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Watershed Condition Assessment for Little River Canyon National Preserve, Alabama

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WATERSHED CONDITION ASSESSMENT FOR LITTLE RIVER CANYON NATIONAL PRESERVE, ALABAMA

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Nathan DeMille Rinehart

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WATERSHED CONDITION ASSESSMENT FOR LITTLE RIVER CANYON NATIONAL PRESERVE, ALABAMA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

WATERSHED CONDITION ASSESSMENT FOR LITTLE RIVER CANYON
NATIONAL PRESERVE, ALABAMA

Nathan Rinehart December 2008 154 Pages

Directed by: Drs. Kenneth W. Kuehn (Advisor), John All, Jun Yan, and Fred Siewers

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A pilot program titled "Assessment of Natural Resources and Watershed Conditions for Selected Parks of the Cumberland Piedmont Network" was implemented by the National Park Service (NPS) in 2006 and is designed to help understand and report on the significance, condition, and challenges associated with park-managed watershed resources. This study provides information for a portion of the NPS pilot program, with Little River Canyon National Preserve (LIRI) as the study area from within the Cumberland Piedmont Network (CUPN) of parks.

The objectives for this study are to: 1) identify natural resources of interest and related issues at LIRI; 2) assemble existing data and Geographic Information Systems (GIS) layers pertaining to these resources; 3) evaluate the data for adequacy and identify information gaps; 4) develop an approach for assessing natural resource conditions and assign a current resource status where possible; and 5) provide appropriate products to assist in meeting management goals at LIRI. This study will assess the condition of selected abiotic watershed characteristics including water resources, landscape characteristics, geology, and soil characteristics as well as identify and discuss potential threats, stressors, and disturbances to the natural resources at LIRI.

Natural resources of interest and related issues were identified and then incorporated into an assessment framework developed by adapting various components

of published assessment approaches well established in the literature. A search through several Internet, local/state/federal agency, and library databases yielded numeric and descriptive information. Temporal and spatial gaps within the data were identified together with instances where no data were available. Methods for assessing current resource conditions involved comparing existing data, where available, to state and federal standards, quantifying variations from a defined reference condition, or defining reasonable criteria from literature sources and expert judgment. Water quality conditions were assessed using a knowledge-based modeling approach to compare the observed conditions to existing standards at the state or federal level, and given a condition rank according to percent attainment over the period of record. Land cover was assessed based on calculating the percent change toward development between two time slices namely 1992 and 2001. Best judgment was used to indicate the knowledge base and current extent of threats, stressors, and disturbances according to available data.

The quality and quantity of existing data about natural resources of interest and related issues were variable temporally and spatially, including length of record and continuity. This study summarizes the status of natural resource conditions, watershed characteristics, and ratings for threats, stressors, and disturbances where possible based on existing information from documentary sources and NPS commissioned studies. This study recognizes several future investigations that can be undertaken as a result of the knowledge gained herein.

CHAPTER 1. INTRODUCTION AND OBJECTIVES

According to its establishment document, the general purpose of the National Park Service (NPS) is to,

> conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations. (United States Code 1916)

Throughout its history, the NPS has made substantial efforts to protect our nation's natural, historical, and cultural heritage. In recent years, it has become increasingly difficult to fulfill its mandate because resources in our National Parks have been compromised by development of adjacent lands, air and water pollution, habitat fragmentation, and human activities within and adjacent to park boundaries. Difficulties in assessing the condition of natural resources in the park units arise because natural systems are composed of organisms that interact with each other and their environments through dynamic processes that vary over time (NPCA 2003). Added difficulties arise when fiscal and human resources are limited in the NPS, which are needed to develop the inventory and monitoring strategies to monitor and assess natural resources.

As part of a national effort, a NPS pilot program titled "Assessment of Natural Resources and Watershed Conditions for Selected Parks of the Cumberland Piedmont Network" was implemented by the NPS in 2006 and is designed to help understand and report on the significance, condition, and challenges associated with park-managed watershed resources (NPS CESU 2006). The program calls for an assessment of biotic and abiotic natural resources as well as watershed conditions for selected park units. The NPS pilot program will provide a consistent, usable format for data analysis and display for communicating to the NPS and its stakeholders the status of watershed and natural

resource issues. Map, graphic, and written products from this NPS pilot program will provide a basis for developing resource management plans and aid in annual reporting of park unit goals for its natural resource conservation.

This study provides information for a portion of the NPS pilot program, with Little River Canyon National Preserve (LIRI) as the selected park unit from within the Cumberland Piedmont Network (CUPN) (NPS CESU 2006). The objectives for this study are to: 1) identify natural resources of interest and related issues at LIRI; 2) assemble existing data and Geographic Information Systems (GIS) layers pertaining to these resources; 3) evaluate the data for adequacy and identify information gaps; 4) develop an approach for assessing natural resource conditions and assign a current resource status where possible; and 5) provide appropriate products to assist in meeting management goals at LIRI (Kuehn 2006). Stated in the form of a research question: What is the approach for assessing watershed conditions at LIRI and what is the current status of these watershed characteristics? This study will assess the condition of selected abiotic watershed characteristics including water resources, landscape characteristics, geology, and soil characteristics as well as identify and discuss potential threats/stressors/ disturbances to the natural resources at LIRI. This study is organized into three sections: 1) park and resources context (adopted and slightly modified from the "Informational Categories and Report Outline" presented in the *Natural Resources Assessment and Ratings Methodology* (NPCA 2003, p.9)); 2) watershed condition assessment; and 3) existing and emerging threats, stressors, and disturbances.

CHAPTER 2. LITTLE RIVER CANYON NATIONAL PRESERVE (LIRI) – 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) shows 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, while the light brown areas covering several Wildlife Management Areas (state-owned and federally managed) represent ~14.4 % of the total. The green

