand average for water temperature is 16.2 ^{o}C with a standard deviation of 7.2 ^{o}C. These average values are acceptable when compared to the parameter limits assigned for the designated use of waters within LIRI (Table 12). Besides water quality, additional threats to the sustainability of fish populations include dams or other impoundments, type of land cover, land use, roadways, and various human activities (Taylor 2009 draft).

5.3.5 Herpetofauna

Evaluating the status of herpetofauna can be difficult because most species conceal themselves and many have low activity levels, low abundance, or both. Determining species richness requires the employment of numerous collection techniques according to Tuberville *et al.* (2005), who conducted such a study in 16 southeastern National Parks between May 2001 and October 2003.

One study of herpetofauna at LIRI was conducted by Accipiter Biological Consultants (2006). Dunaway (1995) conducted a survey of Little River Canyon with at least three sites located within LIRI. Additional supporting reference documents that provide inventories at a statewide level but include sample locations within the boundaries of LIRI include NPS (1991) and Mount (1975). Agencies and entities that provide information about herpetofauna include the Alabama Herpetofauna Atlas Project, Alabama Wildlife, Society for the Study of Amphibians and Reptiles, Auburn University Herpetological Collection, and the Alabama Division of Wildlife and Freshwater Fisheries.

Accipiter Biological Consultants (2006) conducted a detailed study that accomplished four major goals: 1) documented at least 90% of the species believed to occupy LIRI; 2) documented the relative frequencies of occurrence by habitat type; 3) identified the distribution and relative abundance of species of special concern; and 4) collected voucher specimens and photographs of species not already documented. Six primary inventory methods were conducted on 32 random plots yielding 41 species and 418 individuals. An additional 33 species were conditionally added to the survey based on anecdotal evidence, making a total of 74 species. No threatened or endangered species were observed. One state protected species, the green salamander (*Aneides aeneus*), was found and is listed in Table 24.

The survey data contained 72 species in common with a reference list of 73 potentially present species that was compiled earlier from literature sources. One species on the reference list, the mole kingsnake (*Lampropeltis calligaster rhombomaculata*), was not observed in the survey. Two species that were documented in the survey, the green treefrog (*Hyla cinerea*) and eastern glass lizard (*Ophisaurus ventralis*), did not appear on the initial reference list. Comparing the survey data to the reference list yields a Jaccard Index of Similarity of 0.96 (72/(72+1+2)).

Using count data for each of the 41 observed species, the authors calculated their relative abundance by dividing the number of individuals by the total number of sample plots. The Fowler’s toad (*Bufo woodhousii fowleri*) had the highest relative abundance factor (0.659) of any species, meaning that it was observed at nearly 2/3 of the sample plots. The relative abundance according to habitat type also was calculated by dividing the number of individuals observed by the number of sample plots within each of 13 designated habitat types. In this manner, the eastern fence lizard (*Sceloporous undulatus*) displayed the highest relative abundance of 2.4 individuals per site. The number of species (species richness) within each habitat type also was determined with the greatest number (21) occurring in the ‘Pine/Hardwood Forest’ habitat.

In order to investigate the possibility of spatial patterns in these results, a GIS layer was created for our current study and viewed by plot location, habitat type, and the number of species per plot. No distinctive spatial patterns were observed.

The Accipiter Biological Consultants (2006) study concluded with several recommendations such as the preservation of wetland areas, elimination of illegal herpetofauna collecting, restoration of ephemeral pools where appropriate, preservation of beaver ponds, preservation of vegetation corridors and rights-of-way, and development of a monitoring plan.

5.3.6 Mammals

Deer are identified as a high priority at LIRI within the Cumberland Piedmont Network's Vital Signs Monitoring Plan largely because of concerns about overgrazing and population size. It is anticipated that monitoring of deer will likely be done in the future, but it currently cannot be implemented due to limited staffing and funding (Leibfreid *et al*. 2005). Also of note is that a large portion of LIRI is included in the Little River Wildlife Management Area and is used for hunting. The Alabama Division of Wildlife and Freshwater Fisheries (ADWFF 2008) publishes deer harvest data annually for the Little River Wildlife Management Area. Over the past seven years, 2001-2008, there has been a total harvest of 1058 deer, ranging from 123 to 188 per year with an average take of 151 per year. The Alabama Department of Conservation and Natural Resources (ADCNR) provides additional deer harvest data on a county-by-county basis (http://research.dcnr.alabama.gov/DeerDataCollection/statistics.aspx). The ADCNR also published a study titled *Biology and Management of White-tailed Deer in Alabama* (Cook and Gray 2003).

Additional information about the mammals at LIRI is limited. A study by Dr. Michael Kennedy of the University of Memphis is currently underway for bats and terrestrial mammals. The most recent update is a checklist of mammals containing 58 total species, 25 of which were observed directly under Dr. Kennedy's preliminary study in 2007 and 33 of which were not observed but probably exist there. One federally listed endangered species, the gray bat (*Myotis grisescens*) was observed. No exotic species were actually observed during the preliminary survey.

Comparing the reference list of mammals developed for LIRI by Dr. Kennedy with those species actually observed gives a Jaccard Index of Similarity of 0.43 (25/58).

5.3.7 Mollusks

Aquatic mollusks have been studied at LIRI by Godwin and Shelton (1999). Additional supporting reference documents that provide inventories at a statewide level but include sample locations within the boundaries of LIRI include Bogan and Pierson (1993) and Hanley (1983).

The most recent, and most comprehensive, study to date (Godwin and Shelton 1999) accomplished several goals: 1) identified species of aquatic mollusks occupying Little River within the boundaries of the NPS property, 2) documented their distributions, and 3) obtained density and frequency of occurrence information so that management plans can be formulated. Their study was conducted from July 1998 to September 1999, entailing seven trips and 81 sample sites. Six species of mollusks (four snails and two mussels) comprised the total of approximately 3,218 individuals observed. Maintaining or improving water quality was the most important recommendation of this study and several monitoring strategies were presented.

The authors state that freshwater mussels have a life cycle that is intricately connected to fish life cycles, so diverse and sustainable fish populations are important to mussel populations. Fish aid in their dispersion by carrying the parasitic glochidia stage of the mussel life cycle. Snails have different tolerances to varying environmental conditions and use different habitats. In general they have poor dispersal abilities and are transported passively.

Godwin and Shelton (1999) describe the overall state of aquatic mollusks within LIRI to be one of low diversity and low density. The most common species encountered was the Asian clam (*Corbicula fluminea*), an introduced species which occurs in very high density in some places, and comprised approximately 85% of the total specimens. No rare, threatened, or endangered species were found in their study. Hanley (1983) observed one federally endangered mussel species, the Coosa moccasinshell (*Medionidus parvulus*), but the exact location is unknown. It is listed in Table 24.

5.3.8 Vascular Plants and Vegetation Communities

Prior inventories concerning vascular plants at LIRI include Schotz *et al*. (2008) and Whetstone *et al*. (1997). Agencies such as the Alabama Natural Heritage Program, the Natural Resources Conservation Service (NRCS), the US Forest Service, the Alabama Department of Conservation and Natural Resources, and the US Fish and Wildlife Service identify and track rare, threatened, and endangered species as well as species of concern at the state level. The NatureServe Explorer website (http://www.natureserve.org/explorer/) provides descriptive information about plants and animals, conservation status with population trends, distribution, and references to specific reports concerning the species of interest.

In the most recent study of vascular plants at LIRI, Schotz *et al.* (2008) compiled a reference list of 950 vouchered and documented species based on their own survey and pre-existing data. From the 100 sample plots employed, 27 distinct vegetation associations were identified according to the National Vegetation Classification System (NVCS). Eighteen of these associations were considered to be natural and the other nine were considered to be variously altered from their natural state. Two additional vegetation associations were considered likely to occur within the Preserve, but were not found in the study.

According to Shotz *et al.* (2008), the Alabama Natural Heritage Program tracks 38 of the 950 species known to exist within LIRI because they are rare in the state. This includes three federally listed threatened and endangered species: harperella (*Ptilimnium nodosum*), Kral's water plantain (*Sagittaria secundifolia*), and green pitcherplant (*Sarracenia oreophila*). Among these, harperella (*Ptilimnium nodosum*) was not observed by the authors.

Five highly ranked vegetation associations are present within LIRI. The Southern Appalachian Low Mountain Seepage Bog association (CEGL-3914) exists at three locations totaling 1.85 acres and is considered to be critically imperiled (G1) on a global scale. Table 25 provides information on these five associations extracted from a digital vegetation layer for LIRI compiled by Jordan and Madden (2008). Taken together, they represent about 2.52% (346.49 acres) of the total area of LIRI.

NatureServe, in collaboration with The Nature Conservancy and the NPS, developed a method for assessing and categorizing non-native (exotic) plants according to their invasiveness on native communities. Each species is assigned an Invasive Species Impact Rank (I-Rank) of High, Medium, Low, or Insignificant to rank its negative impact on natural biodiversity (Morse *et al.* 2004), though many have not yet been ranked. Figure 21 displays the total number of exotic species in each of the 19 sample plots where they were encountered. The highest I-Rank value within each plot is indicated by a color with red representing the highest potential impact. For example, if there are two low-ranking exotic species and one high-ranking exotic species within the same plot, only the color of the highest I-Rank is displayed. Only 23 of the 95 exotic plant species documented at LIRI were observed during the study by Schotz *et al*. (2008).

Table 25. Five highly ranked vegetation associations at Little River Canyon National Preserve.

Dominant Vegetation (CEGL)[1]	Patch Count	Area (acres)	% of Total Area	Average Patch Size (acres)
Southern Appalachian Low Mountain Seepage Bog (3914) Smooth Alder - Smooth Azalea / Green Pitcherplant - Few-flower Beaksedge Shrubland	3	1.85	0.01%	0.62
Piedmont Beech / Heath Bluff (4539) American Beech - White Oak / Mountain Laurel - (Horsesugar, Catawba Rhododendron) / Galax Forest	10	55.19	0.40%	5.52
Alabama Cumberland Sandstone Glade (4622) Nuttall's Rayless-goldenrod - Woodland Tickseed - Small-head Blazingstar Herbaceous Vegetation	21	15.94	0.12%	0.76
Southern Ridge and Valley Basic Mesic Hardwood Forest (8488) Northern Red Oak - Appalachian Basswood - Carolina Shagbark Hickory / (Southern Sugar Maple, Chalk Maple) / Oakleaf Hydrangea Forest	21	219.74	1.60%	10.46
Bushy St. John's-wort - Smooth Alder / Eastern Gammagrass Shrubland (8495)	34	53.77	0.39%	1.58

[1]Bold text indicates nomenclature from Schotz *et al.* (2008). Regular text coincides with vegetation associations as described by Jordan and Madden (2008). CEGL = Community Element Global number.

There are three locations of potential management concern for exotic plant species. Two of the 19 sample plots display anomalously high counts of exotic species, one located at the confluence of Bear Creek and Little River (16 observed exotic species) and one at Canyon Mouth (10 observed exotic species). An area of possible concern is located just north of Highway 35 Bridge near Little River Falls. This area is shown in Figure 21 as five closely spaced sample plots with a red color indicating they each contain high I-Rank species.

Schotz *et al.* (2008) are confident their study documented at least 90% of the species thought to occupy the Preserve. Their conclusion was based on a species area curve and jackknife estimates created using specialized software (PC-Ord). A diversity value, beta, was determined in the study as follows: gamma (total number of species) divided by alpha (average species richness per plot). The beta value was 7.2, the gamma value was 569, and the alpha value was 78.8. Comparing the gamma value to the reference list of documented species (950) observed within LIRI yields a Jaccard Index of Similarity of 0.60. Schotz *et al*. (2008) provide recommendations for maintaining or improving the condition of vascular plants including the removal of exotic plants, continuation of fire management to preserve important community types, and protection of high quality examples of all natural communities where possible.

5.3.9. Condition Summary and Discussion

Several inventories and studies have been conducted for major biotic taxonomic groups at LIRI, but without continued monitoring of these groups, limited quantitative-based conditions or trends can be derived from the available data. Table 26 provides the current condition status of the biota at LIRI including calculations of any Jaccard Index of Similarity and answers to whether inventories accounted for 90% of species expected to occur in the Preserve. Following are descriptive condition statements that summarize information gathered from the existing

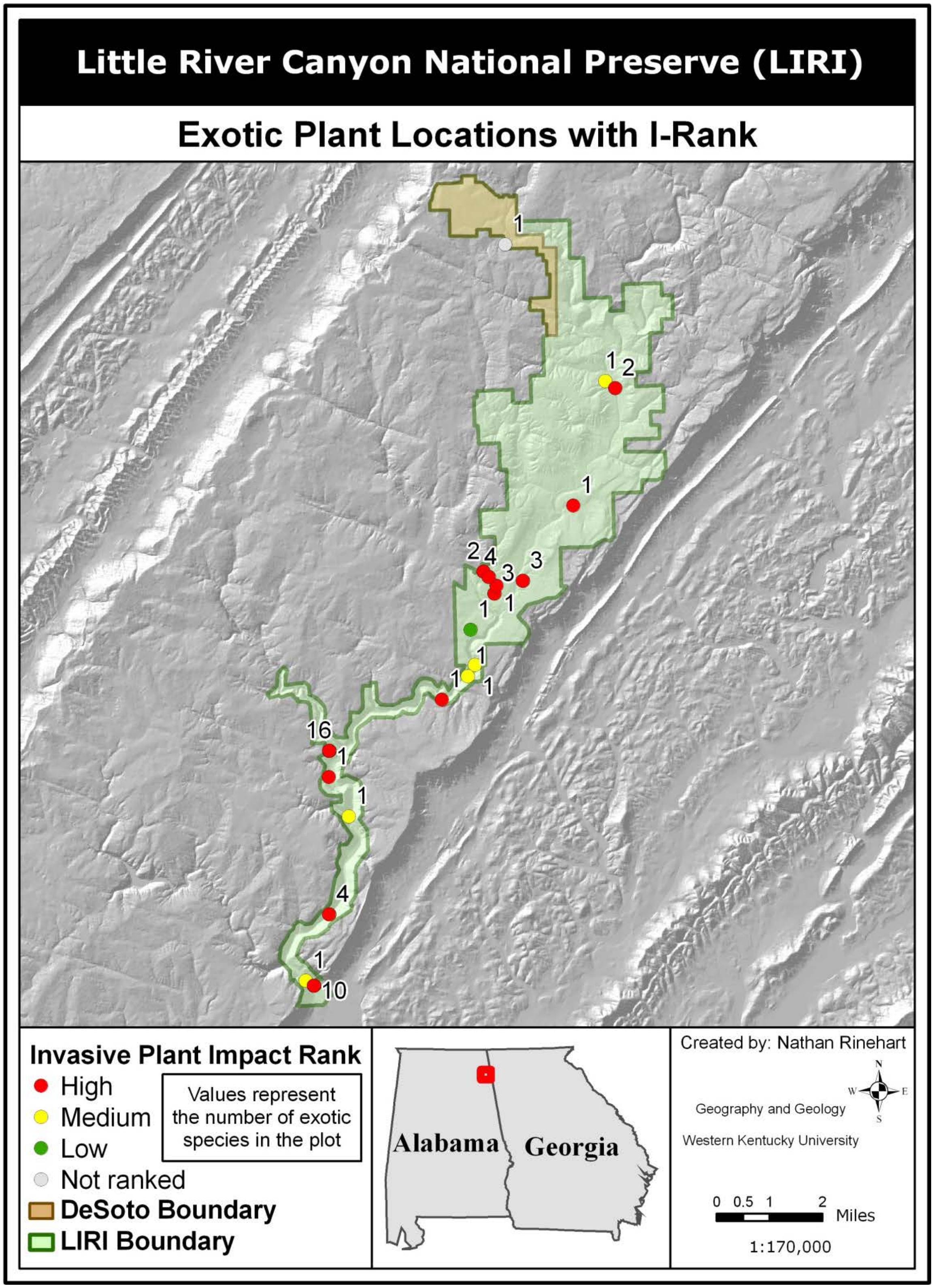


Figure 21. Nineteen sample plots in Little River Canyon National Preserve where exotic plant species were detected by Schotz *et al*. (2008) showing the number of exotic species and highest associated I-Rank for each.

inventories and reports that aided in framing a proposed condition status for these natural resources.

Table 26. Condition status for biota at Little River Canyon National Preserve.

Taxonomic Group	Documented 90% Species Likely to Occur at LIRI	Jaccard Index of Similarity	Condition Status
At-risk Biota	NA	NA	TBD
Aquatic Invertebrates	NA	NA	Green
Birds	No	0.53 (147/275)	Green
Fish	NA	NA	Green
Herpetofauna	Yes	0.96 (72/(72+1+2))	Green
Mammals	NA	Preliminary 0.43 (25/58)	TBD
Mollusks	NA	NA	Red
Plants	Yes	0.60 (569/950)	Yellow
NA = Not Available, TBD = To Be Determined, Green= Good, Yellow = Caution, Red = Significant Concern.			

Several recovery plans have been developed to protect at-risk biota, though some date back to the 1990's. With limited information available concerning at-risk biota, a condition status cannot be determined at this time.

Frazer *et al*. (1991) concludes that the number of caddisfly species observed in the Little River drainage basin is similar to those reported in other southeastern systems of similar size, though the Little River drainage basin displays a lower number of individuals. From the limited statements given above and the preliminary indication that the water at LIRI is in good condition, a green (Good) condition status was given to this resource.

The following general statements on the current condition status of birds within LIRI are extracted from the inventory by Stedman and Stedman (2006): 1) high species diversity, but lower in density than expected; 2) high density of nightjars, but low density of woodcocks; 3) low habitat diversity; 4) high number of Neotropical migrants, Red-headed Woodpecker, and Wood Thrush; 5) low number of Brown-headed Nuthatches and migrant warblers; 6) 90% of species likely to occur at LIRI was not documented. Three exotic species were observed and the low value calculated for the Jaccard Index of Similarity may have been a result of low habitat diversity or bad weather conditions during the survey. Though 90% of species likely to occur at LIRI were not document and the Jaccard Index was low, a green (Good) condition status was given to this resource because the limited habitat diversity at LIRI and the fact that frequent storms influenced the survey numbers of the Stedman and Stedman (2006) study are strong evidence for this occurrence.

Two exotic fish were observed at LIRI. A 68.7% comparison between native species in LIRI to those documented in the HUC-8 sub-basin was observed by Taylor (2009 draft). From these statements, a green (Good) condition status was given to this resource.

At least 90% of species likely to occur at LIRI were documented for herpetofauna. No patterns in the abundance or species richness of herpetofauna were observed. From the statements made above and the fact that no exotic species were observed within LIRI, a green (Good) condition status was given to this resource.

Though a study is underway for bats and terrestrial mammals at LIRI, limited information is currently known. A condition status cannot be determined at this time.

The overall state of aquatic mollusks within LIRI is one of low diversity and low density. One exotic mollusk was observed at LIRI, occurring in very high density in some places, comprising approximately 85% of the total specimens. From these statements, a red (Significant Concern) condition status was given to this resource.

Schotz *et al*. (2008) is confident in documenting at least 90% plant species likely to occur at LIRI. Average species richness per plot is 78.8. Species diversity was calculated as 7.2. The total species observed from all the sample plots was 569. A total of 95 exotic species were documented at LIRI, 23 being observed on 19 (out of 100) sample plots during the survey. Five highly ranked NVCS vegetation associations are present at LIRI. Three points of management concern were noted in our current study pertaining to exotic species and their negative impact to native species. From these statements, a yellow (Caution) condition status was given to this resource.