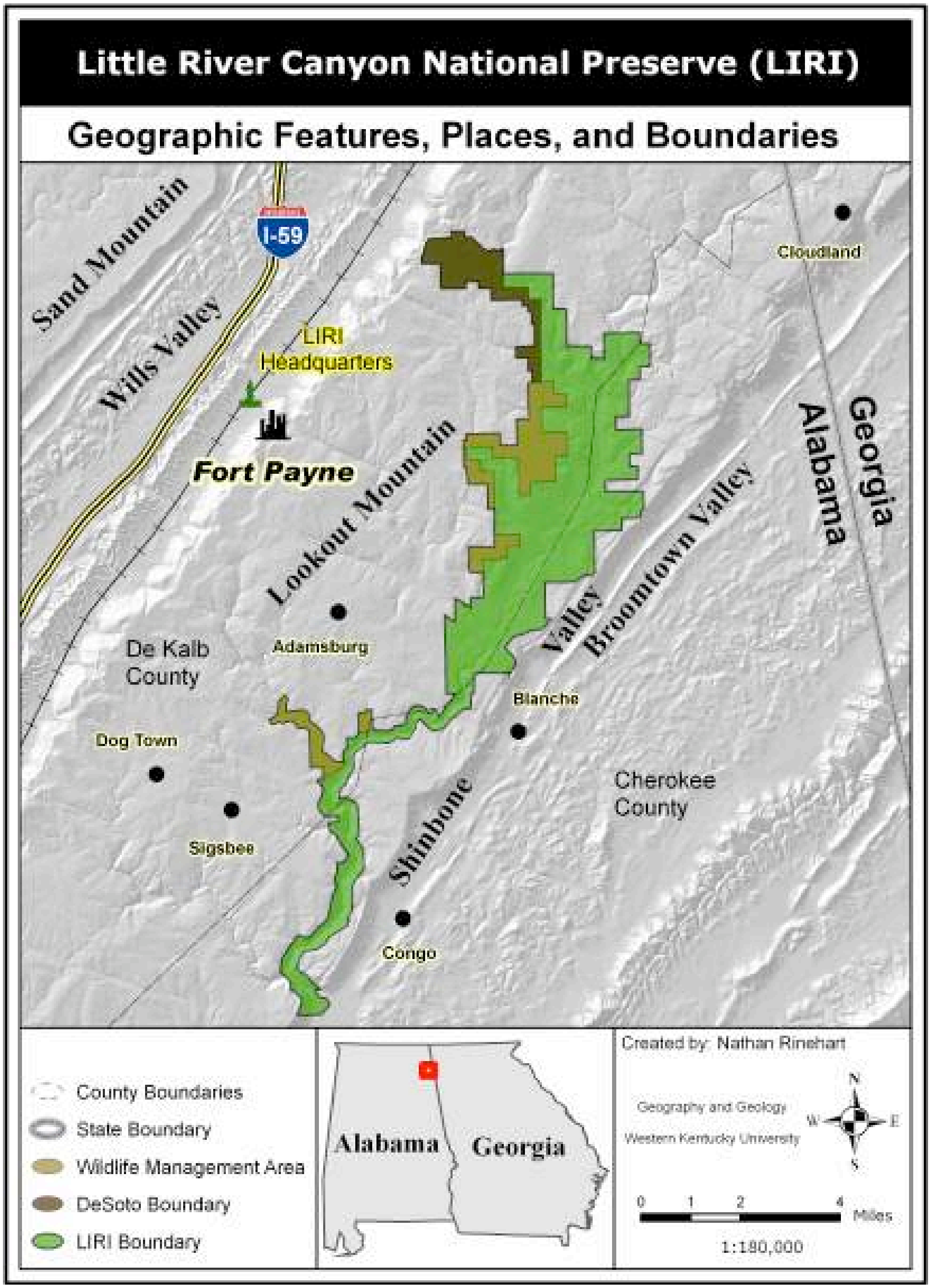


Figure 1. Location and boundary of Little River Canyon National Preserve. Source: (NPS 2006a).

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 NE-SW 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 the erosionally 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*

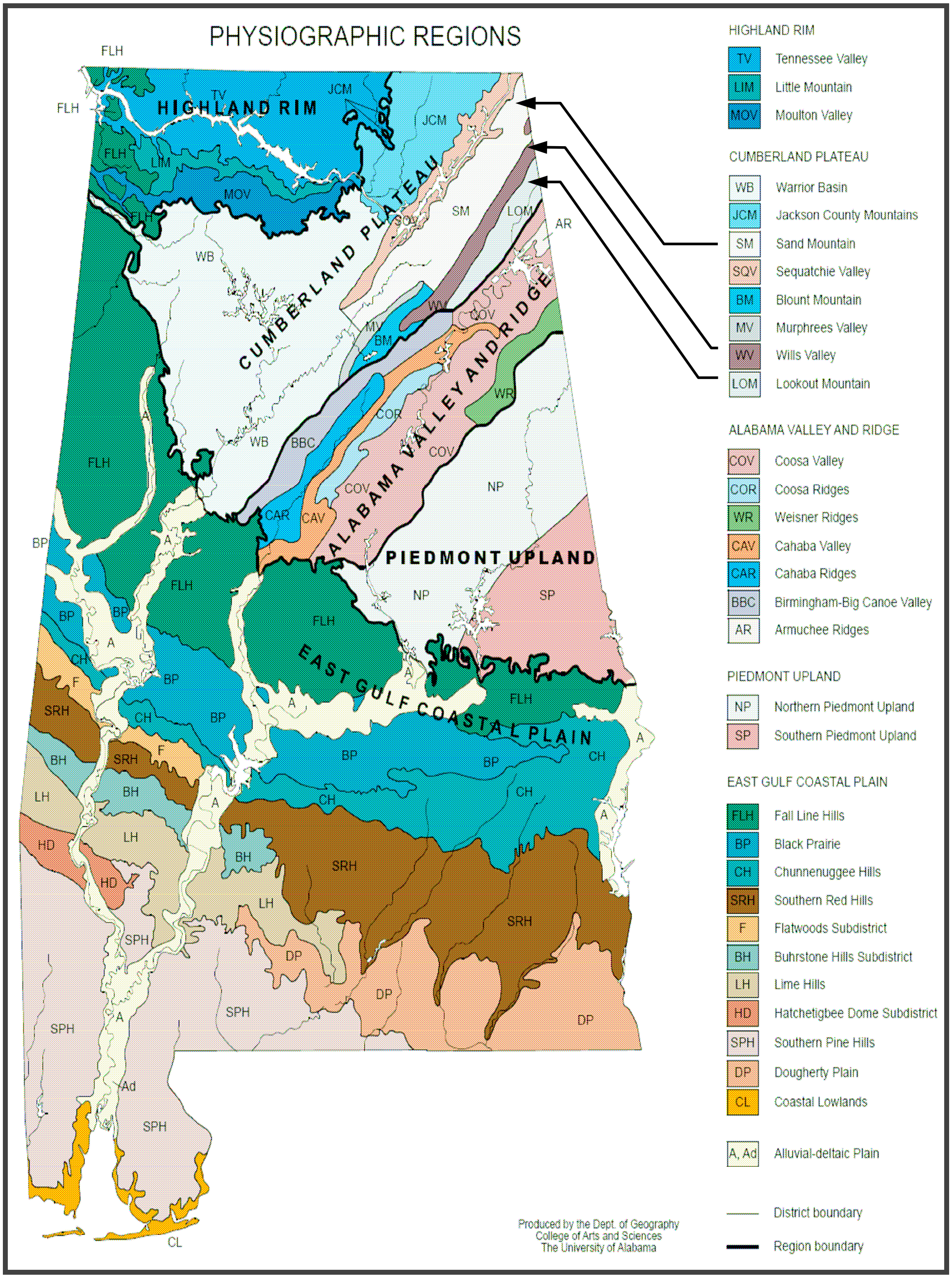


Figure 2. Physiographic Regions of Alabama. Source: (University of Alabama 2007).

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.

(Szabo *et al.* 1988) associated with each unit. The 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 Formations 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.