5.4 Assessment of Air and Climate

The NPS has monitored air quality since the 1970s. Air quality is generally divided into three themes: visibility, deposition, and ozone. Deposition can be further defined as wet and dry deposition. Wet deposition is the accumulation of atmospheric gases and particles incorporated into rain, snow, fog or mist onto water or land surfaces. Dry deposition is the accumulation of gases and particles from the atmosphere to water and land surfaces. Dry deposition can include acidifying compounds such as nitric acid vapor, nitrate and sulfate particles, and acidic gases. Visibility is monitored through agency programs such as the Interagency Monitoring of Protected Visual Environments (IMPROVE) program (http://vista.cira.colostate.edu/improve/). This program was formed in 1985 and is operated by the USEPA. The Visibility Information Exchange Web System (VIEWS) (http://vista.cira.colostate.edu/views/) also provides online air quality information from a variety of sources for the purpose of helping managers reduce regional haze and improve visibility in national parks and wilderness areas. The NPS participates in the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) (http://nadp.sws.uiuc.edu/), which monitors wet deposition. The NADP was formed at the end of 1978 and cooperates with many different state and federal air monitoring agencies. The Mercury Deposition Network (MDN) is part of the NADP and analyzes mercury in precipitation samples. The EPA Clean Air Status and Trends Network (CASTNet) (http://www.epa.gov/castnet/) monitors ozone, dry deposition, and other meteorological parameters in concert with the NPS. Ozone and meteorological data are provided by the NPS and are included within the CASTNet database. The CUPN is scheduled to collect ozone and other atmospheric data at LIRI from April to October 2011, repeating the sampling cycle every six years. AIRNow (http://airnow.gov/) provides near real-time information concerning air quality and public health concerns from air pollutants.

The Clean Air Act (CAA) of 1970 was last amended in 1990 and requires the EPA to set National Ambient Air Quality Standards (NAAQS) for air pollutants considered harmful to public health. The EPA has set NAAQS for six principal or ‘criteria’ pollutants which are: 1) ground level ozone (O_3); 2) particulate matter ($PM_{2.5}$ and PM_{10}); 3) carbon monoxide (CO); 4) sulfur dioxide (SO_2); 5) nitrogen dioxide (NO_2); and (6) lead (Pb). The symbol $PM_{2.5}$ and PM_{10}

refers to particulate matter whose diameter is 2.5 microns or smaller and 10 microns or smaller respectively. Every day, state and local agencies are required to provide an Air Quality Index (AQI) for five (excluding lead) of these criteria pollutants for cities with populations above 350,000 (USEPA 2003). The AQI indicates how polluted the air is and the potential health effects on people. The NAAQS are intended to protect human health and welfare and as such, may not be the best parameters for assessing natural resources.

The NPS has set specific goals for improving air quality throughout the National Park System, which include meeting the NAAQS and making reasonable progress on atmospheric haze by attempting to restore natural background visibility conditions. The NPS identifies 'primary pollutants' (those emitted directly from sources) as: 1) sulfur dioxide (SO_2); 2) nitrogen oxides (NO_x); 3) particulate matter; and 4) volatile organic compounds (VOC) (http://www.nature.nps.gov/air/AQBasics/sources.cfm). Secondary pollutants, those that result from chemical reactions in the atmosphere, include: 1) sulfate (SO_4); 2) nitrate (NO_3); and 3) ozone (O_3). Other air pollutants include ammonium (NH_4) and mercury (Hg). The Clean Air Mercury Rule developed by the EPA to control mercury emissions from coal-fired power plants has been vacated, leaving the country without a nationwide regulation. Until the EPA establishes a new Maximum Achievable Control Technology (MACT) standard for mercury, individual states are to set stringent mercury limits for new power plants on a case-by-case basis (http://www.scdhec.gov/environment/baq/SanteeCooper.aspx).

LIRI is a Class II air quality area, which are "areas of the country protected under the Clean Air Act, but identified for somewhat less stringent protection from air pollution damage than a Class I area, except in specified cases". Although LIRI is a Class II park unit, reference conditions that apply to Class I park units for visibility (in deciviews) were used because there are no established reference conditions for the Class II park units.

According to the NPS (NPS 2007c), monitoring stations are 'reasonably representative' if ozone and deposition sites are located within ten miles of the park unit boundary. Monitoring stations measuring visibility are to be within about 60 miles of the park unit. The closest CASTNet and NADP monitoring station for wet and dry deposition is on Sand Mountain in Alabama, approximately 16 miles from LIRI (Figure 22). The CASTNet station, SND152, and the NADP/NTN station, AL99, share the same location but are run by different cooperators. The CASTNet equipment measures dry deposition and ozone concentrations whereas the NADP/NTN equipment measures wet deposition. The closest IMPROVE monitoring station (visibility) is located at Cohutta, Georgia, approximately 57 miles from LIRI. The closest NADP/MDN station (mercury) is located at Yorkville, Georgia, approximately 43 miles from LIRI. The CASTNet/NADP station is too far away to meet the NPS 'reasonably representative' criterion for LIRI; however, it is the closest available data source for conducting an assessment.

Studies by Fenn and others (2003) suggest that, "sensitive ecosystem components (e.g., lichen species, diatoms, and streamwater nitrate [NO_3^-] levels) can be substantially influenced in some instances by nitrogen deposition levels as low as 3 to 8 kg/ha/yr". Krupa (2003) suggest that, "a critical load of 5–10 kg/ha/yr of total N deposition (both dry and wet deposition combined of all atmospheric N species) would protect the most vulnerable terrestrial ecosystems (heaths, bogs, cryptogams) and values of 10–20 kg/ha/yr would protect forests, depending on soil conditions".

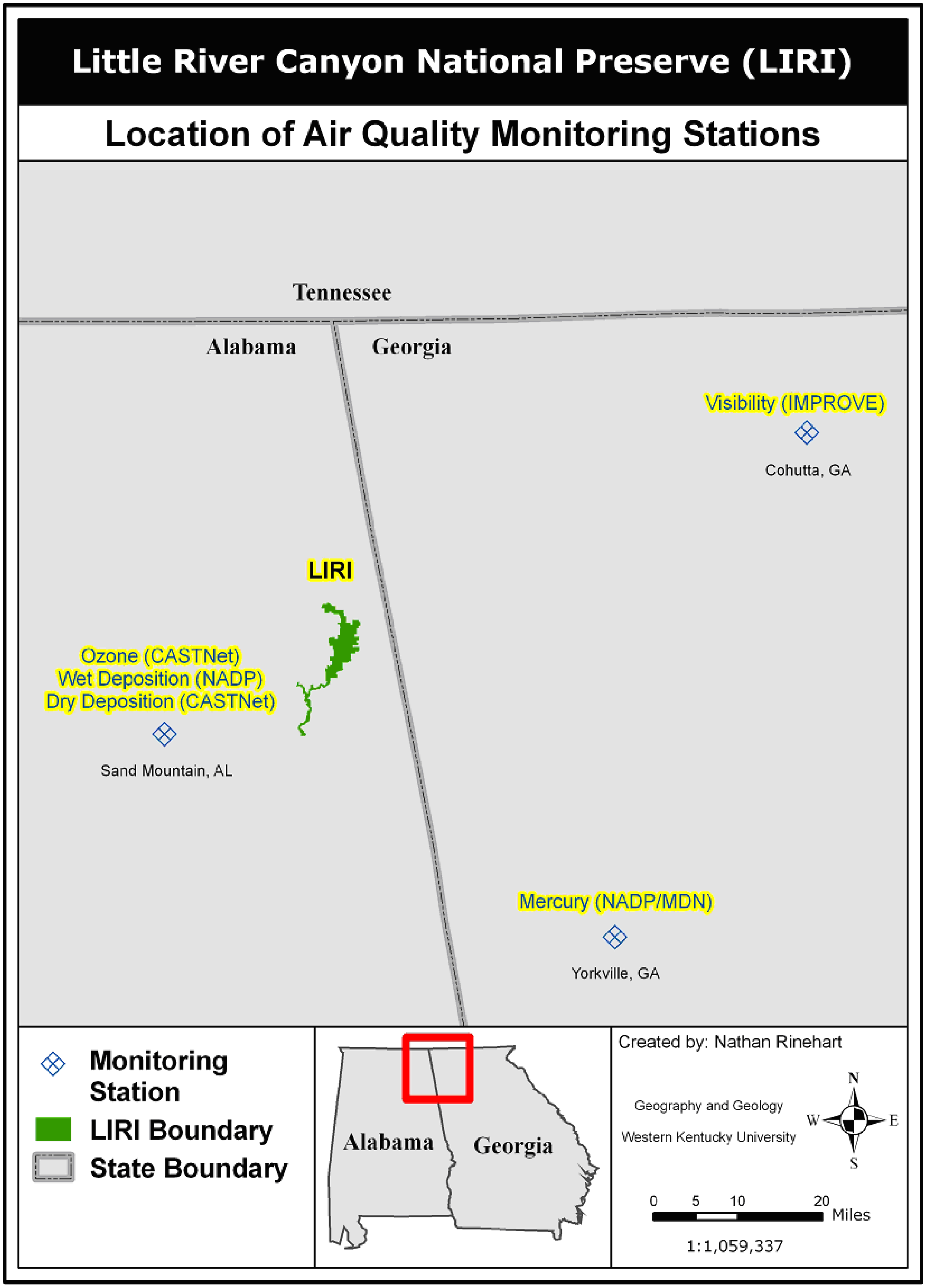


Figure 22. Location of Air Quality Monitoring Stations.

The NPS suggests that 3 kg/ha/yr is the amount above which there is "significant concern" for deposition (NPS 2007c).

For this study, the following air quality parameters were used to assess the current condition status for LIRI: 1) ground level ozone; 2) total deposition-sulfur (S); 3) total deposition-nitrogen (N); 4) fine particulate matter-$PM_{2.5}$; and 5) visibility-deciviews (dv). Reference conditions for these parameters are provided in Table 27.

Table 27. Air quality parameter standards for Little River Canyon National Preserve.

Air Quality Parameter	Reference Condition	Reference Source
Deciviews (dv)	Class 2: TBD; Class 1: <15.6 dv (<8 dv above background)***	NPS 2007c
Ozone (ppb)	<76 ppb*	USEPA 2009
Particulate Matter ($PM_{2.5}$) (µg/m^3)	<16.0 µg/m^3**	USEPA 2009
Total Deposition-S (kg/ha/yr)	Suggested limit: Fenn: 3-8 kg/ha/yr; Krupa: 5-10 kg/ha/yr; Class 2: TBD Class 1: NPS: 3 kg/ha/yr	Fenn *et al.* (2003), Krupa (2003), NPS (2007c)
Total Deposition-N (kg/ha/yr)	Suggested limit: Fenn: 3-8 kg/ha/yr; Krupa: 5-10 kg/ha/yr; Class 2: TBD Class 1: NPS: 3 kg/ha/yr	Fenn *et al.* (2003), Krupa (2003), NPS (2007c)

*3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations over each year must not exceed 75 ppb.
**3-year average of the weighted annual mean $PM_{2.5}$ concentrations must not exceed 15.0 µg/m^3.
***Values apply to Class I park units.

5.4.1. Data Assessment

Table 28 shows a statistical summary of the five parameters used to assess a condition status for air quality at LIRI. It also included information on pH, which is an indicator of potential acid rain effects and was a previously discussed parameter of concern within the water section of this report. Mercury, a highly toxic element, is also included.

The 'Count' column in Table 28 indicates the number of observations according to varying sampling intervals such as 3-day average, weekly average, or annual basis. The NADP has strict criteria on what samples are considered valid based on rain gage depth, sample volume, sampling interval, lab type, and sample validation code. Only valid NADP samples were used to calculate 'Min', 'Max', and 'Mean' values. In contrast, all available CASTNet samples were used to calculate 'Min', 'Max', and 'Mean' values. The percentages of how well the observed values stayed within the reference condition limits are shown in the '% ATN' column of Table 28. The NADP provides an annual trend analysis for selected wet deposition parameters using a 3-year, centered, and weighted moving average.

According to the USEPA NAAQS, ground level ozone concentrations are assessed using a 3-year average of the fourth-highest daily maximum 8-hour average. Available data provided by CASTNet were formatted and calculated according to the NAAQS procedure. A ground level ozone condition was calculated based on the percent attainment of ground level ozone concentrations to the USEPA NAAQS, which states that the concentrations must not exceed 75 ppb (effective May 27, 2008) (USEPA 2009). Figure 23 shows ground level ozone concentrations compared to the USEPA NAAQS. Only two of the 18 (11%) concentration values were within the established ground level ozone limit.

Table 28. Air quality and climate parameters with statistical summary and percent attainment (% ATN).

Parameter	Period of Record	Count	Min	Max	Mean*	% ATN	Source
Ozone							
Ozone (ppb)	1989-2008	986	4.66	68.63	35.87	11%	CASTNET
Deposition							
pH (SU)	1984-2007	807	3.4	6.69	4.64	NA	NADP
Mercury (ng/L)	2000-2007	411	1.19	568.88	14.05	NA	MDN
Total Deposition-S (kg/ha/yr)	1989-2007	12	7.59	12.93	10.51	Fenn *et al.* (2003): 42%; Krupa (2003): 74%; NPS (2007c): 0%	CASTNET
Total Deposition-N (kg/ha/yr)	1989-2007	12	4.96	8.79	7.74	Fenn *et al.* (2003): 100%; Krupa (2003): 100%; NPS (2007c): 0%	CASTNET
Visibility							
PM2.5 (µg/m^3)	2000-2007	746	0.87	50.32	10.38	100%	IMPROVE
Deciviews (dv)	2000-2005	502	6.34	37.56	21.41	0%	IMPROVE

*Weighted mean was calculated for NADP parameters because of criteria requirements for valid samples.
Green = Good, Yellow = Moderate, Red = Of Significant Concern, NA = Not Available, ATN = Attainment.

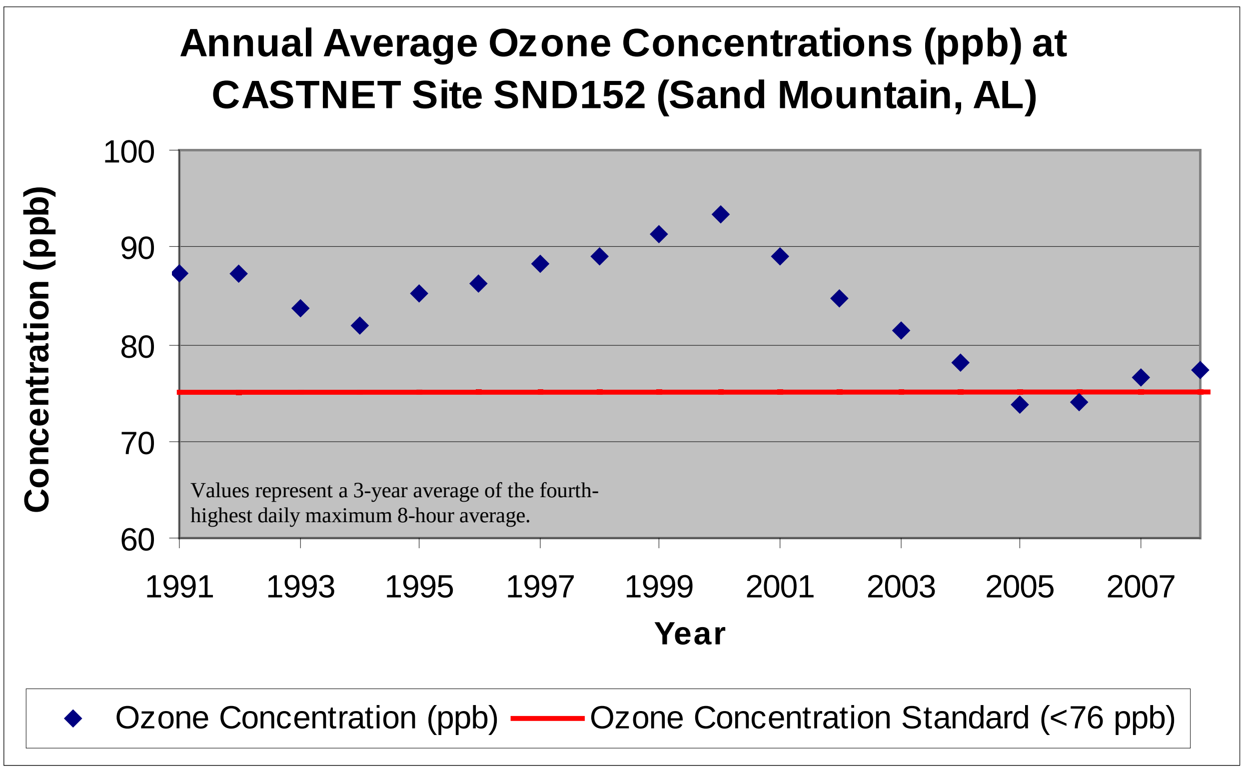


Figure 23. Annual average ozone concentrations (ppb) at CASTNet site SND152 (Sand Mountain, AL).

Figure 24 and Figure 25 show the general trend of total deposition for nitrogen and sulfur, compared with the suggested parameter limits of <9 kg/ha/yr by Fenn and others (2003), >11 kg/ha/yr by Krupa (2003), and <4 kg/ha/yr by NPS (2007c). Total deposition of nitrogen values observed represented 100% attainment compared to suggested limits by Fenn and others (2003)

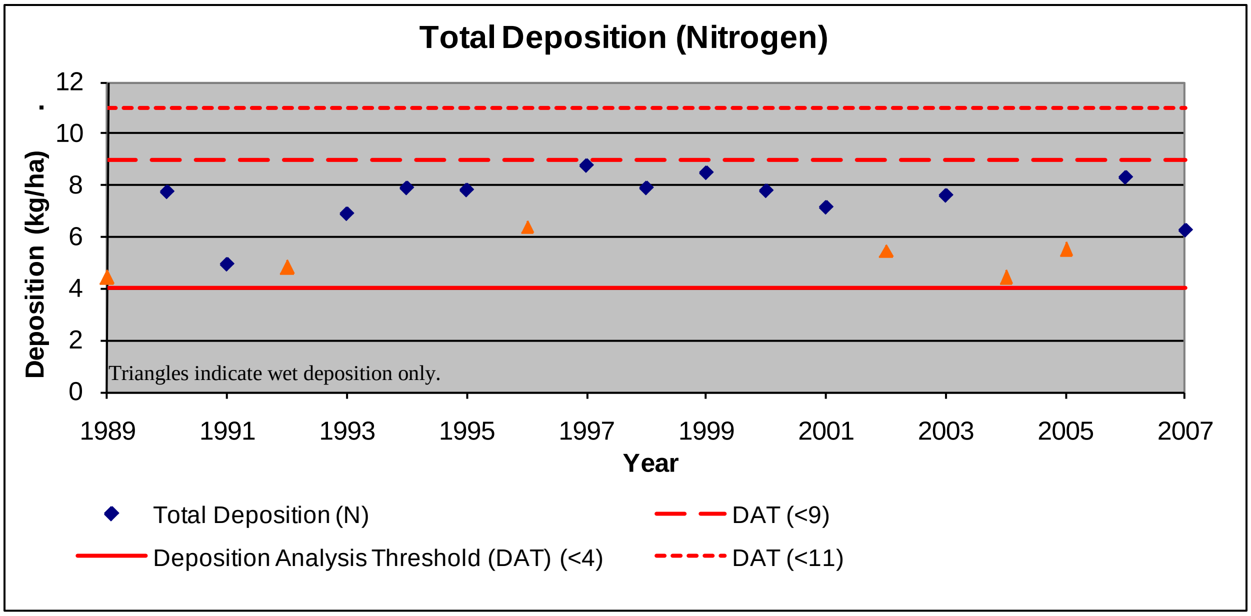


Figure 24. Annual total deposition of nitrogen for CASTNet site SND152 and NADP site AL99 (Sand Mountain, AL).