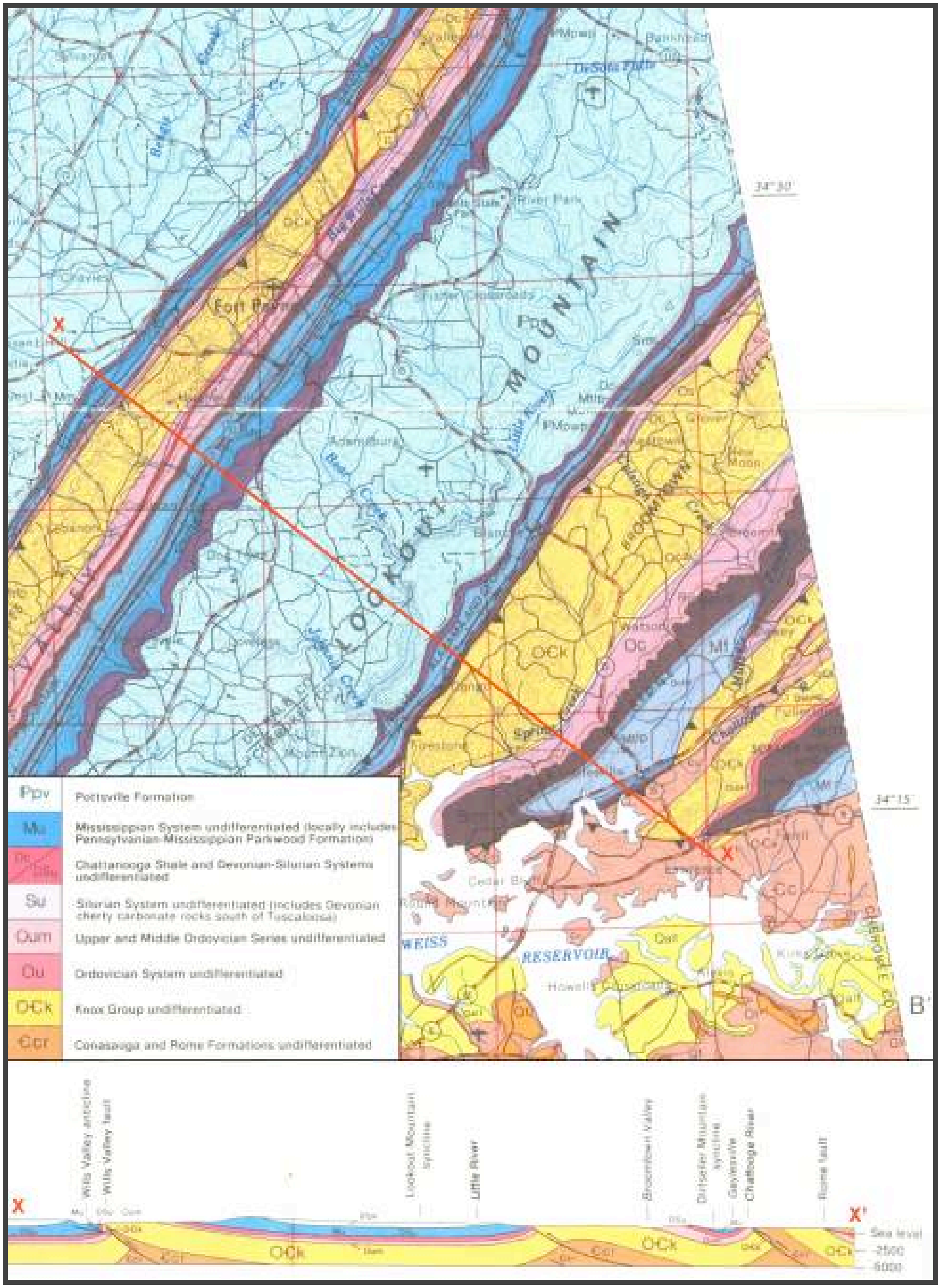


Figure 3. Geologic map of Lookout Mountain with structural cross section. Source: modified from (Szabo et al. 1988).

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 Park (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).

Georgia and Alabama have applied “water use classifications” to 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 for Little River 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

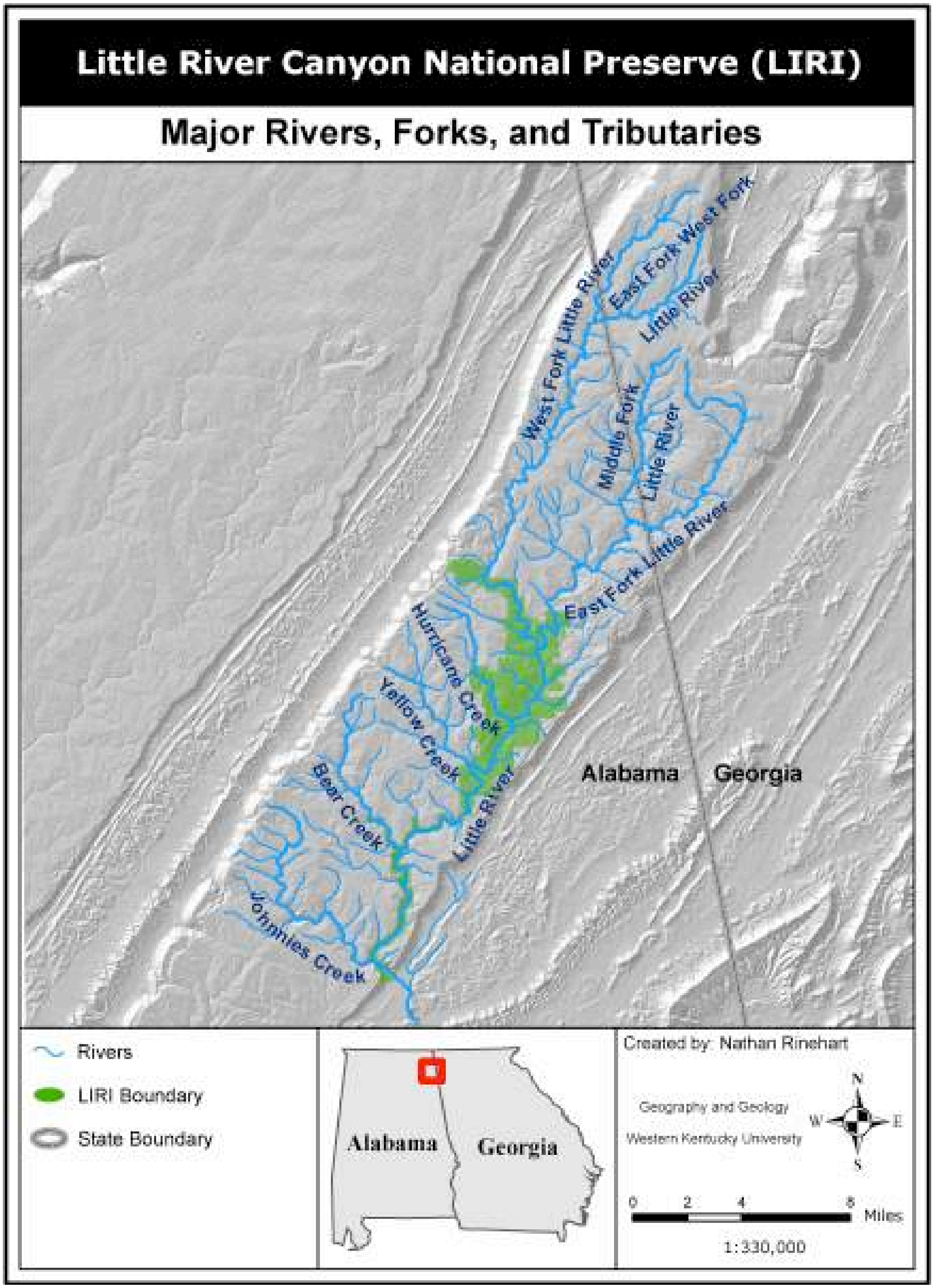


Figure 4. Rivers, forks, and tributaries influencing Little River Canyon National Preserve. Source: (USGS 2007a).

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.

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.

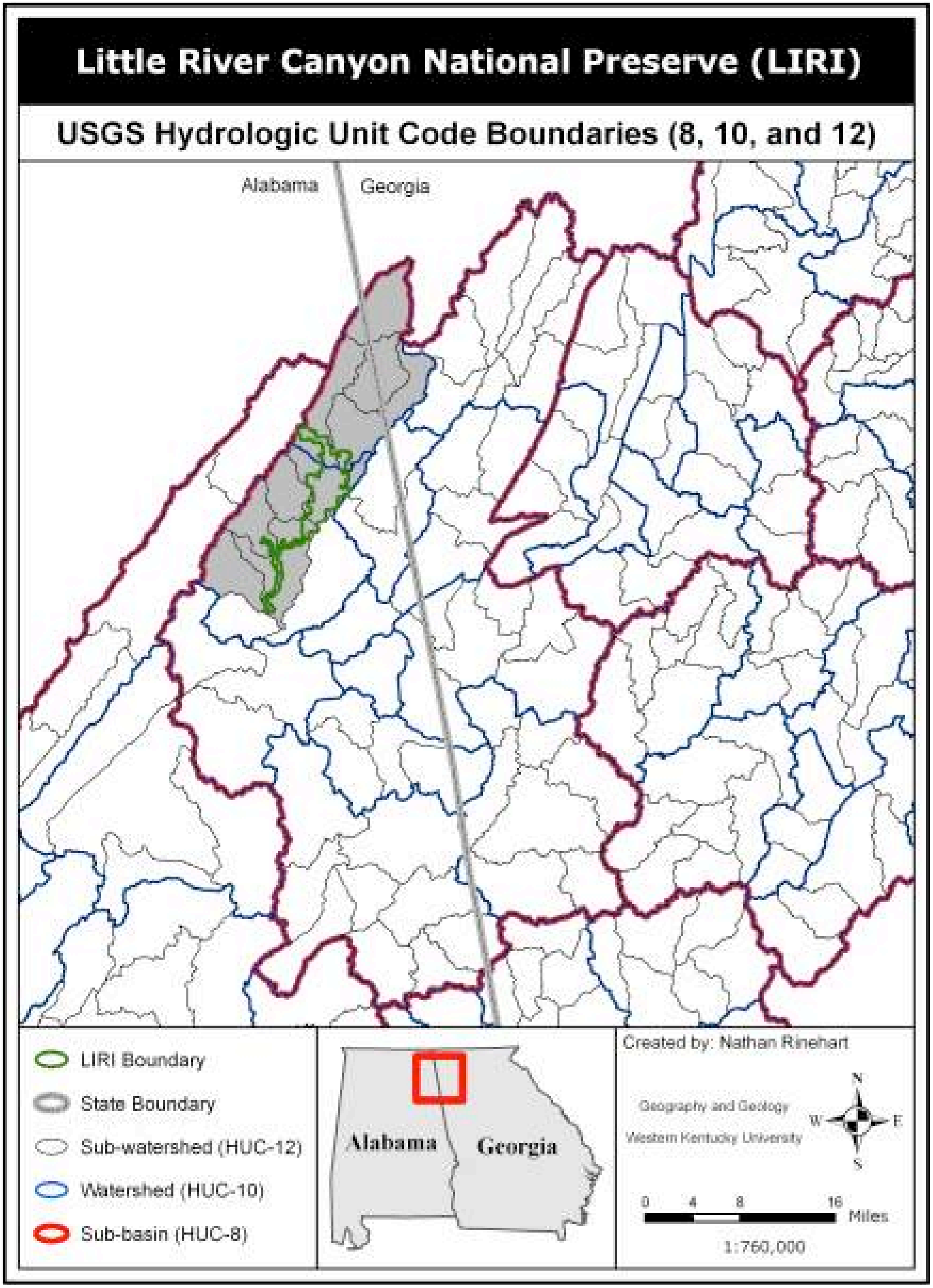


Figure 5. Hydrologic Unit Codes (8, 10, and 12) for Little River Canyon National Preserve. Gray sub-watersheds represent those influencing LIRI. Source: (USGS 2007a).

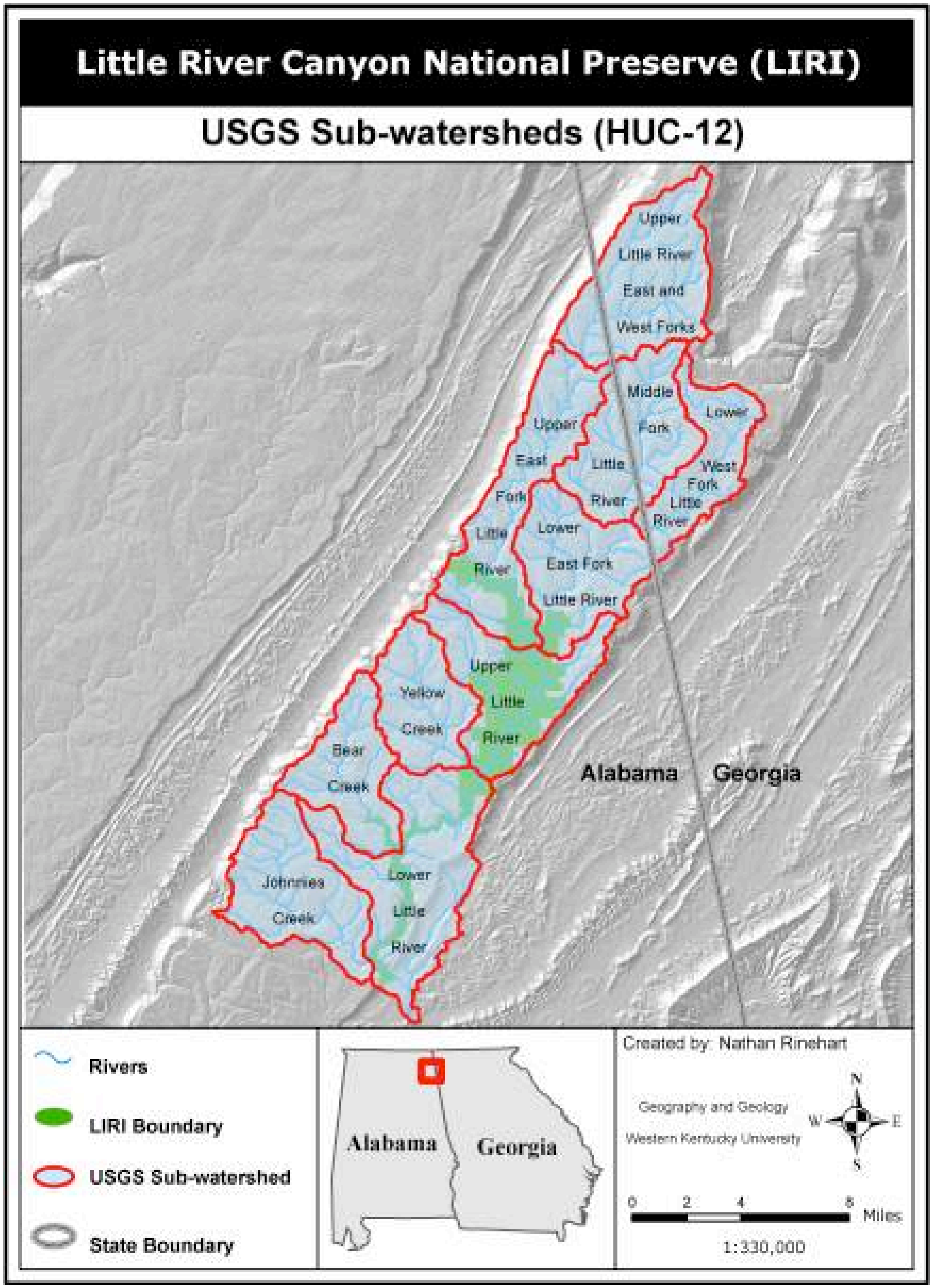


Figure 6. USGS sub-watersheds influencing Little River Canyon National Preserve. Source: (USGS 2007a).