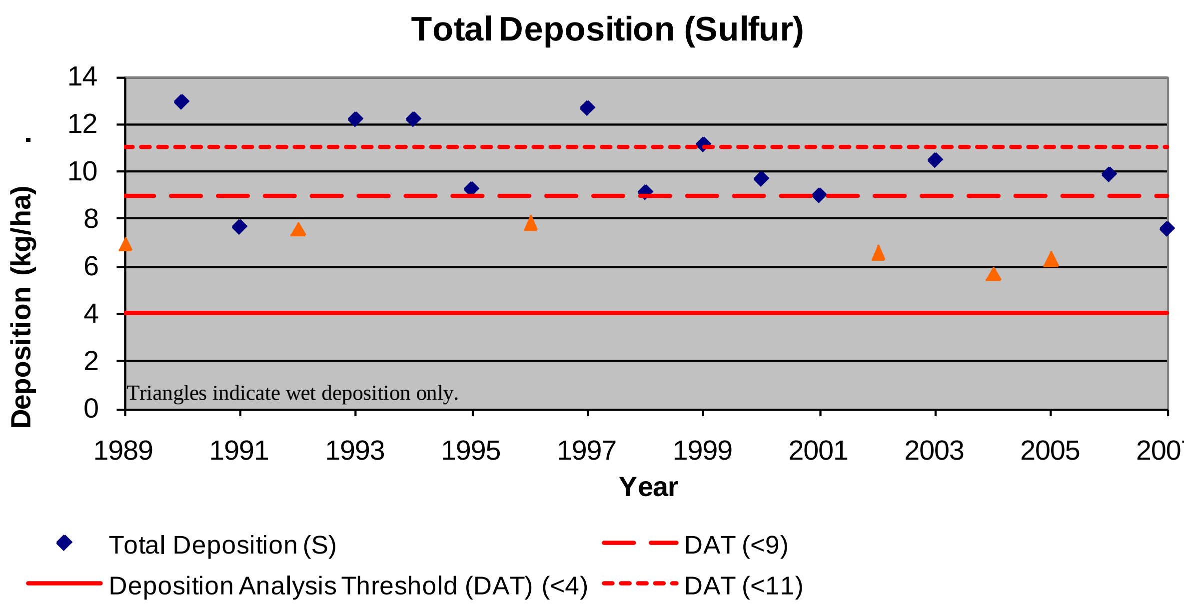


Figure 25. Annual total deposition of sulfur for CASTNet site SND152 and NADP site AL99.

and Krupa (2003). Total deposition of sulfur values observed represented 42% attainment compared to suggested limits by Fenn and others (2003) and 74% compared to suggested limits by Krupa (2003). Observed nitrogen and sulfur values represented 0% attainment according to suggested limits by NPS (2006).

Visibility expressed in terms of $PM_{2.5}$ concentrations is one way to analyze haze conditions. According to the USEPA NAAQS, $PM_{2.5}$ concentrations are assessed using a 3-year average of the weighted annual mean. Available data provided by IMPROVE were formatted and calculated according to the NAAQS procedure. A $PM_{2.5}$ condition was calculated based on the percent attainment of $PM_{2.5}$ concentrations to the USEPA NAAQS, which states that concentrations must not exceed 15.0 µg/m^3 (USEPA 2009). Figure 26 displays the $PM_{2.5}$ concentrations compared to the USEPA NAAQS. In each case, 100 percent of the values are within the limit.

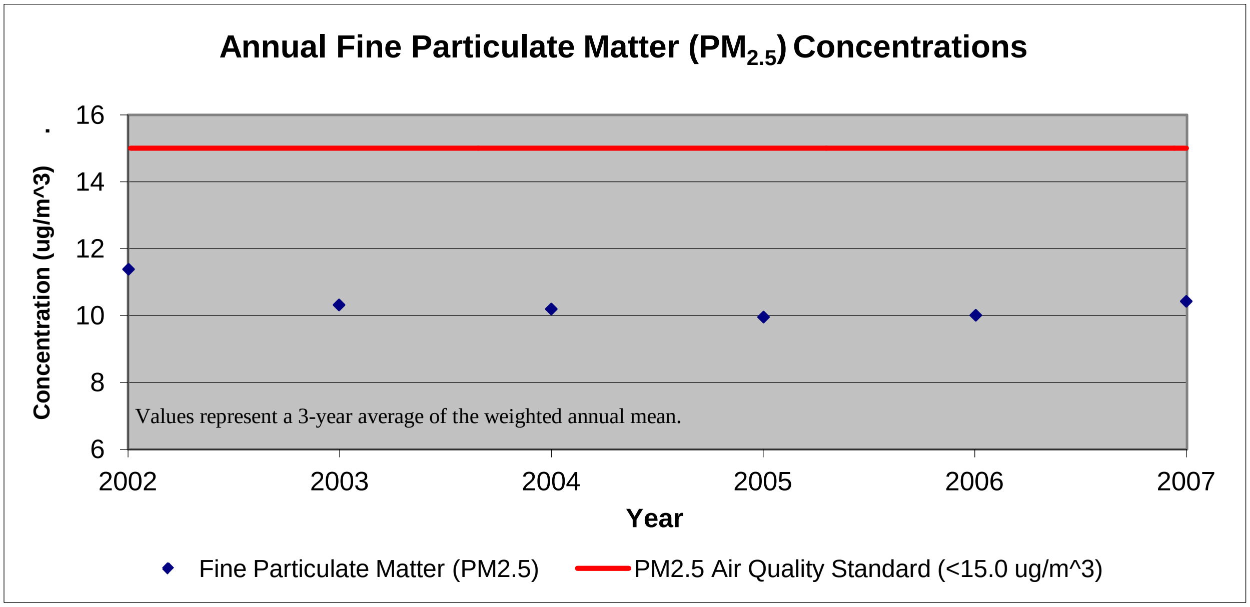


Figure 26. Annual fine particulate matter ($PM_{2.5}$) concentration for IMPROVE site COHU1 (Cohutta, GA).

Visibility expressed in terms of deciviews (dv) is another way to analyze haze conditions. Figure 27 displays annual mean deciview values compared against a value of 8 dv above background conditions, the amount that the NPS considers to be of “significant concern” (NPS 2007c). The annual average background deciviews for the Cohutta, GA IMPROVE site is 7.60 dv, making 15.60 dv the reference condition to compare available data against. In each case, 100 percent of the values exceeded the limit.

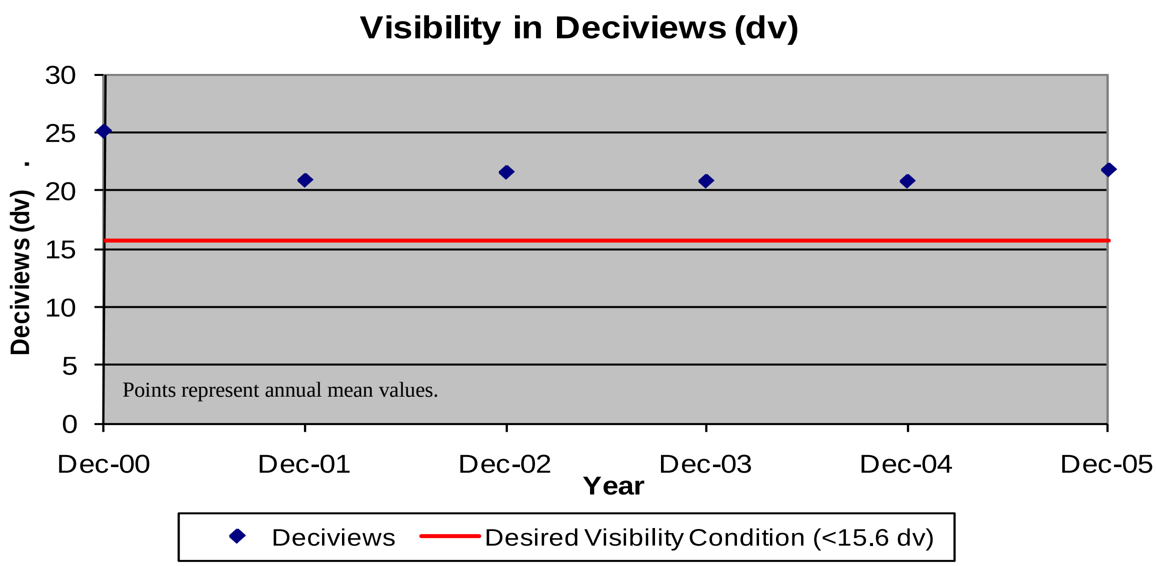


Figure 27. Annual deciview values for IMPROVE site COHU1 (Cohutta, GA).

5.4.2. Summary and Discussion

Four of the five parameters used to assign a condition status for air quality at LIRI are considered 'Of Significant Concern'.

Ground level ozone measurements were outside the NAAQS limits except on two occasions. The NAAQS for ozone was lowered to 75 ppb in 2008 from its previously established limit of 80 ppb in 1997. Even comparing ozone concentrations to the previous NAAQS of 80 ppb, the ozone concentration at LIRI has rarely met the standard.

The total yearly deposition values for sulfur and nitrogen were high compared to the three suggested thresholds. No standard reference condition has been established for total deposition of nitrogen and sulfur, so an "Of Significant Concern" condition was assigned to these parameters. Although fine particulate matter ($PM_{2.5}$) values demonstrated a visibility condition of 'Good' (100% attainment), all of the calculated deciview visibility values were outside the suggested reference condition.

6 - Assessment of Threats, Stressors, and Disturbances

Several threats, stressors, and disturbances were identified through a literature search and workshops with National Park Service (NPS) personnel. These include degradation of species habitat and erosion through All-Terrain Vehicle (ATV) use, change in vegetation type through fires (or lack of), environmental and visibility stresses through human development, erosion through silvicultural practices, contamination from mining activities, loss of species of concern through poaching, degradation of water quality through *E. coli* contamination, potential flooding through failure of degraded dams, exotic species, and forest pests.

6.1 ATV Use

The National Park Service implemented an off-road vehicle management program at LIRI designed to keep the area open to safe and responsible off-road vehicle use, while simultaneously protecting the wildlife habitat and other resources. Although ATVs were restricted to specified trails, they emerged as stressors to biological environments as users traveled off the established pathways. Personnel at LIRI identified numerous areas where ATV use had damaged or destroyed critical habitats. As of September 1, 2010, off-road vehicle use was stopped at LIRI in order to ensure compliance with existing federal and state laws. It is possible in future that limited ATV use will be reviewed and could return pending development of a Backcountry management Plan.

6.1.1 Data Preparation

NPS personnel at LIRI maintain a database for ATV permits issued for the Preserve. These permits have been issued to people from at least fifteen states, not including Alabama and as far away as Arizona and Maryland. Useful information extracted from this database includes the permit issue date for determining the number of permits issued annually. The database was sorted by “date issued” and was checked for data entry errors.

6.1.2 Data Analysis

ATV permits were counted for each year and a graph was generated to show values over time. Figure 28 shows nearly a four-fold increase in ATV permits issued during the six-year period beginning in 2002 with a high of 526 in 2007. During the previous five-year period (1996-2001), the average annual number of permits issued was 110 per year.

6.2 Fire Dynamics

Fires threaten natural resources and watershed characteristics in several ways. They can reduce the infiltration capacity in soil, alter vegetation cover, and destroy habitats, as examples. LIRI has a Fire Management Plan (FMP), which divides the Preserve into two Fire Management Units (FMUs) (Figure 29). Fire suppression has taken place for decades at LIRI and the Preserve has a K100 potential natural vegetation class condition of three (Schmidt *et al*. 2002), which states, “Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This produces dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been significantly altered from their historical range.” (*ibid*. 2002).

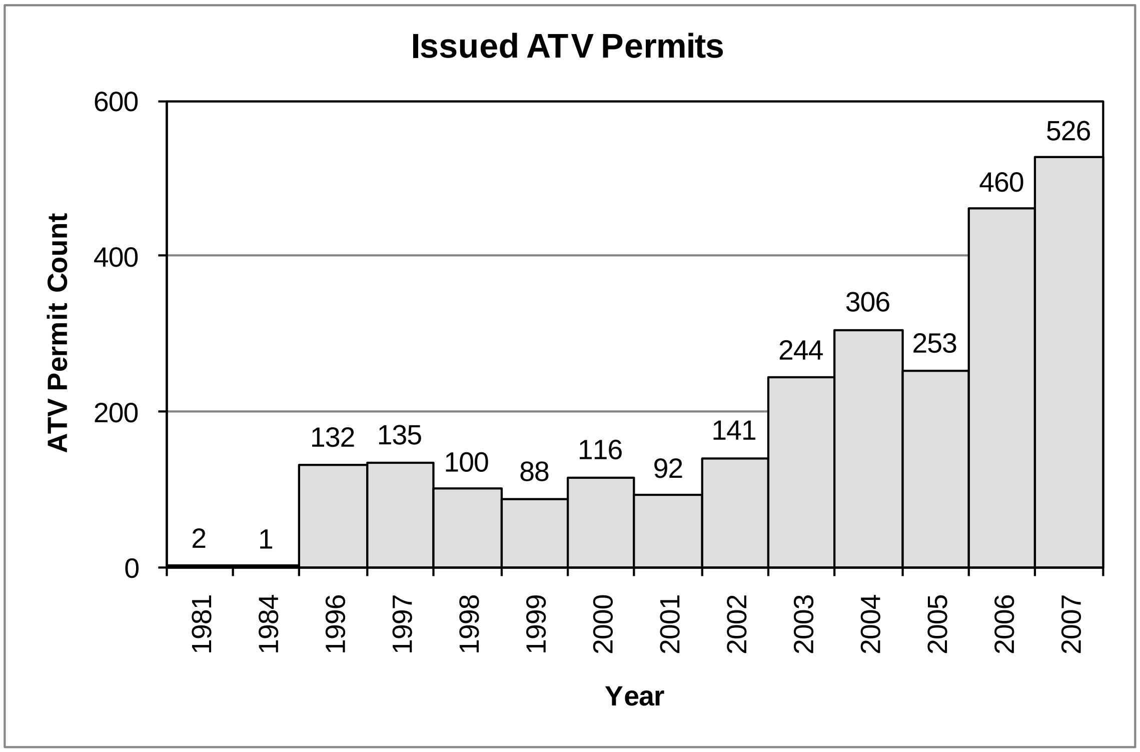


Figure 28. All-Terrain Vehicle (ATV) permits issued by year for Little River Canyon National Preserve. Source: (NPS 2008c).

The FMP for LIRI has established several goals in order to move the Preserve to a better condition class. Goals for the FMU #1 are to: 1) conduct initial attacks within 15-45 minutes of the time a fire report is received; and 2) conduct prescribed burning of 29 units (totaling 9,333 acres) to reduce fuel hazards, promote ecosystem sustainability, and promote the survival of the federally-listed endangered pitcher plant, which is a fire-dependent species (NPS 2005b). Goals for the FMU #2 are to: 1) use the highway along the canyon rim on the western side of Little River to confine any fire occurring between Little River and the western canyon rim, as backfiring could occur from this holding line; 2) cooperate with the Alabama Forestry Commission (AFC) to confine any fire involving FMU #2 within state and Preserve owned boundaries; and 3) conduct prescribed burning of three units (totaling 124 acres) to reduce hazard fuels and promote ecosystem sustainability (*ibid*. 2005b).

6.2.1. Data Preparation

The NPS maintains a database for tracking fires at Park units and Park personnel keep individual fire reports at the Park units. Spreadsheet software was used to import the text file database information for the fire reports. The NPS fire reports database and the individual fire reports from Park personnel were compared and checked for errors during overlapping years from 2000-2006. Fires do not respect political boundaries; fires can start within LIRI and travel outside the boundary or start outside the boundary and travel into LIRI. The individual fire reports distinguish between lands burned on NPS lands and other/private lands, so our analysis can provide information for both land categories. “YrlyContAcres”, “NPSLndBrnd”, and “YrlyNPSAcres” were added as columns to the combined fire database spreadsheet to assess fire frequencies and distribution of burned land inside and outside of LIRI on a yearly basis. “YrlyContAcres” represents a yearly summary of acres burned within Little River Canyon

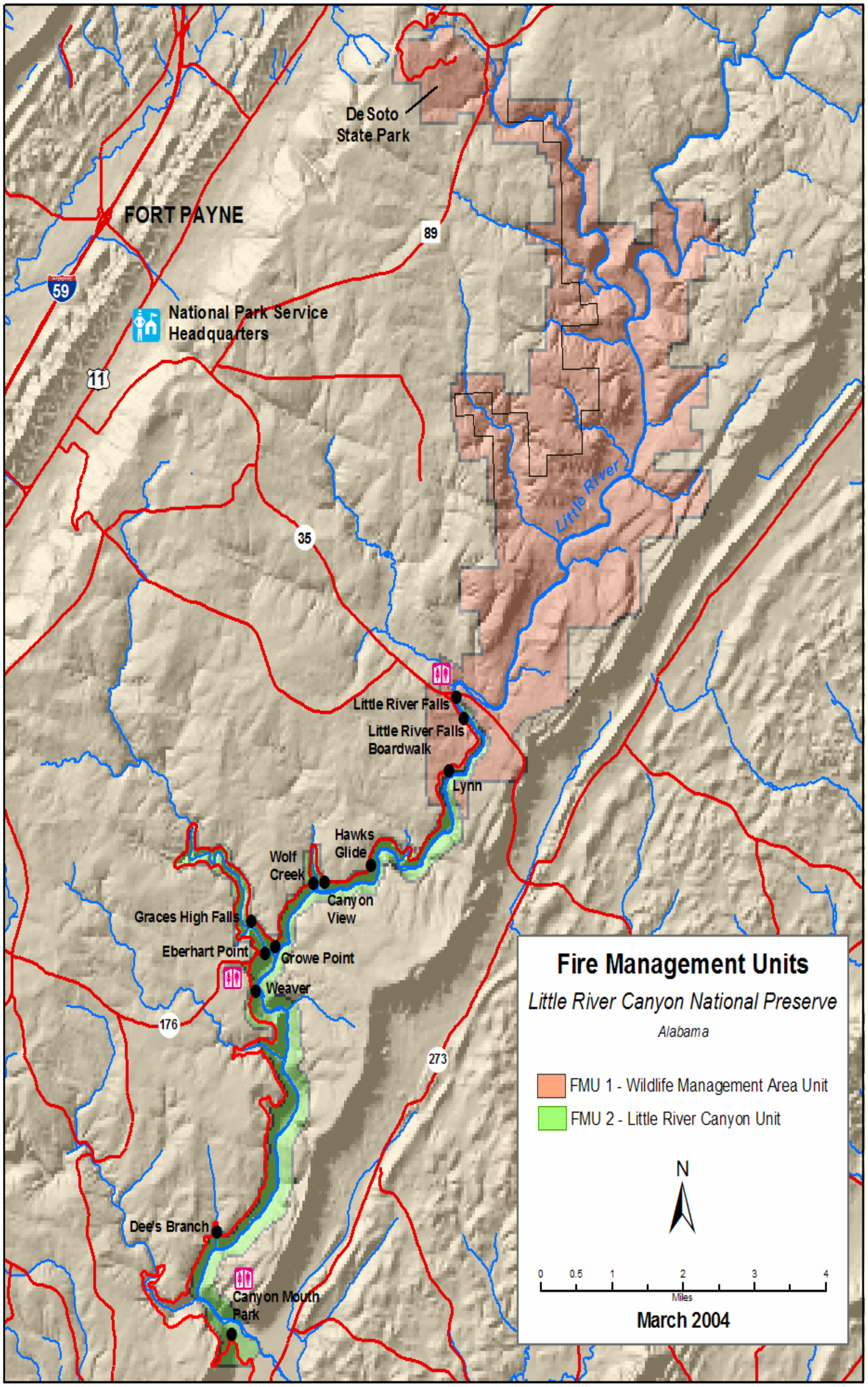


Figure 29. Fire Management Units (FMUs) for Little River Canyon National Preserve. Source: modified from (NPS 2005b).

National Preserve (LIRI) as well as outside LIRI. “NPSLndBrnd” include acres burned within the LIRI and lands under the responsibility of the NPS. “YrlyNPSAcres” represents a yearly summary of acres burned within LIRI and land under the responsibility of the NPS.

During the process of formatting the fire report database for creating a Geographic Information Systems (GIS) layer, data entry errors were observed, corrected where possible, or otherwise omitted. The NPS and United States Geological Survey (USGS) National Burn Severity Mapping Project (USGS 2007c) provided location and burn perimeter layers for fires within LIRI. These data were downloaded and a comparison of these coordinate sources with the combined fire report database was conducted. The combined fire report database records with acceptable coordinates were added to ArcMap as a formatted spreadsheet and a fire location layer was generated, specifying the appropriate input latitude and longitude coordinate reference. The fire location layer datasets were then projected into the “NAD_1983_UTM_Zone_16N” projection.

6.2.2 Data Analysis

Figure 30 provides a summary of fire frequency and extent information from the combined fire report database. The upper graph in Figure 30 shows that 202 documented fires are represented in the combined fire report database from 1983-2007, burning a total of 12,962.3 acres. The highest number of fires in one year was 24 in 1987 (2,281.2 acres), all of which were caused by lightning except for one. Note in the upper graph of Figure 30 (from 2001-2007) that the NPS burn distribution (in yellow) is often less than the total burn distribution (in red). This may suggest that the total burn distribution used to assess area burned may not represent the NPS owned land, and that often some of the land that is burned lies outside the boundary of LIRI. The lower left graph in Figure 30 provides fire size classes with percentages of documented fires that occur within each class. Classes are defined according to the amount of acres burned: Class A-0.1 to 0.25 acres; Class B-0.26 to 9.9 acres; Class C-10.0 to 99.9 acres; Class D-100 to 299.9 acres; Class E-300 to 999.9 acres; and Class F-1000 to 4999.9 acres. There were 43 fires within Class A, 87 fires within Class B, 43 fires within Class C, 17 fires within Class D, eight fires within class E, and three fires within Class F. The largest fire for the period of record is within Class F and occurred in 2007 with 1,650 acres burned. The lower middle graph in Figure 30 shows fire cause classes that describe general cause classifications of fires using a numerical value and include causes such as Natural (1), Campfire (2), Smoking (3), Fire Use (4), Incendiary (5), Equipment Use (6), Railroads (7), Juveniles (8), and Miscellaneous (9). The Preserve has a split fire season from February 1 – May 1 and from October 1 – December 15, as determined by an analysis of historic fire weather and fire occurrence in the local region (NPS 2005b). The lower right graph in Figure 30 shows fires by month, where more fires occur during the split fire seasons. The fire report database shows there are 145 (~71.8%) of the 202 total fires between 1983 and 2007 that occurred during LIRI’s split fire season, burning 10512.8 acres (81.1%) of the total 12962.3 acres burned.

The average fire frequency for LIRI is approximately eight fires per year and the average burn distribution for LIRI is approximately 518 acres per year for the period of record. Figure 31 shows, geospatially, 57 of the 202 fire locations at LIRI. These 57 records are all that contained usable coordinates from the combined fire report database. Figure 31 displays LIRI fires according to the fire size class (classes according to acres burned) and contain fire perimeter layers for four prescribed fires within LIRI. Fires with a general cause class of “5-Incendiary”

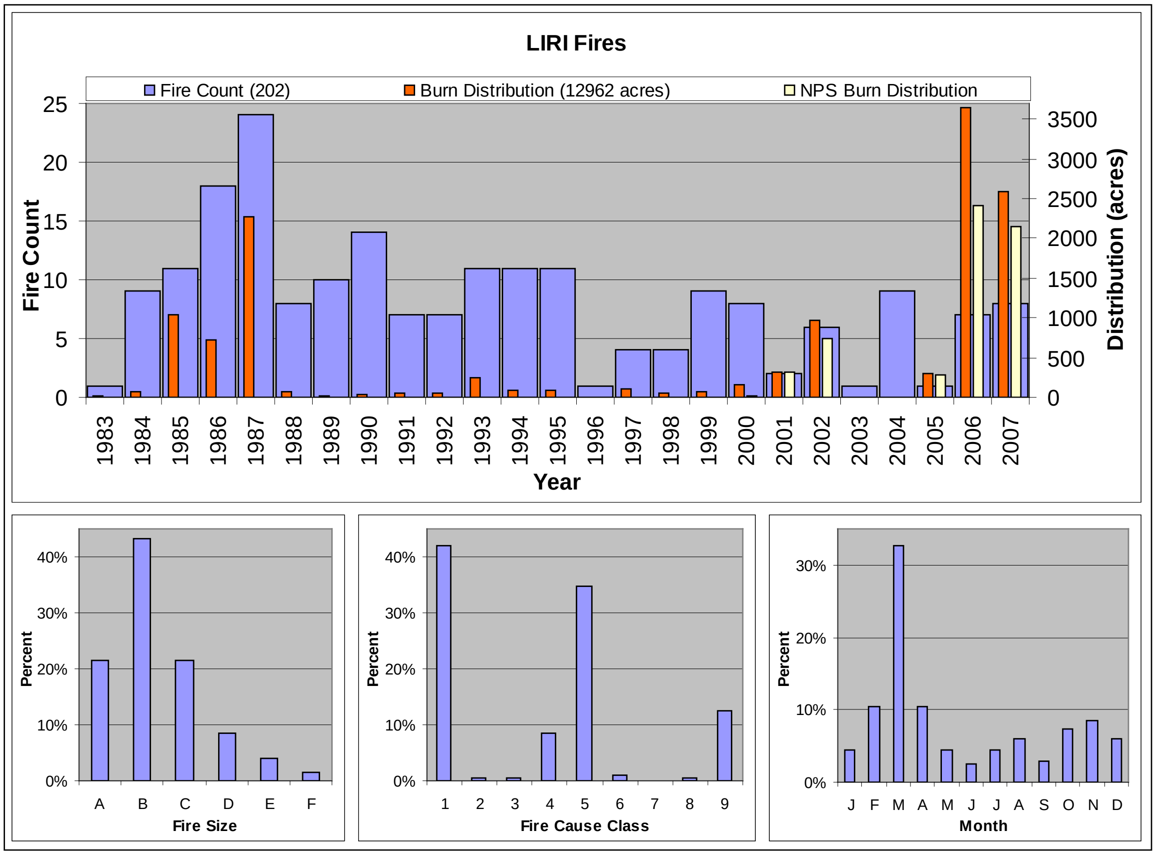


Figure 30. Summary of the fire report database for Little River Canyon National Preserve. Fire size: A (0.1-0.25 acres); B (0.26-9.9 acres); C (10-99.9 acres); D (100-299.9 acres); E (300-999.9 acres); F (1000-4999.9 acres). Fire cause class: 1 (natural); 2 (camp campfire); 3 (smoking); 4 (fire use); 5 (incendiary); 6 (equipment use); 7 (railroads); 8 (juveniles); 9 (miscellaneous). Source: (NPS 2005b; 2008d).

occur near heavily used roadways in and adjacent to LIRI. Fires with the class of "4-Fire Use" are dispersed throughout LIRI and include several prescribed burn events. The one instance of fire caused by "3-Smoking" occurred near the Canyon Mouth.

In general, the number of acres burned by fires were lower in the 1990s than in other years, especially recently in 2006. This rise in burned acreage may be a result of efforts such as prescribed burns aimed at changing the natural vegetation class condition to a better status.

6.3 Population and Viewscape

Lookout Mountain has become a place where regional investors build second homes or summer homes along what is called "brow" property, which is located along the rim generally overlooking a valley. This viewscape is desirable and property is expensive in these locations. Not only are individuals developing properties on the outer edges of Lookout Mountain, they are developing lands adjacent to the LIRI boundary because of the spectacular views into Little River Canyon itself. The NPS is concerned that this will affect the quality of viewscape within LIRI as many visitors come to enjoy the breathtaking views of Little River Canyon. The east ridge of the Little River Canyon forms the boundary line of LIRI and several houses have been built close to the ridge, enabling visitors to see these houses as they look out across the canyon.

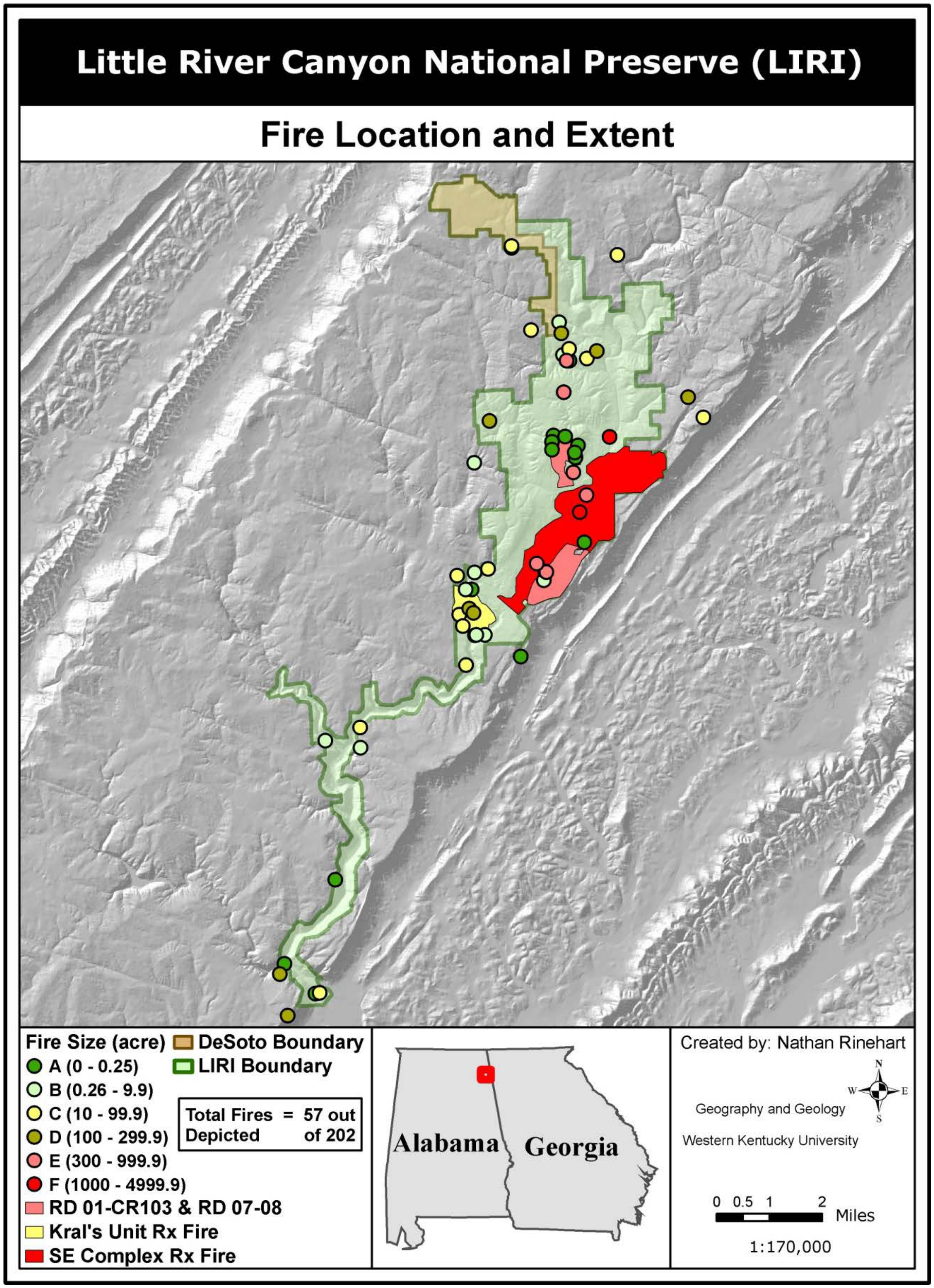


Figure 31. Location, fire size, and extent of selected fires at Little River Canyon National Preserve. Source: (NPS 2008d; USGS 2007c).

This is private land and the NPS has no jurisdiction on what happens on these lands, but the vista is being threatened by this development.

6.3.1 Data Preparation

The United States Census contains population information at various scales to help understand population changes over time. The LIRI watershed lies within two states and comprises five counties namely DeKalb County, AL; Cherokee County, AL; Dade County, GA; Walker County, GA; and Chattooga County, GA. Census information is divided into geographic units called census tracts, block groups, and blocks, with blocks being the smallest unit. Census 2000 data is available at no cost from Environmental Systems Research Institute (ESRI) in Geographic Information Systems (GIS) format and includes geospatial data such as census block polygons as well as demographic data tables that can be joined to the geospatial layers (ESRI 2008a). Data were downloaded for the 2000 census blocks, spatial layers were projected to "NAD_1983_UTM_Zone _16N", data layers were merged, and demographic data tables were joined to geospatial layers.

6.3.2 Data Analysis

Census block level population density within the LIRI watershed for 2000 is shown in Figure 32. Note that the outer edges of Lookout Mountain have higher population density than other portions coinciding with major transportation arteries. Geographic boundaries and boundary IDs for Census data are not consistent between the 1990 and 2000; for instance, boundaries may have been divided or altered between the two years. Demographic data for 1990 that coincide with the 2000 geography layer are available that reconcile these differences and make comparison simpler (ESRI 2008b). Census demographics for 1990 census blocks are not as readily available as the Census 2000 data and require a purchasing fee (~$500). If appropriate data for 1990 were obtained, a comparison of change could be analyzed between 1990 and 2000. In order to provide changes in development adjacent to LIRI, a comparison of land parcel locations and purchase dates could be assessed. Selected parcel data for Alabama are available online for free at http://mapguide.flagshipgis.net and connected sites. A database for housing permits, purchases, and taxes could be used to obtain the houses built near LIRI for a specified time period.

6.4 Silviculture

According to the Society of American Foresters the term 'silviculture' refers to, "the art and science of controlling the establishment, growth, composition, health and quality of forests and woodlands to meet the diverse needs and values of landowners on a sustainable basis" (Helms 1998). Sediment becomes a pollutant to water quality as various silvicultural practices such as manipulation of vegetation cover are implemented. A literature search resulted in references to clear-cutting occurrences east of the Little River Canyon (NPS 1991), but no detailed information was available referencing dates or land cut. A detailed analysis of aerial photography from various dates may provide clear-cut areas, or private silviculture company records may provide coordinates and practices incurred on specific lands near LIRI.

6.5 Mining

The Pennsylvanian strata that cap Lookout Mountain contain coal resources and mining of these resources was a common occurrence in the past. The Abandoned Mine Land Inventory System (AMLIS) database maintained by the United States Office of Surface Mining (OSM) Reclamation and Enforcement provides information for 12 abandoned surface mines and two

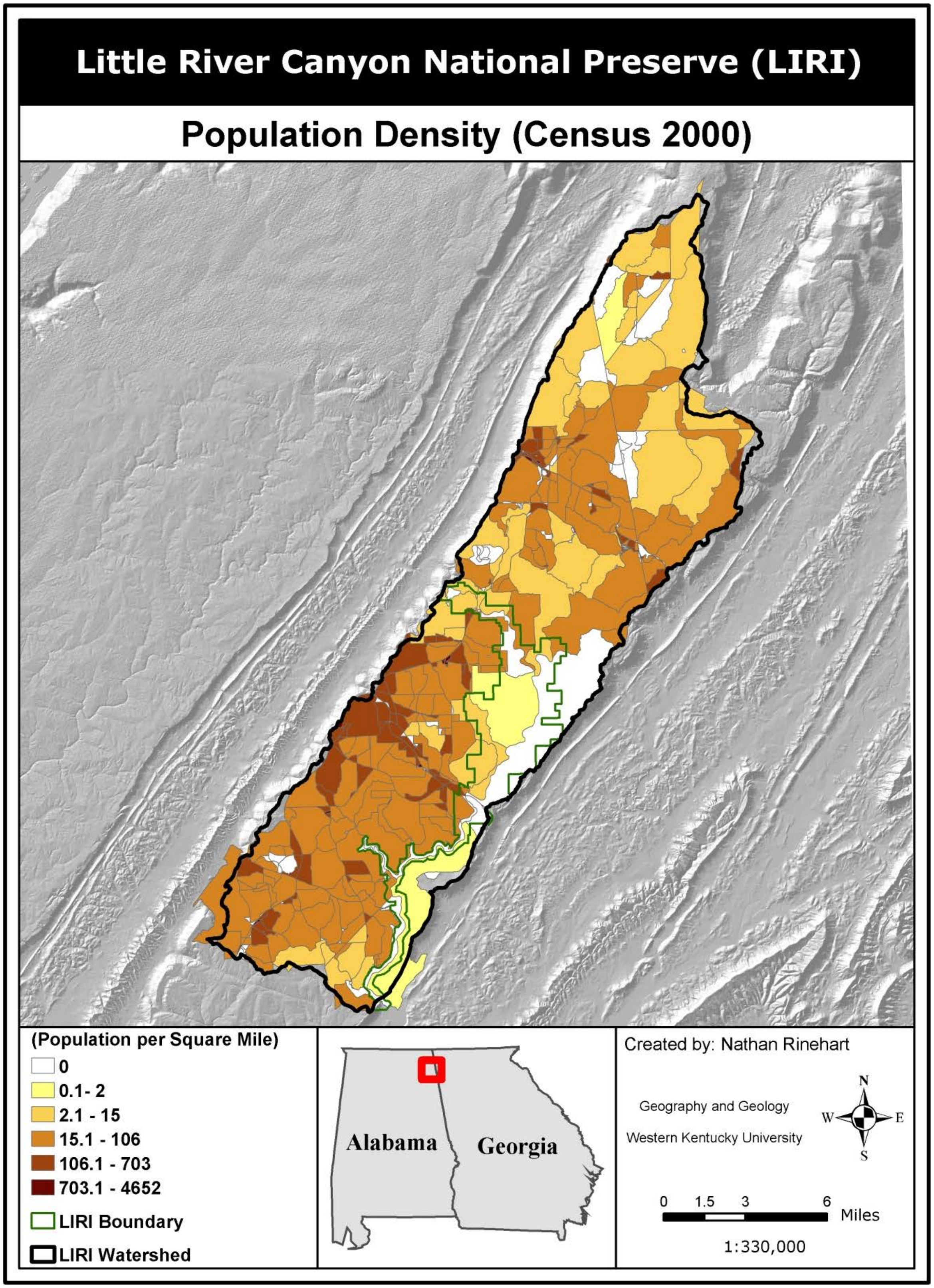


Figure 32. Census block level population density for 2000 at Little River Canyon National Preserve. Source: (ESRI 2008a).

abandoned surface/underground mines adjacent to LIRI and within the LIRI watershed (OSM 2008). Database information for abandoned mines include "priority" values for types of problems associated with mines. Priority 1 expresses a condition that could reasonably cause substantial harm to persons or property, Priority 2 is a condition that could threaten people but not an extreme danger, and Priority 3 is a condition that is causing degradation of environmental resources such as soil, water, wildlife, recreational resources, and agricultural productivity. Problem types identified in the database for abandoned mines include a range of hazards such as dangerous mining structures, waste products, polluted water, and unsealed mine openings.