2.4. Climate, Soils, and Ecological Setting

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).

The Natural Resources Conservation Service (NRCS) provides geospatial data layers that show the distribution of soils in DeKalb and Cherokee Counties (NRCS 2007). The soil description and names, however, do not correlate between counties. 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 the soil associations for DeKalb County, Alabama which mostly comprises the Hartsells-Muskingum and the Muskingum-Rockland-Hartsells soil

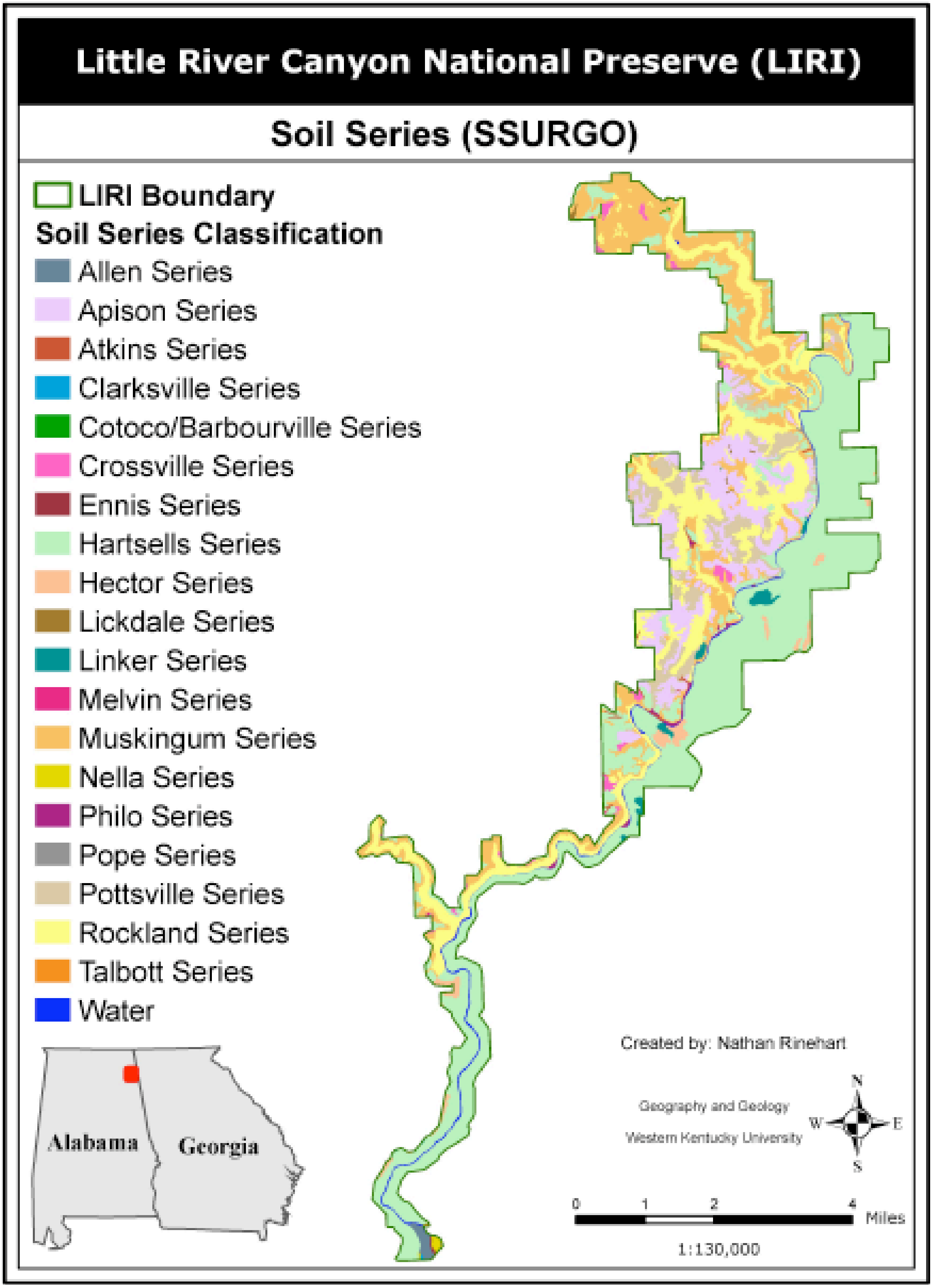


Figure 7. Little River Canyon National Preserve soil series from the Soil Survey Geographic (SSURGO) database. Source: modified from (NRCS 2007).