The NPS provides information for six active surface mines and four mines of unknown type within the LIRI watershed (NPS 2008e). Four of these active surface mines are located within the redefined sub-watershed pertaining to the East Fork Little River (EFLR, see Figure 12) sample location and the remaining two within the sub-watershed pertaining to the Middle Fork Little River (MFLR) sample location. Information about active mines includes the name of the mine, the company that owns the mine, and what products are being extracted. Figure 33 shows the location of active and abandoned mines within the LIRI watershed. Upon inspection of a few abandoned mines, these don't appear to be affecting natural resources within LIRI, though knowledge is limited concerning the potential effects.

6.6 Poaching

Wildlife occurs within LIRI that can be harvested and sold illegally such as the Green Pitcher Plant and Ginseng. This is a threat to natural resources within LIRI, but little knowledge or information is available. The current management personnel at LIRI are only aware of one instance of plant poaching in the fourteen years since establishment.

6.7 Degradation of Dams

The knowledge about dams along the Little River and its tributaries is limited, in part because Alabama is among the last states in the United States to implement state dam safety regulations. The Office of Water Resources (OWR) is working on the establishment of an Alabama Dam Security and Safety Program, which is currently in draft form (ADECA 2008). This legislation has been under development and was reemphasized in 2002 when the OWR assumed overall management of dam safety and National Flood Insurance Program initiatives from the Alabama Emergency Management Agency (AEMA) (*ibid*. 2008). Once regulations are established, the program will provide an updated dam inventory in Alabama.

Based on information provided by the National Inventory of Dams (NID) and the National Performance of Dams Program (NPDP) there are 13 dams located within the LIRI watershed. All of these are considered to be low-hazard dams. These inventories select dams for their database according to criteria such as their height and storage capacity. Since there is little regulatory oversight, information on the structural status of these dams is unknown and there may be more dams in the LIRI watershed that were not included in these inventories. Figure 34 displays locations of the 13 known dams within the LIRI watershed.

6.8 Pathogenic Bacteria

Pathogenic bacteria indicators such as *E. coli* and fecal coliform are common in the waters of LIRI. The water quality assessment provided in this study suggests a condition of good (light green) for the sample location at Canyon Mouth (CMLR, see Figure 16) and fair (yellow) for an

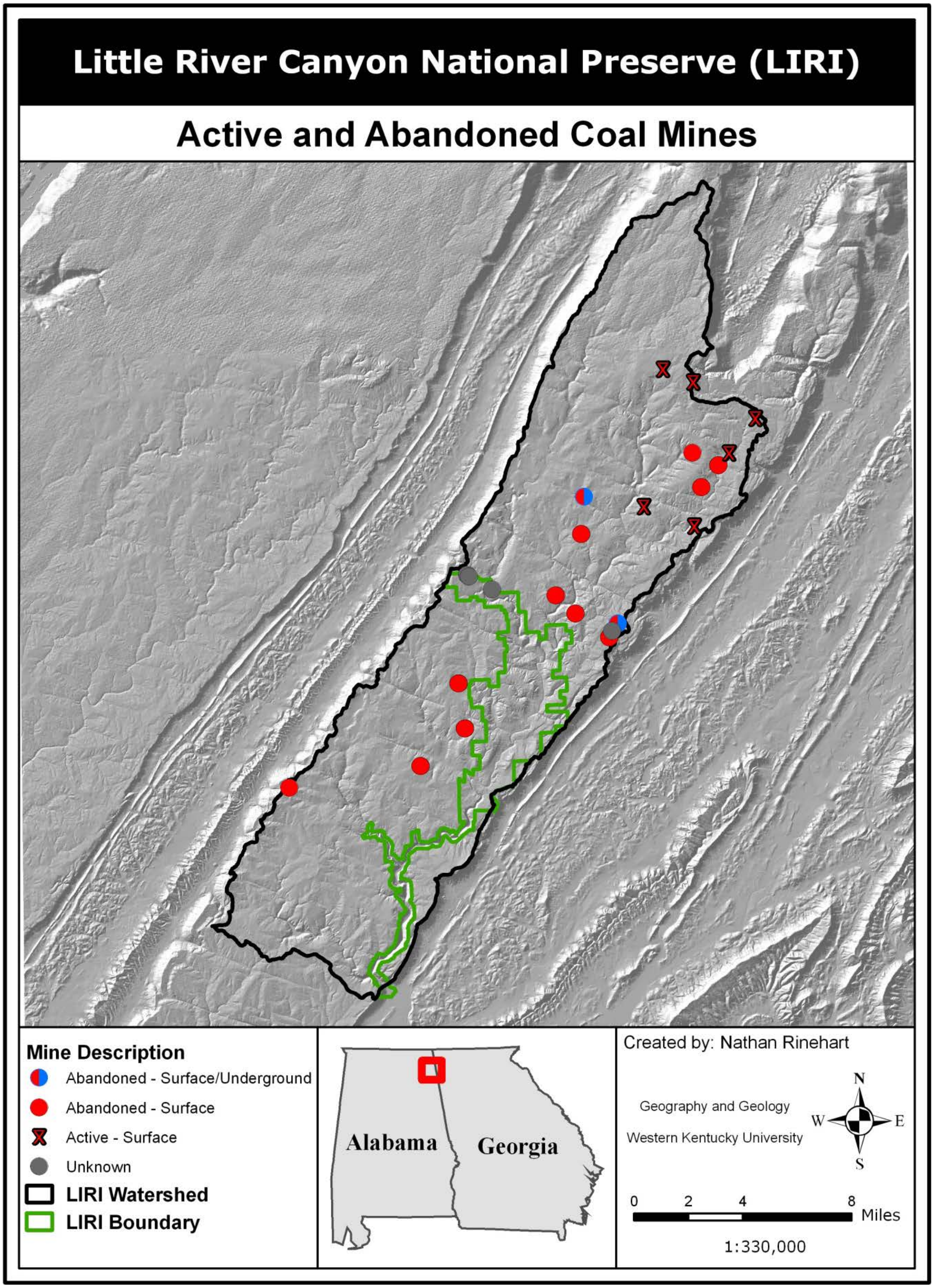


Figure 33. Abandoned and active mines within the Little River Canyon National Preserve watershed. Source: (NPS 2008e; OSM 2008; GeoCommunity 2008).

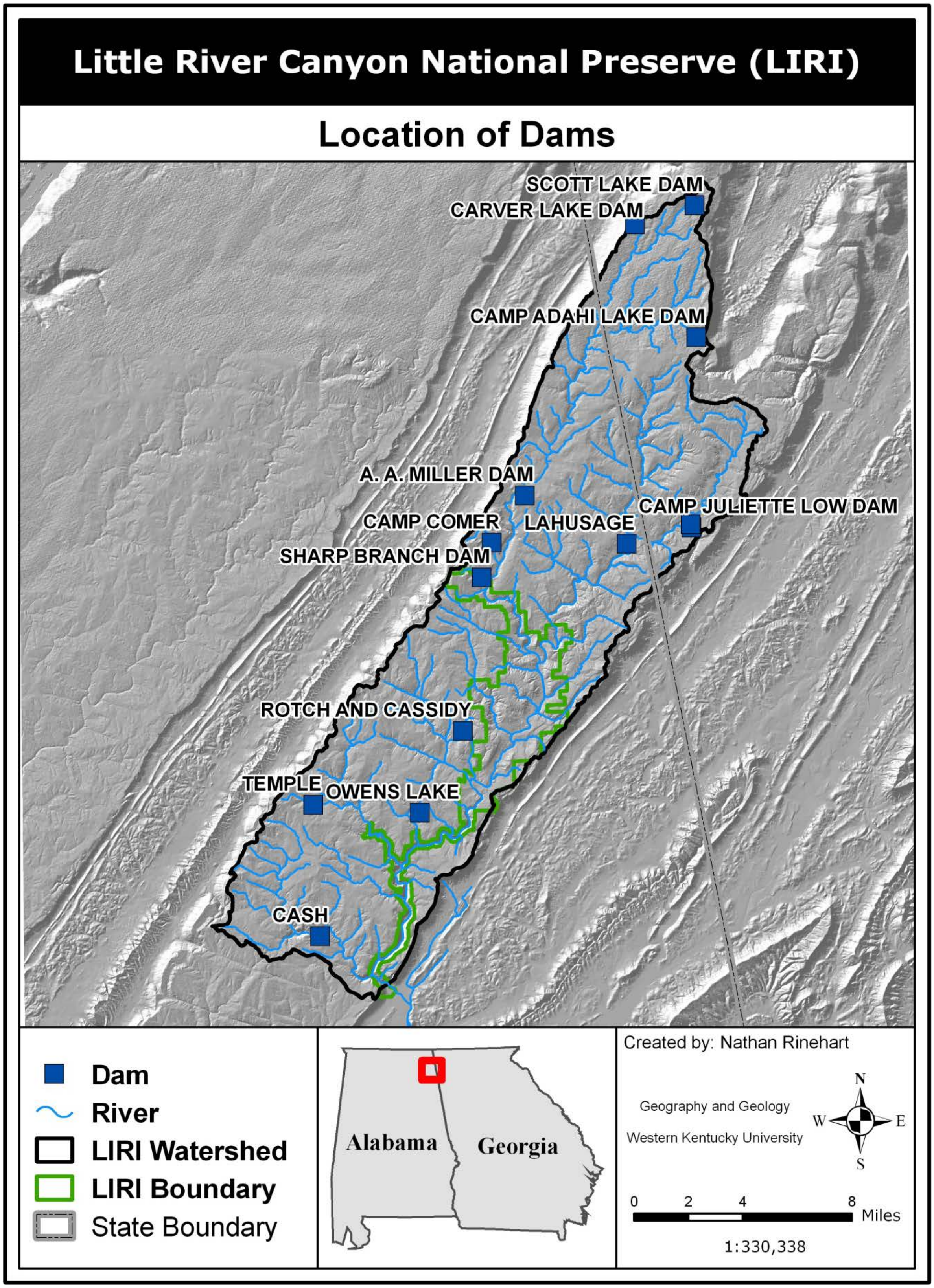


Figure 34. Location of dams within the Little River Canyon National Preserve watershed. Source: (NPDP 2008).

accumulation of all sample location data values for *E. coli* for the period of record (see Table 19). Refer to Figure 16 for individual sample location conditions throughout the LIRI watershed.

6.9 Exotic Species

Although there is quite a bit of overlap between 'exotic' and 'invasive' species in the literature, these terms really should not be used synonymously. The term 'Exotic' species refers to 'non-native' species. An 'Invasive' species is a generic term that generally refers to an organism with a competitive advantage allowing it to 'invade' or increase in number to the detriment of other organisms. It is generally proper to avoid referring to 'native' species as 'invasive' because if it was native, then it really didn't invade an area because it was already present. There are cases where a native species goes through periodic, cyclic outbreaks where it increases in number and crashes. In addition, not all exotics are 'highly' invasive and of major management concern. The I-Rank list provided by NatureServe is one attempt to differentiate non-native plants. Figure 21, from a previous section in this report, displays the I-Ranks for vascular plants within LIRI. Plans are still in the works for developing a similar rank for animals. Table 29 is a list of all non-native species observed in LIRI, noting which ones are of management concern.

Table 29. Non-native species, occurring in Little River Canyon National Preserve, with an Invasive Species Impact Rank (I-Rank) were possible.

Category	Scientific Name	Common Name	I-Rank	Source
Bird (3)	*Carpodacus mexicanus*	House Finch	Not Ranked	1
	Columba livia	Rock Pigeon	Not Ranked	1
	Sturnus vulgaris	European Starling	Not Ranked	1
Fish (2)	*Oncorhynchus mykiss*	rainbow trout	Not Ranked	5
	Lepomis auritus	redbreast sunfish	Not Ranked	2
Mollusks (1)	*Corbicula fluminea*	Asian clam	Not Ranked	3
Vascular Plants (95)	*Achillea millefolium*	common yarrow	Not ranked	4
	Ailanthus altissima	tree of heaven	Medium	4
	Albizia julibrissin	silktree	Medium/Low	4
	Alternanthera philoxeroides	alligatorweed	Medium	4
	Anthemis cotula	stinking chamomile	Medium/Insignificant	4
	Anthoxanthum odoratum	sweet vernalgrass	Not ranked	4
	Arabidopsis thaliana	mouseear cress	Not ranked	4
	Arenaria serpyllifolia	thymeleaf sandwort	Not ranked	4
	Arthraxon hispidus	small carpgrass	Medium/Low	4
	Barbarea verna	early yellowrocket	Not ranked	4
	Bromus tectorum	cheatgrass	High	4
	Calystegia sepium	hedge false bindweed	Not ranked	4
	Capsella bursa-pastoris	shepherd's purse	Insignificant	4
	Cardamine hirsuta	hairy bittercress	Not ranked	4
	Cerastium glomeratum	sticky chickweed	Not ranked	4
	Cerastium semidecandrum	fivestamen chickweed	Not ranked	4
	Chenopodium album	lambsquarters	Not ranked	4
	Cirsium vulgare	bull thistle	Medium/Low	4
	Commelina communis	Asiatic dayflower	Not ranked	4
	Consolida ajacis	doubtful knight's-spur	Not ranked	4
	Crotalaria spectabilis	showy rattlebox	Not ranked	4

Table 29. Non-native species, occurring in Little River Canyon National Preserve, with an Invasive Species Impact Rank (I-Rank) were possible (continued).

Category	Scientific Name	Common Name	I-Rank	Source
Vascular Plants (95)	*Cruciata pedemontana*	piedmont bedstraw	Not ranked	4
	Cynodon dactylon	Bermudagrass	Medium/Low	4
	Cyperus iria	ricefield flatsedge	Not ranked	4
	Dactylis glomerata ssp. glomerata	orchardgrass	Not ranked	4
	Daucus carota	Queen Anne's lace	Low	4
	Digitaria ischaemum	smooth crabgrass	Not ranked	4
	Digitaria violascens	violet crabgrass	Not ranked	4
	Dioscorea oppositifolia	Chinese yam	High/Low	4
	Draba verna	spring draba	Low/Insignificant	4
	Duchesnea indica	Indian strawberry	Low/Insignificant	4
	Echinochloa crus-galli	barnyardgrass	Medium/Insignificant	4
	Erodium cicutarium	redstem stork's bill	Medium/Low	4
	Hedera helix	English ivy	High/Medium	4
	Heliotropium indicum	Indian heliotrope	Not ranked	4
	Holcus lanatus	common velvetgrass	High/Medium	4
	Ipomoea coccinea	redstar	Not ranked	4
	Ipomoea hederacea	ivyleaf morning-glory	Not ranked	4
	Ipomoea purpurea	Tall morning-glory	Medium/Low	4
	Kummerowia striata	Japanese clover	Low	4
	Lactuca serriola	prickly lettuce	Low/Insignificant	4
	Lamium amplexicaule	henbit deadnettle	Not ranked	4
	Lamium purpureum var. purpureum	purple deadnettle	Not ranked	4
	Lathyrus hirsutus	Caley pea	Not ranked	4
	Lespedeza cuneata	Chinese lespedeza	Medium	4
	Leucanthemum vulgare	oxeye daisy	Medium/Low	4
	Ligustrum sinense	Chinese privet	High/Medium	4
	Ligustrum vulgare	European privet	High/Medium	4
	Linaria vulgaris	butter and eggs	High/Low	4
	Lolium perenne	perennial ryegrass	Medium	4
	Lolium pratense	meadow ryegrass	High/Low	4
	Lonicera japonica	Japanese honeysuckle	High/Medium	4
	Malus pumila	paradise apple	Medium/Insignificant	4
	Medicago lupulina	black medick	Medium/Insignificant	4
	Medicago sativa ssp. sativa	alfalfa	Not ranked	4
	Melia azedarach	Chinaberry tree	Medium/Low	4
	Microstegium vimineum	Nepalese browntop	High/Medium	4
	Murdannia keisak	wartremoving herb	Medium/Low	4
	Muscari neglectum	starch grape hyacinth	Not ranked	4
	Nicandra physalodes	apple of Peru	Not ranked	4
	Paspalum dilatatum	dallisgrass	Not ranked	4
	Pennisetum glaucum	pearl millet	Not ranked	4
	Perilla frutescens var. frutescens	beefsteakplant	Not ranked	4
	Phyllostachys aurea	golden bamboo	Not ranked	4
	Plantago lanceolata	narrowleaf plantain	High/Low	4

Table 29. Non-native species, occurring in Little River Canyon National Preserve, with an Invasive Species Impact Rank (I-Rank) were possible (continued).

Category	Scientific Name	Common Name	I-Rank	Source
Vascular Plants (95)	*Polygonum aviculare*	prostrate knotweed	Low	4
	Prunus persica	peach	Insignificant	4
	Pueraria montana var. lobata	kudzu	Not ranked	4
	Pyrus communis	common pear	High/Low	4
	Ranunculus sardous	hairy buttercup	Not ranked	4
	Rosa multiflora	multiflora rose	Medium/Low	4
	Rubus bifrons	Himalayan berry	Not ranked	4
	Rumex acetosella	common sheep sorrel	Medium/Low	4
	Rumex crispus	curly dock	Not ranked	4
	Secale cereale	cereal rye	Not ranked	4
	Sedum sarmentosum	stringy stonecrop	Not ranked	4
	Sherardia arvensis	blue fieldmadder	Not ranked	4
	Sonchus asper	spiny sowthistle	Not ranked	4
	Sorghum halepense	Johnsongrass	High/Medium	4
	Stellaria media ssp. media	common chickweed	Not ranked	4
	Taraxacum officinale ssp. officinale	common dandelion	Not ranked	4
	Trifolium arvense	rabbitfoot clover	Low	4
	Trifolium campestre	field clover	Not ranked	4
	Trifolium dubium	suckling clover	Not ranked	4
	Trifolium incarnatum	crimson clover	Not ranked	4
	Trifolium pratense	Red clover	Low/Insignificant	4
	Trifolium repens	white clover	Medium/Low	4
	Verbascum thapsus	common mullein	Medium	4
	Verbena brasiliensis	Brazilian vervain	Not ranked	4
	Veronica arvensis	corn speedwell	Not ranked	4
	Veronica persica	birdeye speedwell	Not ranked	4
	Vicia grandiflora	large yellow vetch	Not ranked	4
	Vicia sativa ssp. nigra	garden vetch	Not ranked	4
	Vicia villosa ssp. varia	winter vetch	Not ranked	4
	Vinca major	bigleaf periwinkle	Not ranked	4
1 Stedman and Stedman, **2** Ballard and Pierson 1996, **3** Godwin and Shelton 1999, **4** Schotz *et al*. 2008, 5 Leifreid pers. com. 2011				

6.10 Forest Pests, Disease, and Trauma

In 2004, the USDA Forest Service established an early warning system for forest health threats in the United States in response to direction contained in Title VI of the Healthy Forests Restoration Act of 2003 (USDA Forest Service 2004). The Early Warning System is based upon four key steps necessary to detect and respond to environmental threats: 1) Identify Potential Threats; 2) Detect Actual Threats; 3) Assess Impacts; and 4) Respond. This report describes efforts and links that can be used to gather information on pests and construct management plans to respond to these threats.

The USDA Forest Service continues to monitor forest insect and disease conditions in the United States (USDA Forest Service 2007). A forest insect, the southern pine beetle (*Dendroctonus* *frontalis*), has been known to exist within the LIRI area. The activity of this insect has decreased in Alabama, from 4,444 spots detected in 2005 to approximately 1,100 spots detected in 2006. Dogwood anthracnose (*Discula destructive*), a fungus that causes serious losses to flowering dogwoods, continues to intensify within the generally infested area with eight counties being infected within Alabama in 2006. The two counties attributed to LIRI were among the eight counties infected.

Products are available to display hazard maps of selected forest pests including the southern pine beetle. Figure 35 displays a Southern Pine Beetle hazard classification map of LIRI with the area represented by each hazard classification and the percentage of each class.

Forest health information can be obtained through the USDA Forest Service, which conducts research through the Forest Inventory and Analysis (FIA) program. The Forest Health Protection (FHP) produces products such as Insect and Disease Risk Maps and Invasive Species Risk Maps. Other efforts of the FHP include Forest Health Monitoring (FHM), Invasive Species Surveys, Native Pest Detection Surveys, Pest alerts, Damage and impact surveys, and Forest Health Specialist Reports. The North American Forestry Commission (NAFC) provides a North American Exotic Forest Pest Information System (EXFOR) that includes risk assessments regarding potential for pest establishment, spread, economic damage, and environmental damage, along with potential and probable pathways of introduction. The USDA Animal and Plant Health Inspection Service (APHIS) maintains the National Agricultural Pest Information System (NAPIS), which is part of the Cooperative Agricultural Pest Survey (CAPS) program. NAPIS manages plant pest data gathered on a national, regional, and/or state scale. APHIS also facilitates Pest Risk Assessments (PRAs), which evaluate the likelihood that specific invasive organisms may be introduced and established in new forest ecosystems along with the environmental consequences. The USDA Cooperative State Research, Education, and Extension Service (CSREES) inform the public about pest alerts for invasive species in regional, state, and local areas. The Alabama forestry commission also contains information about forest health.

6.11 Summary and Discussion

Table 30 shows a summary of the current extent of the problem and current knowledge base concerning threats, stressors, and disturbances at LIRI. ATV use is an existing problem at LIRI for degradation of land and biota and pose a potential problem for water quality through increased erosion. When ATV users recreate beyond the designated roads and trails, they impact the environment that biota use for habitat as well as the biota itself. The lack of fire events has altered the historical vegetation attributes and current habitats for protected species. Fires can be both useful and detrimental to natural resources within the study area in that fire disturbance can reduce the available habitat for biota, but can also clear out undesirable biota needed to secure prime habitat conditions for specific species such as the Green Pitcher Plant. Fires also consume dead foliage that, if accumulated over a long period of time, can cause damaging fire events. Human development poses several potential threats to land and water resources within LIRI. Houses built along scenic views of the LIRI canyon have disrupted viewscapes. These houses are built on private property adjacent to the boundaries of LIRI; therefore, this stress to the scenic beauty is beyond the ability of the NPS to rectify. As more development occurs in an area, there will be greater potential for environmental impacts such as increased runoff through more impervious surfaces and potential leaking of contaminants through septic tanks and other human influenced spills. Silvicultural practices pose a potential problem to land and water resources in

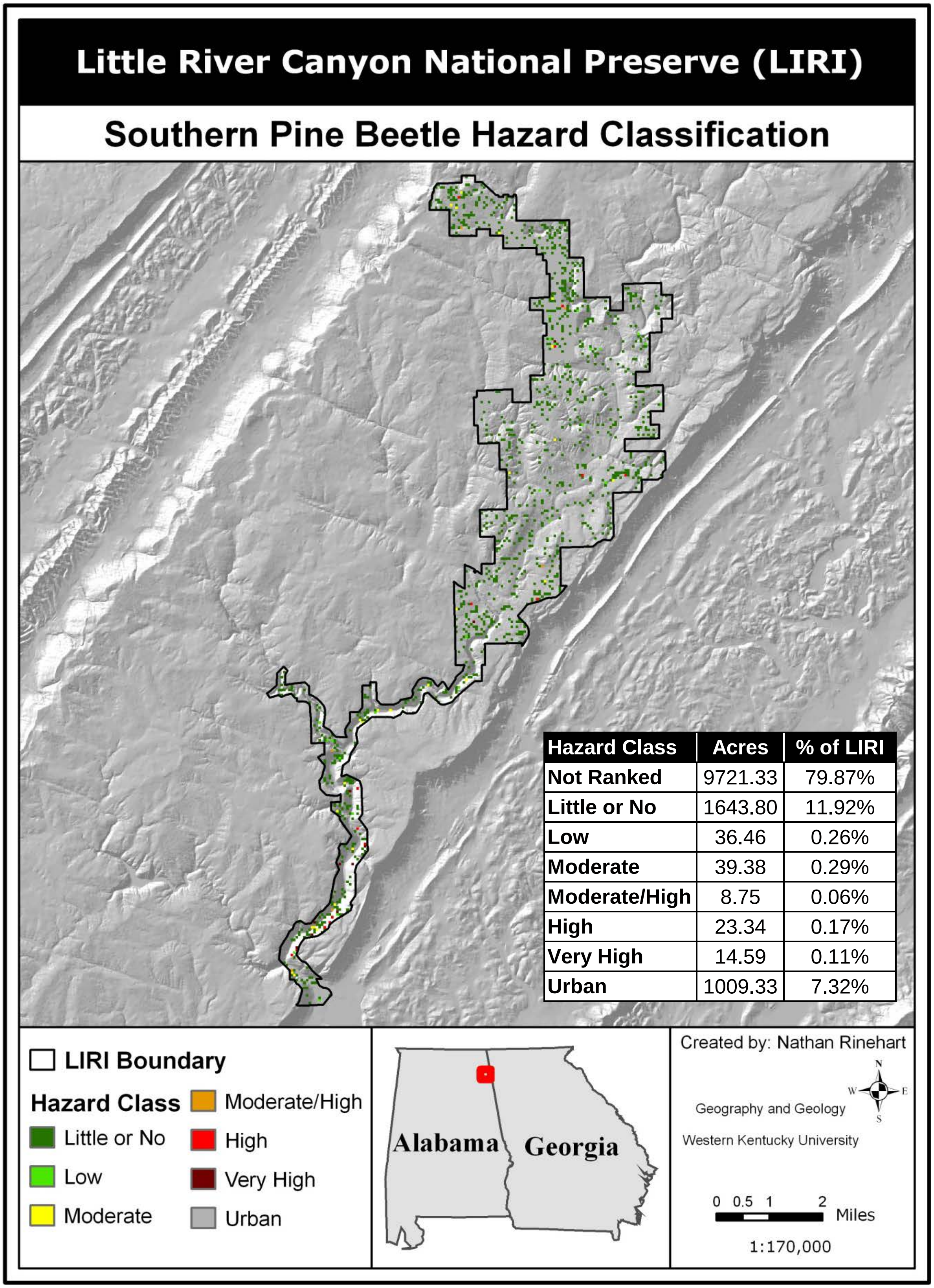


Figure 35. Southern pine beetle hazard classification with classification area and percent of Little River Canyon National Preserve area. Source: Author, (USDA Forest Service 2009).

that they may cause undesirable changes in land cover at clear-cut areas and cause erosion processes after clear-cutting that affect water quality in nearby water bodies. Mining activities potentially affect water, air, and biota resources in that these create contaminants that degrade water quality and affect the health of biota in streams. Poaching is a potential problem at LIRI, though the knowledge base is limited in this area. The Green Pitcher Plant and other desired herbaceous plants such as Ginseng are found within LIRI that are potential targets for poaching.

Table 30. Threat, stressor, disturbance matrix for Little River Canyon National Preserve. Source: Author.

Threat/Stressor/Disturbance	Land	Water	Biota	Air
All-Terrain Vehicle (ATV) use	EP	PP	EP	Unk
Fires	EP	Unk	EP	Unk
Population and Viewscape	EP	PP	Unk	Unk
Silvicultural practices	PP	PP	Unk	Unk
Mining activities	Unk	PP	PP	Unk
Poaching	Unk	Unk	PP	NA
E. coli contaminants	Unk	EP	PP	NA
Degradation of dams	PP	PP	PP	NA
Impervious surface	OK	PP	PP	NA
Exotic Species	EP	EP	EP	NA
Forest Pests	EP	Unk	EP	NA

Extent of problem: OK = OK, EP = Existing problem, PP = Potential problem, Unk = Unknown, NA = Not Applicable
Knowledge base: Light blue = Good, Pink = Fair, Grey = Poor

Pathogenic bacteria such as *E. coli* have been found to exceed established state/federal parameter limits for Little River's water use classification. Among the possible effects, high bacteria values may increase production of algae affecting growing rates of Kral's water plantain and Harperella, both being threatened or endangered species found within LIRI. Dams present potential effects to land, water, and biota resources in that they can deteriorate and fail. Dam failures can result in extensive flooding, can destroy riparian habitat and species adjacent to streams, and endanger human life. Exotic species can lower native species populations, change land cover and vegetation patterns, and disrupt the life cycles of aquatic species. As mentioned before, not all exotic species have highly negative impacts to their environments, but the ones that do would be species of management concern. Forest pests can damage or kill large areas of forest, thus changing the habitat for species. Land cover change may occur during this transition of forest.

7 - Summary, Conclusions, and Recommendations

7.1 Summary

Information gained through the compilation and analysis of data in this study will help National Park Service (NPS) personnel better understand the significance, condition, and challenges associated with Park-managed water resources at Little River Canyon National Preserve (LIRI). The five objectives identified for this study in Chapter 1 were accomplished for the selected resources at LIRI.

Objective one, to identify Park natural resources of interest and related issues, was accomplished through a list compilation from the Cumberland Piedmont Network (CUPN) Vital Signs Monitoring Plan (VSMP) (Leibfreid *et al*. 2005), assistance from the NPS pilot program team, and NPS personnel at LIRI. These resources and related issues were then incorporated into an assessment framework developed by adapting various components of published assessment approaches well established in the literature (Section 3, Table 3).

Objective two, to assemble existing data and Geographic Information Systems (GIS) layers pertaining to these resources, was accomplished by conducting a comprehensive literature search through the generation of key search terms and a search through several Internet, local/state/federal agency, and library databases. Searches yielded numeric and descriptive information. Descriptive information is provided in the "Park and Resources Context" sections (Section 2) of this document. Numeric information is presented in the data analysis portions of this document (Section 5).

Objective three, to evaluate the data for adequacy and to identify information gaps, was accomplished through compiling search results and examining the complete record for quantitative and qualitative content. Data were evaluated by best professional judgment on length of record, continuity of record, number of samples, spatial extent, and comparing results to other complete data and literature information. Temporal and spatial gaps within the data were identified together with instances where no data were available. Information gaps identified by this study are noted in Table 31.

Table 31. Information gaps identified for natural resources and related issues at Little River Canyon National Preserve. Source: Author.

Resource or Issue	Information Gap
Water Quality	Information on aquatic macroinvertebrates
Hydrology	Flood risk, risk and impacts of failure of degraded dams, updated inventory of dams, groundwater resource information
*Silvicultural Practices	Specific locations, management strategies, how adjacent silviculture affects the Park lands
*Mining Activities	Knowledge of the impacts to water quality and biota, effects of surface disturbances
Viewscape	Land parcel information, building permits
*Population Density	Census block demographic data for 1990 in 2000 geography
*Poaching	Possible locations, risk potential
Cliff Characteristics	Locations of concern, cliff species inventory, impacts from visitors on cliff faces and biota

Table 31. Information gaps indentified for natural resources and related issues at Little River Canyon National Preserve. Source: Author. (continued).

Resource or Issue	Information Gap
Vegetation Characteristics	Additional vegetation data layers for geospatial comparison and analysis
Soils	Erosion and sedimentation characteristics, soil quality
Geology	Detailed geologic map
*Extreme Disturbance Events	Records of geohazards, landslides, earthquakes, etc.
Visitor and Recreational Use	Visitor impacts
Air Quality	
Biota	Aquatic invertebrates inventory, mammals inventory, condition of At-risk biota,
*Issues include threats, stressors, and disturbances	

Objective four, to develop an approach for assessing natural resource conditions and assign a current resource status where possible, was accomplished at LIRI in cases where sufficient data were available or where federal or state determined reference conditions were already established. For resources with insufficient data or where no agreement among experts was established, no resource status condition was given. Table 3 provides the framework for assessment developed for this study. Methods for assigning a status condition for these category levels were established where possible. Air quality (Section 5.4) and water quality (Section 5.1) conditions were assessed using a knowledge-based modeling approach to compare the observed conditions to existing standards at the state or federal level. Each air and water quality parameter was given a condition status according to its percent attainment over the period of record (Table 19, Figure 16, and Table 28). In the case of land cover (Section 5.2), the assessment was based on human impacts by calculating the area of "Developed" land cover and percent impervious surfaces. A condition status of "Good" was given to these indicators as they represented a very small portion of the park. This assessment also calculated the percent change toward development between two time slices namely 1992 and 2001. It was not possible to place a condition status on this indicator. Little data were available for geology and soil characteristics at LIRI, but available information for these are discussed in Sections 2.2 and 2.4.2. No information for defining a condition status was available for geology or soils at LIRI. A condition status was given to biotic resources using condition statements from inventory reports or topic experts, presence of exotic species, and species observed compared to those likely occurring within LIRI. Information was identified for threats, stressors, and disturbances that could impact conditions for natural resources (Section 6). Best judgment was used to indicate the knowledge base and current extent of threats, stressors, and disturbances according to available data (Table 30).

Objective five, to provide appropriate products to assist in meeting Park management goals, was accomplished for the selected natural resources by creating numerous original maps, graphics, and descriptions that occur throughout this report.

7.2 Conclusions

General conclusions or "lessons learned" that were identified from this study include:

- The quality and quantity of existing data about natural resources of interest and related issues are variable. Data varied temporally and spatially, including length of record and continuity. Some data provided information over a lengthy period of time, but not over a sufficient spatial area. Other data provided information for many spatial locations, but only over a small period of time.

- Existing Inventory and Monitoring (I&M) Program data were critical for analysis of natural resources of interest and watershed characteristics. Monitoring programs developed by the NPS and implemented within the CUPN provide the 'backbone' for information at LIRI. Survey of the literature turned up relatively little additional data.
- Results from this study represent the first comprehensive look at natural resources at LIRI on both an extensive (broad) and intensive (deep) scale. This provides the NPS personnel an opportunity to use results from this study to examine existing protocols in regard to current and future stewardship efforts.
- Some existing and potential impacts on natural resources (e.g. adjacent land use change, adjacent viewscape degradation) from influences outside the Preserve may be addressed by cooperating with local governments and agency groups.

The data available on resources of interest in this study were limited partly because of the relatively recent establishment of LIRI in 1992 and the more recent establishment of the CUPN I&M Program and VSMP. As additional monitoring and contracted research are conducted within LIRI and adjacent areas, data can be added to the framework developed in this study for a more comprehensive condition assessment for resources and related issues.

The specific conclusions provided in Table 32 summarize the status of natural resource conditions and ratings for threats, stressors, and disturbances based on existing information from documentary sources and NPS commissioned studies. Items in Column 1 and Column 2 come from the USEPA-SAB framework and from the *NPS Ecological Monitoring Framework*. The "Selected Indicators" column represents items currently being monitored or that will be monitored through the I&M Program, those that have been identified as resources or issues of interest by NPS personnel, and those identified by the NPS NRCA team as significant for the assessment. The "Current Condition Status" column identifies resource conditions where available. The "Reference Condition" column indicates any existing state and federal standards, desired resource conditions, or criteria based on literature sources and judgment of third party experts. The "Comments" column indicates details supporting the current condition status of the resource indicator.

Table 32. Condition status summary of natural resources and related issues for Little River Canyon National Preserve. Source: Author.

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
WATER					
Hydrology	Surface Water Dynamics	Daily Mean Discharge	TBD	NA	DeSoto (1997-2007): 0.01-4120 cfs, Canyon Mouth(1958-2007): 0.20-27100 cfs
		Gage Height	TBD	NA	DeSoto: 1.08-12.04 in, Canyon Mouth: 1.38-12.73 in
Water Quality	Water Chemistry	Acid Neutralizing Capacity (ANC)		≥0 mg/L $CaCO_3$	100% ATN at 11 sample locations
		Dissolved Oxygen		AL: >5.5 mg/L, GA: >5.0 mg/L	87% ATN at 11 sample locations
		pH		6.0-8.5 SU	85% ATN at 11 sample locations
		Specific Conductance		>10 µS/cm	100% ATN at 11 sample locations
		Sulfate		<250mg/L as SO_4	100% ATN at 11 sample locations
	Nutrient Dynamics	Nitrate		<90 mg/L as N	100% ATN at 11 sample locations
		Phosphate		<0.05 mg/L as total P	100% ATN at 11 sample locations
	Physical Parameters	Temperature		<32.2 C	100% ATN at 11 sample locations
		Turbidity		<05 NTU over background	100% ATN at 11 sample locations
	Microorganisms	*E. Coli*		<298 CFU/100mL	91% ATN at 11 sample locations
LANDSCAPE					
Landscape Dynamics	Land Cover and Use	Land Cover Change		NA	<2% Developed
		Impervious Surface		<10% Imperviousness	0.11% of LIRI has impervious surfaces
		Landscape Pattern and Fragmentation	TBD	NA	29 NVCS associations, 1802 patches
		Silviculture Impacts	TBD	NA	Evidence of past clear-cut activities adjacent to the Preserve
		Mining Impacts	TBD	NA	Mines within the LIRI watershed: 14 abandoned, 6 active, and 4 of unknown type
Viewscape	Viewscape	View Obstructions		NA	Noticeable structures from view points along the canyon rim

Table 32. Condition status summary of natural resources and related issues for Little River Canyon National Preserve. Source: Author (continued).