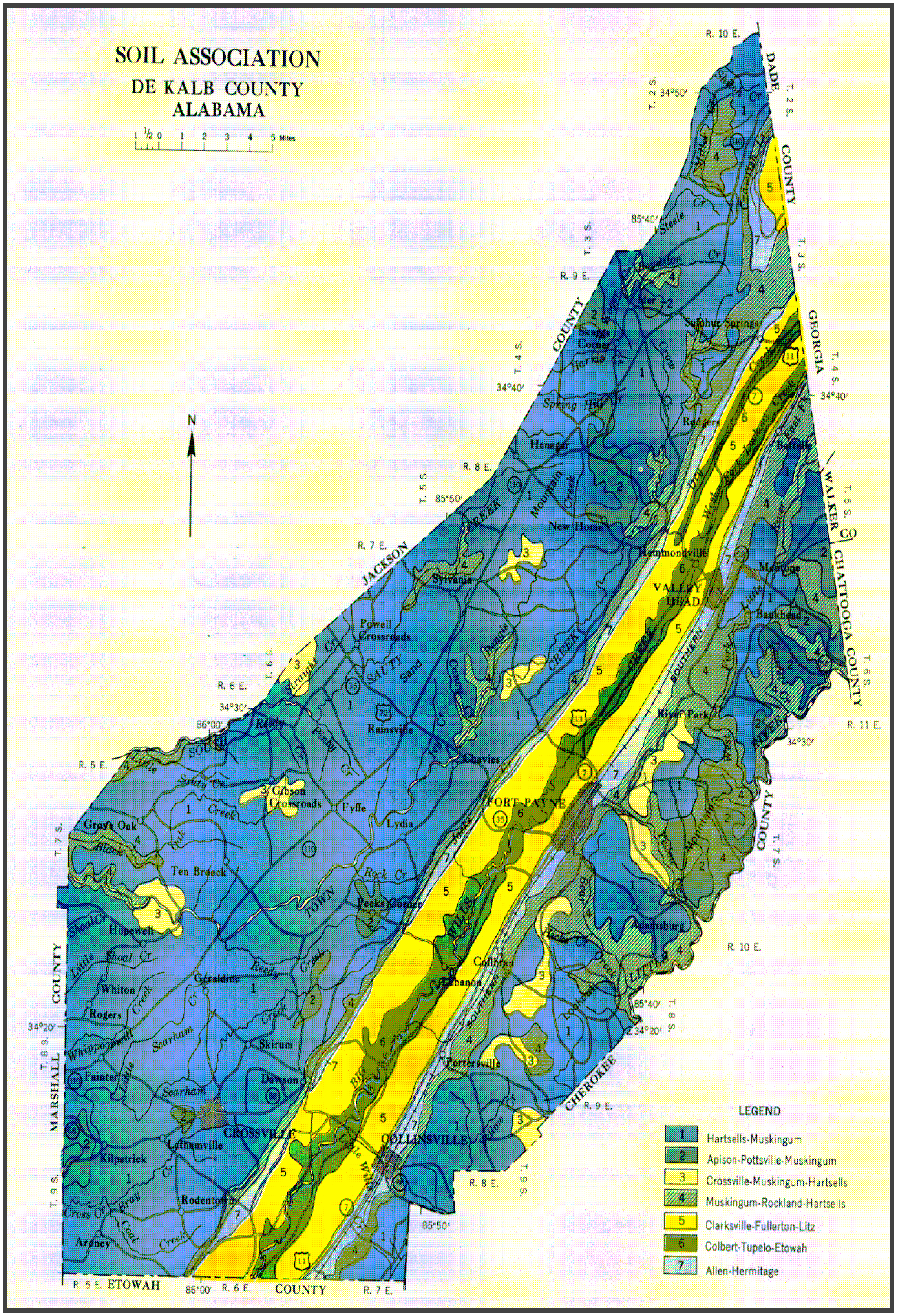


Figure 8. Soil Associations in DeKalb County, Alabama. Source: (Swenson et al. 1958).

association. 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, according to Swenson and others (1958), contain soils from which water is removed readily, but not rapidly, and possess 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 stream valleys. 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 (NRCS 2007). 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 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.

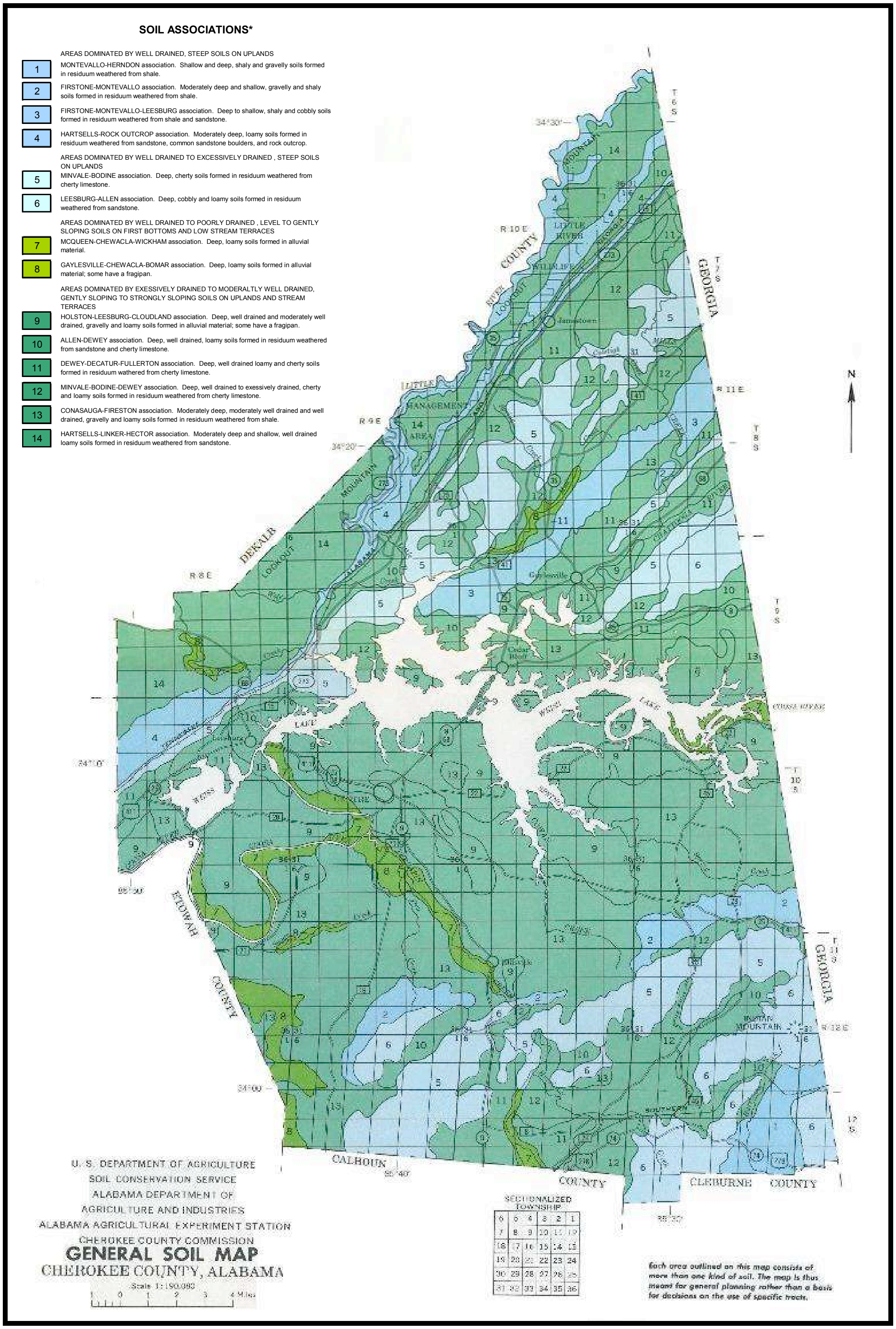


Figure 9. Soil Associations in Cherokee County, Alabama. Source: modified from (Montgomery 1978).

The Hartsells-Rock outcrop association is described as, "moderately deep, loamy soils formed in residuum weathered from sandstone, common sandstone boulders, and rock outcrop" (ibid. 1978, p.4) and features 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 as, "moderately deep and shallow, well drained loamy soils formed in residuum weathered from sandstone" (ibid. 1978, p.8) 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.

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, and monitoring of ecosystems and their components (ibid. 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 system of Roman numerals. 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 differs, however, 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).