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
GEOLOGY AND SOILS					
Soil Quality	Soil Function and Dynamics	Soil Type		NA	19 soil series types, mostly Hartsells and Rockland soil series, well-drained soils, high erosion hazard on steep slopes
THREATS, STRESSORS, AND DISTURBANCES					
Fire and Fuel Dynamics	Fire and Fuel Dynamics	Fire Location and Frequency, Fire Management Plan (FMP) Goals		NA	Adhering to FMP goals (reaction time and prescribed burns)
Invasive Species	Invasive/Exotic Plants	# Exotic Species		no exotics	95
		# Highly Ranked Species			6
	Invasive/Exotic Animals	# Exotic Species		no exotics	6
		# Highly Ranked Species			TBD
Infestation, Disease, and Trauma	Insect Pests	Southern Pine Beetle (SPB) Extent and Risk Factor		NA	SPB sittings decreasing in AL, 0.28% of LIRI considered High Hazard Class
	Plant Disease/Trauma	Risk Factor of Ozone Sensitive Plants	TBD	NA	Dogwood anthracnose (*Discula destructive*) intensifying in AL
Visitor and Recreation Use	Visitor Use	Population Density		NA	0-15 individuals per square mile
		ATV Use Trend (1991 to 2007)		NA	Nearly five-fold increase in ATV permits issued from 1998 to 2007 years. ATV use banned beginning September 2010.
		Rock Climbing Impact to Cliffs and Biota	TBD	NA	Information gap
		Impacts from Dams	TBD	NA	Limited dam safety regulations, 13 dams within LIRI watershed, evidence of structural damage to select dams
		Poaching Risk Factor	TBD	NA	Multiple poaching incidences including green pitcher plant, ginseng, and deer
BIOTA					
Flora					
Ecosystems and Communities	Community Extent	Floral Class Extent	TBD	NA	27 NVCS vegetation associations: 9 natural, 18 altered from natural state

Table 32. Condition status summary of natural resources and related issues for Little River Canyon National Preserve. Source: Author (continued).

LEVEL 1 CATEGORY Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
BIOTA					
Flora					
Ecosystems and Communities	Community Composition	Inventory of Species, Species Richness		NA	950 documented vascular plant species, 95 exotics, significant vegetation cover change in upstream sub-watersheds, several high quality wetlands
	Physical Structure	Successional State	TBD	NA	
Species and Populations	Population Size	Species of Concern Populations	TBD	NA	
	Habitat Suitability	Habitat Limitations	TBD	NA	Wetlands display relatively low ratings for provision of wildlife habitat and relatively moderate ratings for the support of wetland plants.
Fauna					
Ecosystems and Communities	Community Composition	Inventory of Species, Species Richness	TBD	NA	122 species aquatic insects, 147 species birds, 50 species fish, 74 species herps, 25 preliminary species mammals, 6 mollusks.
Species and Populations	Population Size	Species of Concern Populations	TBD	NA	
	Habitat Suitability	Habitat Limitations	TBD	NA	Possibly low habitat diversity for birds
Focal Species and Communities	Freshwater Invertebrates	Non-native Species, Species Richness		no exotics, detect at least 90% species	6 mollusk species, 1 exotic mollusk with high density in places and comprising 85% of specimens observed, low diversity and density, number of caddisfly species are similar to other drainage areas of similar size
	Birds	Non-native Species, Species Richness		no exotics, detect at least 90% species	147 species, 3 exotics, 90% species likely occurring not detected, rich species diversity but low species density, habitat limitations may affect species richness
	Herpetofauna	Non-native Species, Species Richness		no exotics, detect at least 90% species	74 documented species, no exotics, 90% species likely occurring detected
	Fishes	Non-native Species, Species Richness		no exotics, detect at least 90% species	50 documented species, 2 exotics,
	Mammals	Non-native Species, Species Richness	TBD	no exotics, detect at least 90% species	25 preliminary species, no exotics

Table 32. Condition status summary of natural resources and related issues for Little River Canyon National Preserve. Source: Author (continued).

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Current Condition Status	Reference Condition	Comments
BIOTA					
At-Risk-Biota	Threatened & Endangered (T&E) Species and Communities	Presence, Populations	TBD	NA	6 T&E species, 5 highly ranked NVCS associations
AIR AND CLIMATE					
Air Quality	Ozone	Ozone Concentration		<76 ppb	11% ATN
Air Quality	Wet and Dry Deposition	Total deposition of Sulfur		Class II: TBD Class I Parks: <0.010 kg/ha/yr	Class I: 0% ATN
Air Quality	Wet and Dry Deposition	Total deposition of Nitrogen		Class II: TBD Class I Parks: <0.010 kg/ha/yr	Class I: 0% ATN
Air Quality	Visibility and Particulate Matter	Fine Particulate Matter (PM2.5) Levels		<16.0 µg/m3	100% ATN
Air Quality	Visibility and Particulate Matter	Visibility in Deciviews (dv)		Class II: TBD Class I Parks: <15.6 (<8 dv above background)	Class I: 0% ATN
Air Quality	Air Contaminants	Mercury Levels	TBD	NA	NA
Air Quality	Air Contaminants	Acid Rain (pH) Impacts		Designated use waters: 6-8.5 SU	low pH values compared to WQ standard, but waters may be considered naturally low
Weather and Climate	Weather and Climate	Precipitation and Temperature Trends	TBD	NA	

NA = Not Available, TBD = To Be Determined, ATN = Attainment, Green = Good or Excellent (refer to text), Yellow = Caution, Red = Of Significant Concern.

7.3 Recommendations

Several future investigations can be undertaken as a result of the knowledge gained in this study. Plans and efforts can be made to fill the information gaps identified in Table 31 enabling the NPS resource managers to achieve a more comprehensive assessment of natural resources. NPS managers and technical personnel can utilize the results of this study to examine existing monitoring protocols as well as develop a 'desired future condition statement' for a resource of interest. Such statements can be incorporated into NPS planning and monitoring documents such as a General Management Plan (GMP) and Resource Stewardship Strategy (RSS) documents.

Existing recommendations from literature sources pertaining to selected natural resource categories at LIRI include the following:

1. Water Resources:
    - Maintain pristine surface waters that as a minimum meet the state or federal water quality standards.
    - Investigate locations of high land cover change and mining areas, to identify and isolate sources of contaminants concerning water quality.
    - Monitor flood events for their potential impacts to landscape and species of management concern.
2. Landscape Resources:
    - Review existing land development regulations and coordinate efforts to enforce the prevention/reduction of contaminants from roads and developing lands.
    - Investigate ways in which to expand the boundaries of LIRI, such as allowing viewscape buffers for the Little River Canyon bluffs and purchasing lands owned by The Nature Conservancy and The Conservation Fund.
    - Explore incentives for minimizing the amount of clearing and ground disturbance needed at development sites and promote low impact development options.
3. Geology and Soils:
    - Maintain climbing management plan efforts and more closely monitor for climbing violations.
    - Maintain natural soils classified by the USDA NRCS.
4. Biota
    - Ensure that state and federal listed threatened and endangered species and their habitats are protected and sustained.
    - Conduct an inventory of cliff species.
5. Air and Climate
    - Maintain current monitoring protocols.
6. Threats, Stressors, and Disturbances
    - Increase education and public awareness concerning wildlife poaching and more closely monitor for poaching violations.
    - Press the state to enact dam safety regulations and update the inventory of dams.
    - Ensure that exotic species are reduced in numbers and area, or eliminated.
    - More closely monitor for ATV violations and investigate the establishment of restrictions on the ATV use permits issued.

- Ensure the fire management procedures in the Preserve are in accordance with the Fire Management Plan
- Ensure that techniques such as prescribed burns are scheduled to maintain habitats for species of management concern.

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Appendixes

Appendix A. Prioritized natural resources and issues at Little River Canyon National Preserve. Source: Author, NPS LIRI personnel.

CATEGORY Sub-category	Indicator/Metric	Priority Rank (1=highest)
LAND CONDITION		
Land-use/Cover	Viewscape	1
	Change in Land Development 1992/2001(by sub-watershed)	2
	Silviculture	3
	Impervious Surface (by sub-watershed)	4
	Mining Activities (previous/current)	5
Soils	Soil Type	
Fire		
Human Activities	Change in Human Population Density (1990-2000)	1
	Swimming	3
	ATV Use	2
	Rock Climbing	4
	Visitors (traffic counters)	6
	Poaching	5
BIOTIC CONDITION		
Plants	Exotic (Non-Native) Plants (species diversity, proportion)	1
	Plant Diversity	4
	Plant Species of Concern (Endangered species)	2
	Vegetation Communities	3
	Ozone Sensitive Plants	5
Animals	Birds (species diversity)	2
	Fish	4
	Deer	6
	Forest Pests	5
	Herpetofauna (species diversity, population)	3
	Benthic Macro-invertebrates	1
WATER CONDITION		
Water Quality	Dissolved Oxygen	1
	Ph	6
	Temperature	7
	Turbidity	2
	E. Coli	3
	Total Fecal Coliform	5
	Enterococci	4
Water Quantity	Stream Flow/Volume (USGS gages)	
	Deterioration of Dams	
AIR CONDITION		
Weather		1
Ozone and Ozone Impact		2

Appendix B. NPS Ecological Monitoring Framework. Source: Extracted from NPS 2005e.

NPS Ecological Monitoring Framework

The NPS Ecological Monitoring Framework is a systems-based, hierarchical, organizational tool for promoting communication, collaboration, and coordination among parks, networks, programs, and agencies involved in ecological monitoring. Vital signs selected by parks and networks for monitoring are assigned to the Level 3 category that most closely pertains to that vital sign. For example, the vital sign "Shoreline Change" is assigned to the Level 3 category of "Coastal/oceanographic features and processes" within the Level 2 category of Geomorphology and Level 1 category of "Geology and Soils". The Level 1 categories will be used in a "Natural Resource Scorecard" to report on the condition of park resources. To promote collaboration among networks, a database has been developed using the framework to show which parks and networks will implement monitoring of vital signs within each Level 1, 2, and 3 category.

Ecological Monitoring Framework

Level 1 Category	Level 2 Category	Level 3 Category	Comments
Air and Climate	Air Quality	Ozone	
		Wet and Dry Deposition	
		Visibility and Particulate Matter	
		Air Contaminants	
	Weather and Climate	Weather and Climate	
Geology and Soils	Geomorphology	Windblown Features and Processes	
		Glacial Features and Processes	
		Hillslope Features and Processes	
		Coastal/Oceanographic Features and Processes	

Ecological Monitoring Framework			
Level 1 Category	**Level 2 Category**	**Level 3 Category**	**Comments**
Geology and Soils		Marine Features and Processes	
		Stream/River Channel Characteristics	
		Lake Features and Processes	
	Subsurface Geologic Processes	Geothermal Features and Processes	
		Cave/Karst Features and Processes	
		Volcanic Features and Processes	
		Seismic Activity	
	Soil Quality	Soil Function and Dynamics	
	Paleontology	Paleontology	
Water	Hydrology	Groundwater Dynamics	
		Surface Water Dynamics	
		Marine Hydrology	
	Water Quality	Water Chemistry	
		Nutrient Dynamics	
		Toxics	
		Microorganisms	
		Aquatic Macroinvertebrates and Algae	
Biological Integrity	Invasive Species	Invasive/Exotic Plants	
		Invasive/Exotic Animals	
	Infestations and Disease	Insect Pests	
		Plant Diseases	
		Animal Diseases	
	Focal Species or Communities	Marine Communities	Includes coral communities
		Intertidal Communities	
		Estuarine Communities	
		Wetland Communities	Marshes, swamps, bogs
		Riparian Communities	

Ecological Monitoring Framework			
Level 1 Category	**Level 2 Category**	**Level 3 Category**	**Comments**
Biological Integrity	Focal Species or Communities	Freshwater Communities	Standing water (inland ponds and lakes) and flowing water (rivers and streams); emphasis on aquatic biota
		Sparsely Vegetated Communities	
		Cave Communities	Cave flora and fauna. Physical and chemical features and processes should go under Caves/Karst Features and Processes
		Desert Communities	
		Grassland/Herbaceous Communities	Includes tundra and alpine meadows, lichens, fungi
		Shrubland Communities	
		Forest/Woodland Communities	
		Marine Invertebrates	
		Freshwater Invertebrates	
		Terrestrial Invertebrates	
		Fishes	
		Amphibians and Reptiles	
		Birds	
		Mammals	
		Vegetation Complex (use sparingly)	Catch-all category to be used in rare cases where no other community type can be used.
		Terrestrial Complex (use sparingly)	Catch-all category to be used in rare cases where no other category can be used.
	At-risk Biota	T&E Species and Communities	
Human Use	Point Source Human Effects	Point Source Human Effects	
Human Use	Non-point Source Human Effects	Non-point Source Human Effects	
	Consumptive Use	Consumptive Use	
	Visitor and Recreation Use	Visitor Use	

Ecological Monitoring Framework

Level 1 Category	Level 2 Category	Level 3 Category	Comments
	Cultural Landscapes	Cultural Landscapes	
Landscapes (Ecosystem Pattern and Processes)	Fire and Fuel Dynamics	Fire and Fuel Dynamics	
	Landscape Dynamics	Land Cover and Use	Includes landscape pattern, fragmentation
	Extreme Disturbance Events	Extreme Disturbance Events	Records of floods, windthrow, ice storms, hurricanes, etc., which might also be placed in Climate category.
	Soundscape	Soundscape	
	Viewscape	Viewscape/Dark Night Sky	
	Nutrient Dynamics	Nutrient Dynamics	
	Energy Flow	Primary Production	

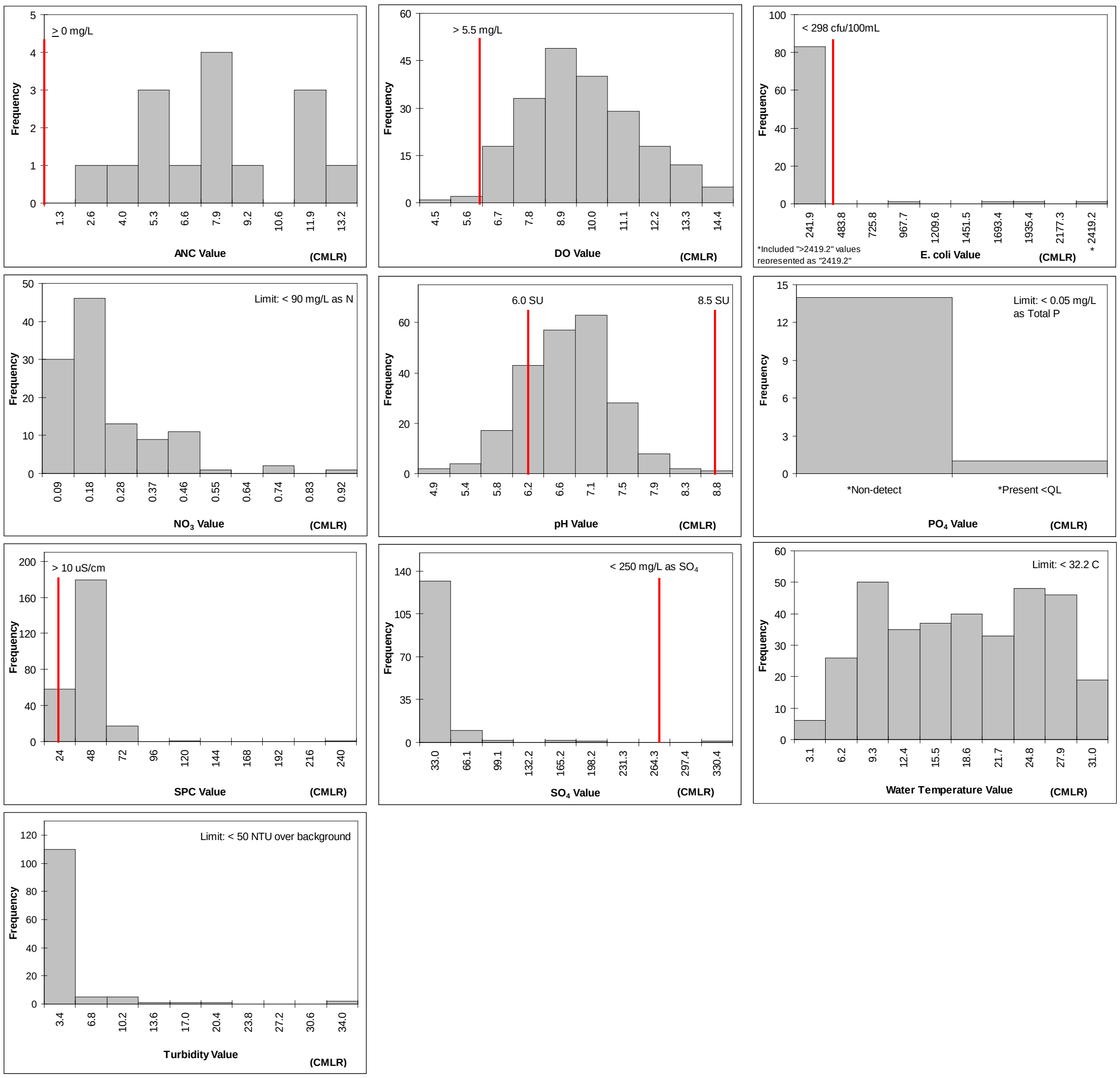
Key Sources consulted during development of the framework: National Vegetation Classification system; Parks Canada Ecological Integrity Monitoring Framework; H. John Heinz III Center for Science, Economics and the Environment. 2002. The State of the Nation's Ecosystems. Cambridge University Press; M. A. Harwell *et al.* 1999. A framework for an ecosystem integrity report card. BioScience 49(7):543-556; Noss, R. F. 1990. Indicators for Monitoring Biodiversity. A Hierarchical Approach. Conservation Biology 4:355-363; Cowardin Wetland Classification System; EPA Framework for Assessing and Reporting on Ecological Condition; European EUNIS Habitat Classification System.

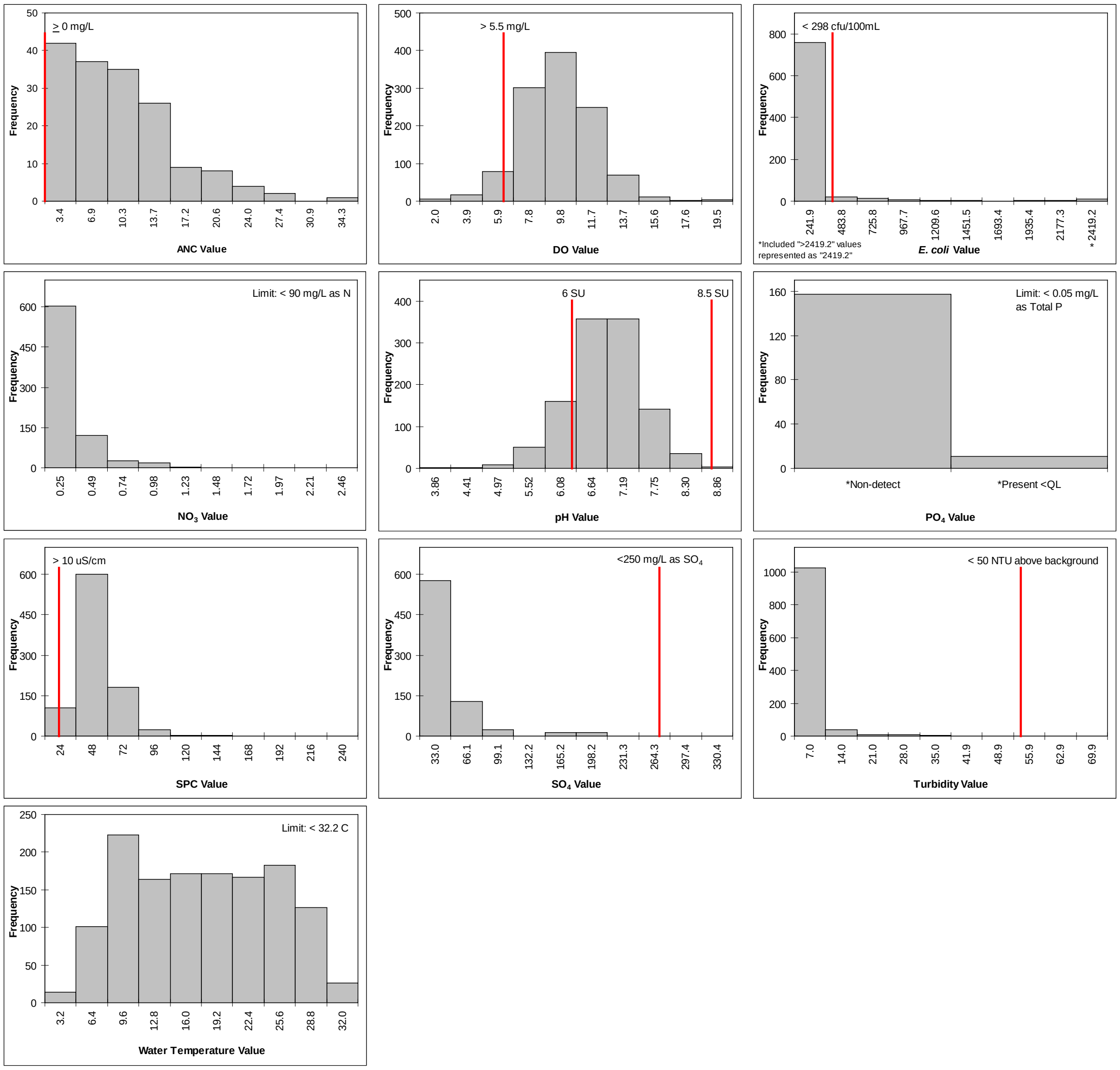
Appendix C. Summary of Essential Ecological Attribute (EEA) categories and subcategories, with example indicators and measures. Source: Extracted from (USEPA SAB 2002).

LANDSCAPE CONDITION		
Category	Subcategory	Example Indicators and Measures
Extent of Each Ecological System/Habitat Type		e.g., area; perimeter-to-area ratio; core area; elongation
Landscape Composition		e.g., number of habitat types; number of patches of each habitat; size of large patch; presence/absence of native plant communities; measures of topographic relief, slope, and aspect
Landscape Pattern/Structure		e.g., dominance; contagion; fractal dimension; distance between patches; longitudinal and lateral connectivity; juxtaposition of patch types or serial stages; width of habitat adjacent to wetlands
BIOTIC CONDITION		
Ecosystems and Communities	Community Extent	e.g., extent of native ecological communities; extent of successional states
	Community Composition	e.g., species inventory; total species diversity; native species diversity; relative abundance of species; % non-native species; presence/abundance of focal or special interest species (e.g., commonness/rarity); species/taxa richness; number of species in a taxonomic group (e.g., fishes); evenness/dominance across species or taxa
	Trophic Structure	e.g., food web complexity; presence/absence of top predators or dominant herbivores; functional feeding groups or guilds
	Community Dynamics	e.g., predation rate; succession; pollination rate; herbivory; seed dispersal
	Physical Structure	e.g., vertical stand structure (stratification or layering in forest communities); tree canopy height; presence of snags in forest systems; life form composition of plant communities; successional state
Species and Populations	Population Size	e.g., number of individuals in the population; size of breeding population; population distribution; number of individuals per habitat area (density)
	Genetic Diversity	e.g., degree of heterozygosity within a population; presence of specific genetic stocks within or among populations
	Population Structure	e.g., population age structure
	Population Dynamics	e.g., birth and death rates; reproductive or recruitment rates; dispersal and other movements
	Habitat Suitability (Focal Species)	measures of habitat attributes important to focal species
Organism Condition	Physiological Status	e.g., glycogen stores and blood chemistry for animals; carbohydrate stores, nutrients, and polyamines for plants; hormone levels; enzyme levels
	Symptoms of Disease or Trauma	e.g., gross morphology (size, weight, limb structure); behavior and responsiveness; sores, lesions and tumors; defoliation
	Signs of Disease	e.g., presence of parasites or pathogens (e.g., nematodes in fish); tissue burdens of xenobiotic chemicals
CHEMICAL AND PHYSICAL CHARACTERISTICS (WATER, AIR, SOIL, SEDIMENT)		
Nutrient Concentrations	Nitrogen	e.g., concentrations of total N; NH_4, NO_3; organic N, NOx; C/N ratio for forest floor
	Phosphorus	e.g., concentrations of total P; ortho-P; particulate P; organic P
	Other Nutrients	e.g., concentrations of calcium, potassium, and silicon
Trace Inorganic and Organic Chemicals	Metals	e.g., copper and zinc in sediments and suspended particulates
	Other Trace Elements	e.g., concentrations of selenium in waters, soils, and sediments
	Organic Compounds	e.g., methylmercury, selenomethionine
Other Chemical Parameters	pH	e.g., pH in surface waters and soil
	Dissolved Oxygen/ Redox Potential	e.g., dissolved oxygen in streams; soil redox potential
	Salinity	e.g., conductivity
	Organic Matter	e.g., soil organic matter; pore water organic matter concentrations
	Other	e.g., buffering capacity; cation exchange capacity
Physical Parameters	Soil/Sediment	e.g., temperature; texture; porosity; soil bulk density; profile morphology; mineralogy; water retention
	Air/Water	e.g., temperature; wind velocity; relative humidity; UV-B PAR; concentrations of particulates; turbidity

ECOLOGICAL PROCESSES		
Energy Flow	Primary Production	e.g., production capacity (total chlorophyll per unit area); net primary production (plant production per unit area per year); tree growth or crop production (terrestrial systems); trophic status (lakes); 14-CO_2 fixation rate (aquatic systems)
	Net Ecosystem Production	e.g., net ecosystem organic carbon storage (forests); diel changes in O_2 and CO_2 fluxes (aquatic systems); CO_2 flux from all ecosystems
	Growth Efficiency	e.g., comparison of primary production with net ecosystem production; transfer of carbon through the food web
Material Flow	Organic Carbon Cycling	e.g., input/output budgets (source identification-stable C isotopes); internal cycling measures (food web structure; rate and efficiency of microbial decomposition; carbon storage); organic matter quality and character
	N and P Cycling	e.g., input/output budgets (source identification, landscape runoff or yield); internal recycling (N_2-fixation capacity; soil/sediment nutrient assimilation capacity; identification of growth-limiting factors; identification of dominant pathways)
	Other Nutrient Cycling (e.g., K, S, Si, Fe)	e.g., input/output budgets (source identification, landscape yield); internal recycling (identification of growth-limiting factors; storage capacity; identification of key microbial terminal electron acceptors)
HYDROLOGY AND GEOMORPHOLOGY		
Surface and Groundwater Flows	Pattern of Surface Flows (rivers, lakes, wetlands, and estuaries)	e.g., flow magnitude and variability, including frequency, duration, timing, and rate of change; water level fluctuations in wetlands and lakes
	Hydrodynamics	e.g., water movement; vertical and horizontal mixing; stratification; hydraulic residence time; replacement time
	Pattern of Groundwater Flows	e.g., groundwater accretion to surface waters; within-groundwater flow rates and direction; net recharge or withdrawals; depth to groundwater
	Spatial and Temporal Salinity Patterns (estuaries and wetlands)	e.g., horizontal (surface) salinity gradients; depth of pycnocline; salt wedge
	Water Storage	e.g., water level fluctuations for lakes and wetlands; aquifer capacity
Dynamic Structural Characteristics	Channel Morphology; Shoreline Characteristics; Channel Complexity	e.g., mean width of meander corridor or alternative measure of the length of river allowed to migrate; stream braidedness; presence of off-channel pools (rivers); linear distance of marsh channels per unit marsh area; lithology; length of natural shoreline
	Distribution and Extent of Connected Floodplain (rivers)	e.g., distribution of plants that are tolerant to flooding; presence of floodplain spawning fish; area flooded by 2-year and 10-year floods
	Aquatic Physical Habitat Complexity	e.g., pool-to-riffle ratio (rivers); aquatic shaded riparian habitat (rivers and lakes); presence of large woody debris (rivers and lakes)
Sediment and Material Transport	Sediment Supply and Movement	e.g., sediment deposition, sediment residence time and flushing
	Particle Size Distribution Patterns	e.g., distribution patterns of different grain/particle sizes in aquatic or coastal environments
	Other Material Flux	e.g., transport of large woody debris in rivers
NATURAL DISTURBANCE REGIMES		
Example 1: Fire Regime in a forest	Frequency	e.g., recurrence interval for fires
	Intensity	e.g., occurrence of low intensity (forest litter fire) to high intensity (crown fire) fires
	Extent	e.g., spatial extent in hectares
	Duration	e.g., length of fire events (from hours to weeks)
Example 2: Flood Regime	Frequency	e.g., recurrence interval of extreme flood events
	Intensity	e.g., number of standard deviations from 30-year mean
	Extent	e.g., number of stream orders (and largest order) affected
	Duration	e.g., number of days, percent of water year (October 1- September 30)
Example 3: Insect Infestation	Frequency	e.g., recurrence interval for insect infestation outbreaks
	Intensity	e.g., density (number per area) of insect pests in an area
	Extent	e.g., spatial extent of infested area
	Duration	e.g., length of infestation outbreak

Appendix D. Histograms for the ten water quality parameters at Canyon Mouth (CMLR) sample location and charts for the ten parameters from the accumulation of all sample location values.




≥ 0 mg/L
Frequency
ANC Value
> 5.5 mg/L
DO Value
< 298 cfu/100mL
*Included ">2419.2" values represented as "2419.2"
E. coli Value
Limit: < 90 mg/L as N
NO_3 Value
6 SU
8.5 SU
pH Value
Limit: < 0.05 mg/L as Total P
*Non-detect
*Present <QL
PO_4 Value
> 10 uS/cm
SPC Value
<250 mg/L as SO_4
SO_4 Value
< 50 NTU above background
Turbidity Value
Limit: < 32.2 C
Water Temperature Value

Appendix E. Water quality summary tables for the eleven sub-watersheds in the Little River Canyon National Preserve watershed.

Parameter (BHLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	0	5.1	12.8	5.37	4.57	100%
DO_2 (mg/L)	15	6.76	8.98	11.76	8.97	1.51	100%
E. coli (CFU/100mL)	15	1	8.5	461.1	72.41	158.30	87%
NO_3 (mg/L as N)	15	*Non-detect	0.2	0.4	0.21	0.11	100%
pH (SU)	15	4.35	6.55	7.21	6.19	0.91	73%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	15	18.86	33.8	58.3	34.77	10.50	100%
SO_4 (mg/L as SO_4)	15	1	6	12	5.98	3.32	100%
Turbidity (NTU)	15	0.72	1.05	40.4	3.90	10.13	100%
Water Temp. (^oC)	15	5.9	13.3	29.2	16.15	7.45	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (CMLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	2.10	7.20	13.20	7.18	3.40	100%
DO_2 (mg/L)	207	3.40	8.96	14.40	9.23	1.98	99%
E. coli (CFU/100mL)	92	*Present <QL	8.45	>2419.2	74.21	261.09	96%
NO_3 (mg/L as N)	123	*Non-detect	0.13	0.92	0.18	0.15	100%
pH (SU)	225	4.50	6.58	8.77	6.53	0.59	84%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	256	1.00	32.00	240.00	33.75	16.92	100%
SO_4 (mg/L as SO_4)	148	0.84	7.00	330.41	18.75	35.89	99%
Turbidity (NTU)	125	0.34	1.21	33.96	2.52	4.70	100%
Water Temp. (^oC)	343	1.00	16.70	31.00	16.57	7.59	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (DFLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	14	0.2	4.45	11.1	5.31	3.33	100%
DO_2 (mg/L)	118	2.7	8.4	18.7	8.42	2.41	89%
E. coli (CFU/100mL)	92	*Present <QL	9.8	1986.28	86.80	280.88	96%
NO_3 (mg/L as N)	96	*Non-detect	0.08	0.4	0.12	0.10	100%
pH (SU)	113	4.67	6.6	8.01	6.51	0.63	80%
PO4 (mg/L as P)	14	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	67	17.49	28.3	122.2	30.97	12.81	100%
SO_4 (mg/L as SO_4)	70	0.2	22.25	198.08	24.82	31.21	100%
Turbidity (NTU)	123	0.66	1.98	15.56	2.91	2.61	100%
Water Temp. (^oC)	125	3.1	16.6	31.3	16.91	7.35	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (DSLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	0.1	7.2	17.8	7.17	5.38	100%
DO_2 (mg/L)	122	4	8.88	15.18	8.76	1.97	96%
E. coli (CFU/100mL)	91	*Present <QL	8.4	1299.65	55.10	157.27	96%
NO_3 (mg/L as N)	99	*Non-detect	0.11	0.78	0.14	0.12	100%
pH (SU)	115	5.24	6.63	7.86	6.58	0.60	81%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	68	16.81	29.4	75.3	31.86	9.62	100%
SO_4 (mg/L as SO_4)	68	0.36	18.35	188.36	30.66	44.14	100%
Turbidity (NTU)	125	0.36	1.08	21.08	1.95	3.05	100%
Water Temp. (^oC)	130	3.3	16.2	29.8	16.01	6.95	100%

^Values representing “*Non-detect”, “*Present < QL”, and “>2419.2” were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (EFLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	1.2	4.5	20.7	7.77	6.52	100%
DO_2 (mg/L)	83	2.4	8.6	17.21	8.64	2.28	93%
E. coli (CFU/100mL)	78	*Present <QL	21.6	1986.28	89.53	250.90	94%
NO_3 (mg/L as N)	50	*Non-detect	0.08	0.5	0.12	0.11	100%
pH (SU)	80	5.3	6.665	8.24	6.81	0.63	94%
PO4 (mg/L as P)	17	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	77	19.27	41.6	173.2	48.30	21.62	100%
SO_4 (mg/L as SO_4)	64	0.56	27.36	158.68	28.14	25.89	100%
Turbidity (NTU)	78	0.42	0.945	69.9	2.32	7.89	99%
Water Temp. (^oC)	89	2.7	15.6	28.2	15.21	6.39	100%

^Values representing “*Non-detect”, “*Present < QL”, and “>2419.2” were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (EPLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	2.2	6.5	13.6	7.11	3.53	100%
DO_2 (mg/L)	115	2.3	8.6	14.7	8.60	2.16	92%
E. coli (CFU/100mL)	89	*Present <QL	12.1	>2419.2	99.66	290.53	90%
NO_3 (mg/L as N)	95	*Non-detect	0.115	0.84	0.17	0.17	100%
pH (SU)	111	4.77	6.36	8.86	6.43	0.66	75%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	68	12.5	40.45	118	40.67	13.06	100%
SO_4 (mg/L as SO_4)	67	0.36	25	198.24	28.49	34.06	100%
Turbidity (NTU)	122	0.26	0.98	18.5	1.98	3.09	100%
Water Temp. (^oC)	121	3	16	30.1	16.05	7.17	100%

^Values representing “*Non-detect”, “*Present < QL”, and “>2419.2” were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (HBLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	1.4	5.9	17.7	7.16	5.05	100%
DO_2 (mg/L)	127	4	8.7	13.1	8.82	1.87	97%
E. coli (CFU/100mL)	93	*Present <QL	8.6	1413.6	67.99	208.94	96%
NO_3 (mg/L as N)	99	*Non-detect	0.08	1	0.11	0.14	100%
pH (SU)	124	3.3	6.63	7.96	6.52	0.70	85%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	69	11.2	34.4	57	35.54	9.36	100%
SO_4 (mg/L as SO_4)	71	0.48	25.61	147.88	27.38	26.23	100%
Turbidity (NTU)	125	0.27	1.1	25.9	2.11	3.60	100%
Water Temp. (^oC)	131	2	16.6	31.7	16.81	7.66	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (JCJC)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	4	12.3	34.3	14.84	8.50	100%
DO_2 (mg/L)	106	3.9	8.8	14	9.00	1.98	96%
E. coli (CFU/100mL)	93	*Present <QL	18.5	>2419.2	81.33	196.31	91%
NO_3 (mg/L as N)	93	*Non-detect	0.305	2.46	0.35	0.36	100%
pH (SU)	102	5.07	6.65	8.14	6.68	0.50	95%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	81	16	47.3	85.7	48.65	16.76	100%
SO_4 (mg/L as SO_4)	71	0.68	20.5	177.12	29.21	40.72	100%
Turbidity (NTU)	104	0.44	1.48	40.7	3.06	5.25	100%
Water Temp. (^oC)	111	3.5	15.4	27.5	15.81	6.83	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (LCLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	1.2	5.5	23.8	7.69	6.24	100%
DO_2 (mg/L)	87	1.7	8.4	18.7	8.48	2.44	89%
E. coli (CFU/100mL)	93	*Present <QL	9.1	>2419.2	81.70	291.79	95%
NO_3 (mg/L as N)	90	*Non-detect	0.07	0.9	0.13	0.14	100%
pH (SU)	85	5.03	6.75	8.71	6.80	0.65	89%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	68	18.44	45.35	71.6	46.09	12.23	100%
SO_4 (mg/L as SO_4)	68	*Non-detect	28.4	190.12	35.41	38.40	100%
Turbidity (NTU)	118	0.08	2.125	28.1	3.38	4.14	100%
Water Temp. (^oC)	117	2.8	15.7	29	15.95	6.84	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (MFLR)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	0.8	5.5	17.6	7.05	5.38	100%
DO_2 (mg/L)	83	1.2	7.7	19.5	7.90	2.57	84%
E. coli (CFU/100mL)	81	*Present <QL	16	2419.17	105.72	316.95	91%
NO_3 (mg/L as N)	50	*Non-detect	0.075	0.6	0.11	0.12	100%
pH (SU)	81	4.9	6.65	8.24	6.68	0.73	80%
PO4 (mg/L as P)	17	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	80	15	43.9	130	46.91	17.76	100%
SO_4 (mg/L as SO_4)	66	*Non-detect	31.62	167.6	31.23	28.79	100%
Turbidity (NTU)	79	0.49	1.8	55.1	2.89	6.20	99%
Water Temp. (^oC)	90	3	16	30.7	15.89	6.87	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

Parameter (YCYC)	Count	Min	^Median	Max	^Mean	^Std Dev	% ATN
ANC (mg/L)	15	4.8	9.8	21.5	11.13	5.59	100%
DO_2 (mg/L)	70	0	7.85	17.82	7.62	3.04	81%
E. coli (CFU/100mL)	77	*Present <QL	39.9	2419.17	187.95	415.41	86%
NO_3 (mg/L as N)	49	*Non-detect	0.245	0.96	0.32	0.27	100%
pH (SU)	66	5.13	6.64	8.14	6.76	0.54	94%
PO4 (mg/L as P)	15	*Non-detect	--	*Present <QL	--	--	100%
SpC (µS/cm)	66	29	51.95	82.9	54.49	11.63	100%
SO_4 (mg/L as SO_4)	52	2	28.55	161.96	33.09	31.15	100%
Turbidity (NTU)	75	0.62	2.71	45.8	3.97	5.71	100%
Water Temp. (^oC)	74	3.3	15.2	32	15.63	7.10	100%

^Values representing "*Non-detect", "*Present < QL", and ">2419.2" were not included in calculations.
Green = Excellent, Light Green = Good, Yellow = Fair, Red = Poor.

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