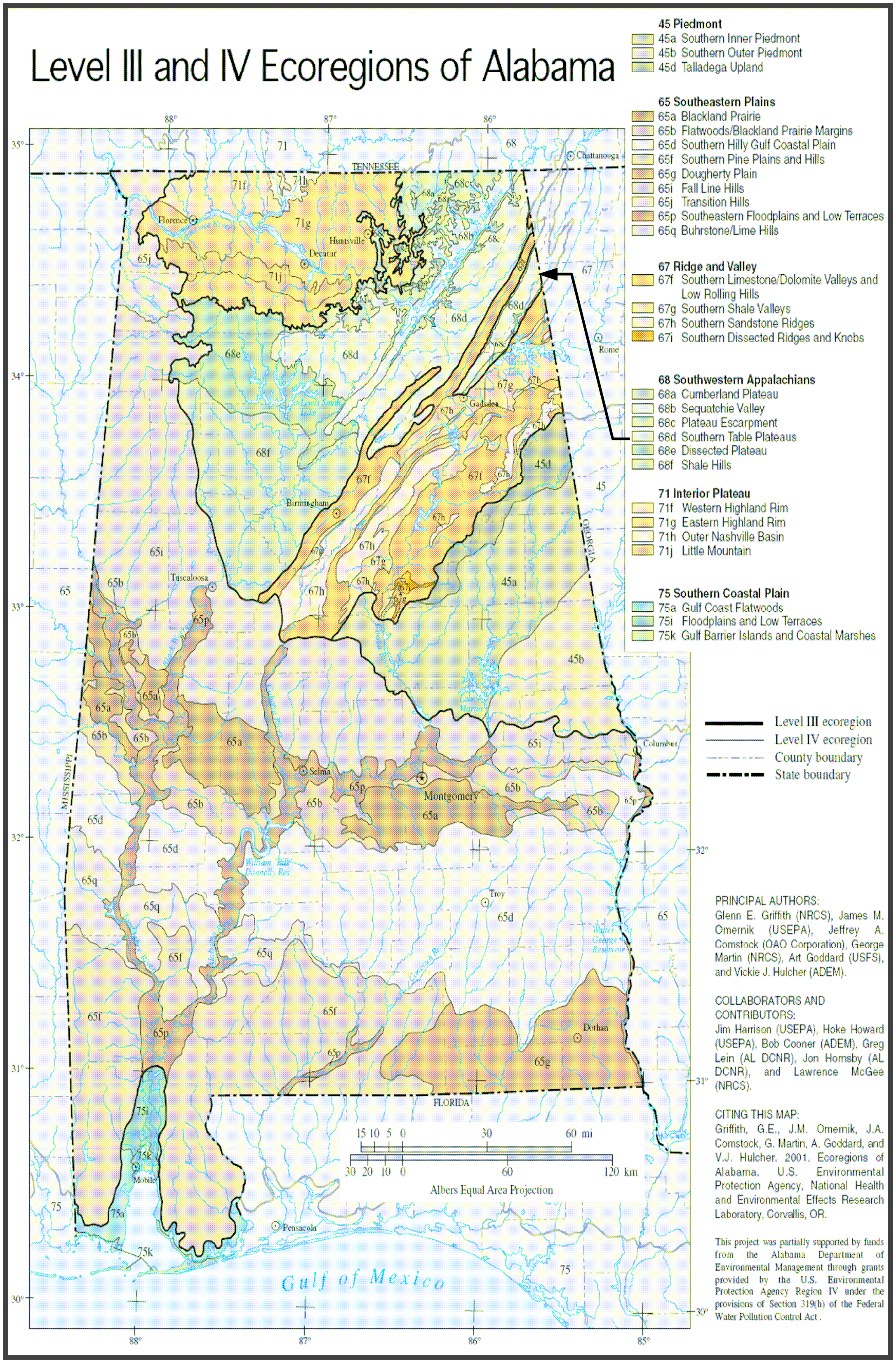


Figure 10. USEPA Level III and IV Ecoregions of Alabama. Source: modified from (Griffith et al. 2001).

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 wilderness 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 Characterisitcs (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 includes private summer camps for children such as Comer Boy Scout Reservation, DeSoto Falls, DeSoto State Park, and various resorts in the city of Mentone, Alabama. A private 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 resort and chair lift are no longer in operation, though the state maintains picnic areas, hiking trails, and restroom facilities nearby. Several fords along the Little River provide sunbathing and picnicking opportunities for horseback riders and all-terrain vehicle (ATV) users. Canyon Mouth Park 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. Lands just east of the Little River Wildlife Management Area have been clear-cut in the past. Opportunities for land development has influenced the construction of summer homes and second homes along the brows of Lookout Mountain and 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. (Public Law 102-427 1992, p.247)

LIRI is a National Preserve, not a National Park. The difference between the two is that a Preserve permits hunting and resource extraction, whereas a Park does not (NPS 2005a). 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, p.6).
2) It has virtually pristine/unpolluted water (NPS 2005b, p.1-2).
3) It is the deepest/most extensive canyon and gorge system east of the Mississippi River (ibid. 2005b, p.1-2).
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, p.1-2). 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, p.4).
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, p.4).

6) The Preserve contains some of the most rugged and outstanding canyon scenery in the southeastern United States (ibid. 2005c, p.4).
7) The area possesses exceptional value in illustrating and interpreting the theme of river systems in the Appalachian Plateaus (ibid. 2005c, p.4).

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 ten scenic overlooks featuring an elevation change greater than 400 feet 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. Because access constraints to several remote areas around LIRI limit human activity, the water quality of Little River has remained relatively pristine, although the presence of biological contamination is an ongoing concern. 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. Coordination with the United States Fish and Wildlife Service (USFWS) and the Alabama Natural Heritage Program for LIRI's Fire Management Plan (FMP) (ibid. 2005b) listed 13 threatened, endangered, or rare/uncommon plant and animal species known to inhabit or visit LIRI. The Gray bat and Rafinesque's big-eared bat may potentially occur at LIRI and thus are included on the list (Table 3). 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, a series of off road trails for ATVs, and horseback riding. Portions of LIRI

Table 3. Threatened, endangered, and rare/uncommon plant and animal species known to inhabit or visit Little River Canyon National Preserve. Source: modified from (NPS 2005b).

NAME	FEDERAL STATUS	STATE STATUS
Plants		
Green Pitcher Plant (*Sarracenia* oreophila)	Federally-listed endangered	S2
Harperella (*Ptilimnium* nodosum)	Federally-listed endangered	S1
Kral's water plantain (*Sagittaria* secundifolia)	Federally-listed threatened	S2
Harper's dodder (*Cuscuta* harperi)		S1
Little River onion (*Allium* speculae)		S2
Longleaf sunflower (*Helianthus* longifolius)		S1/S2
Rose gentian (*Sabatia* capitata)		S2
Sun-facing coneflower (*Rudbeckia* heliopsidis)		S2
Woodland tickseed (*Coreopsis* pulchra)		S2
Animals		
Blue Shiner (*Cyprinella* caerulea)	Federally-listed threatened	S1 state-protected
Bald eagle (*Haliaeetus* leucocephalus)	Federally-listed threatened	S3B state-protected
Gray bat (*Myotis* grisescens)	Federally-listed endangered	S2 state-protected
Rafinesque's big-eared bat (*Corynorhinus* rafinesquii)	Federally-listed species of special concern	S2 state-protected

S1 = critically imperiled in state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from AL.

S2 = imperiled in state because of rarity or because of some factor(s) making it very vulnerable to extirpation from AL.

S3B = uncommon during the breeding season (spring/summer) in AL.

also include hunting and fishing opportunities through the Little River Wildlife Management Area.

2.6.3. Archeological, Historical, and Cultural Resources

Detailed studies of historical and cultural resources have not been conducted within LIRI, although 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 (1200-500 B.C.E.).

CHAPTER 3. 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 strategic planning. The RSS 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.

3.1. 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 reliant 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, p.v)

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 data 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). 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 (ibid. 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, p.19)

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 macroinvertebrates, 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 two 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 watershed assessment.

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). Regulation 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 of data were used in determining the essential water quality parameters for long term monitoring and to identify the best monitoring locations within selected park units. LIRI was not included in the preliminary round of testing because extensive knowledge and data were already available from existing monitoring programs. These data were used in selecting sample locations and a list of water quality parameters at LIRI. 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, p.8)

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, p.2)

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 2006b, p.1)

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 for 2007-2014

(NPS CESU. 2006). As mentioned previously, this thesis is serving as a portion of the NPS pilot program initiated within the CUPN at Little River Canyon National Preserve.

3.2. Management Planning Status

The status of LIRI's GMP and resource stewardship planning was evaluated to determine whether it had already defined its management zones and determined the desired conditions and associated metrics for its natural resources. LIRI is currently developing a GMP that is anticipated to be available in 2009. 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. According to Mary Shew (pers. com. 2007), Resource Manager at LIRI, this goal specifically states: "By September 30, 2008, 24 miles (100% of 24 miles) of streams and rivers managed by LIRI will meet 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.

CHAPTER 4. LITERATURE REVIEW

4.1. Review and Evaluation of Assessment Frameworks

A review of the literature suggests that there are three major assessment framework approaches that could be utilized for this study. These approaches include watershed assessment frameworks, conservation planning frameworks, and ecological integrity assessment frameworks. Three watershed assessment frameworks, three conservation planning frameworks, and three ecological integrity assessment frameworks were reviewed. Prior NPS Watershed Condition Assessment (WCA) assessments utilized these established assessment frameworks and procedures.

4.1.1. Watershed Assessment Frameworks

The *California Watershed Assessment Guide* (Shilling *et al.* 2005a) offers the following step-by-step process for conducting watershed assessments: 1) Organize the assessment team; 2) Define the purpose and develop a plan for the assessment; 3) Collect data and information; 4) Analyze the data; and 5) Integrate and report the data to inform decision-making. This quick reference guide in conjunction with the manual (Shilling *et al.* 2005b) summarizes key ideas and processes for conducting an assessment, while the manual describes in detail the possible mechanics for conducting one. This framework offers various modeling approaches that can be used to analyze data. Options provided in this manual for analyzing compiled data were to use a team of experts to systematically review the data and use professional judgment to assess watershed conditions, use statistics to show relationships and correlations between various factors within a watershed, use a relative risk model for ranking stressors in a watershed and the likelihood that they are associated with adverse impacts, or use knowledge-base models

to compare observed conditions to reference values for a variety of watershed components.

The *Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis* (Regional Ecosystem Office 1995) offers the following six-step process that is issue driven and focuses on seven core analysis topics: 1) Characterization of the watershed; 2) Identification of issues and key questions; 3) Description of current conditions; 4) Description of reference conditions; 5) Synthesis and interpretation of information; and 6) Recommendations for management. The seven core analysis topics are erosion processes, hydrology, vegetation, stream channel, water quality, species and habitat, and human uses. This process framework is intended to be flexible and adaptable but still follows a consistent overall approach. The authors assume that every watershed analysis will be different, depending on the reasons for conducting the analysis and the resource concerns unique to the watershed, even though a common approach based on the six analysis steps would be followed. There are two sections to this federal guide. Section I provides an overview of the analysis process and related considerations including detailed descriptions of the six steps for conducting ecosystem analysis at the watershed scale. Section II (Regional Ecosystem Office 1996) is a supplement to Section I and it provides several optional analytical methods and techniques to address core topics and questions, as well as other pertinent issues identified by watershed analysis teams. Section II does not provide all the methods and techniques required, so assessment teams are encouraged to use any standard analysis methods and techniques that are widely accepted by local resource specialists and that are appropriate to analyze issues in their watersheds. These documents provide another step-by-step process for

conducting a watershed analysis; however, the core analysis topics touch only slightly on biotic natural resources within watersheds.

In the *Northwest Forest Plan-the First 10 Years (1994–2003): Preliminary Assessment of the Condition of Watersheds* (Gallo *et al.* 2005), decision-support models were used to assess the condition of watersheds by using relevant evaluation criteria. These computer-based models capture evaluation procedures and apply a consistent decision process across time and space. Criteria were developed by expert panels to evaluate individual data parameters. Data were compared to the criteria and given an evaluation score of –1, 0, or 1. Scores for the attributes were aggregated into an overall assessment of watershed condition. After each attribute datum was evaluated, the model aggregated these scores in a hierarchical fashion. Mathematical functions were also available for determining whether the situation was of a "limiting factor" type, where the worst condition score determines the combined score, a "partially compensatory" situation, where score are all counted equally, or a "fully compensatory" situation, where the best score determines the combined score. In addition, each node in the model can be assigned a relative weight. When the experts constructed the model structure, they also developed evaluation criteria for each attribute. This framework document is diverse in that it provides a variety of decision-support models depending on different circumstances in individual watersheds. The document provides guidance for weighting individual indicators and totaling scores into an overall resource condition. Summary charts of the evaluation criteria provide useful information including how the indicators were measured, visual representations of indicator trends through time, and sources for indicator criteria.

4.1.2. Conservation Planning Frameworks

The Five-S Framework for Site Conservation: A Practitioner's Handbook For Site Conservation Planning and Measuring Conservation Success (TNC 2000) is a "how-to" guide designed to help project managers identify conservation targets, analyze threats, plan conservation strategies, and measure the success from the strategies. The goal of this framework is to assist in maintaining viable occurrences of conservation target. Two planning steps involve defining conservation targets and critical threats to these targets and ranking these according to an ordered classification based on the best available knowledge and judgment. Authors suggest that there should be no more than eight focal targets for any given site and targets can be comprised of a combination of ecological systems and species of interest. These targets are ranked (i.e. very good, good, fair, poor) and given an associated predefined score value (i.e. 1, 2, 3, 4) according to viability and biodiversity health for a site. An analysis of threats is divided into the terms "stress" and "source of stress". The author defines "stress" as the impairment or degradation of conservation targets such as loss of habitat. "Source of stress" is an extraneous factor (human or biological) that affects a conservation target resulting in stress. An example of a "source of stress" would be ATV use while the 'stress' it causes could be loss of habitat or increased localized erosion. Sources of stress are separated into "active" sources, which are expected to deliver additional stresses to a target and "historical" sources, which are not expected to deliver additional stresses to a target. Stresses are ranked (very high, high, medium, and low) according to severity of damage and scope of damage. Sources of stress are ranked (very high, high, medium, low) according to "degree of

contribution to the stress" and "irreversibility of the stress". The author describes a process in which an overall threat rank can be calculated.

The *Open Standards for the Practice of Conservation* (CMP 2004) is organized into the following seven steps: 1) Conceptualization; 2) Planning; 3) Implementation; 4) Analysis; 5) Adaptation (evaluate and improve); 6) Communication; and 7) Iteration (repeat the process). Key principles, tasks, and guidance are laid out for each step for the successful implementation of conservation projects. The framework is less a recipe that must be followed exactly than a framework and guidance for conservation action. It brings together concepts, approaches, and terminology in conservation project design, management, and monitoring in order to help improve the practice of conservation. The term "Open Standards" is borrowed/adapted from the information technology field and are standards that are developed through public collaboration, freely available to anyone. These standards are not the property of anyone and can thus be freely distributed. Standards are common property, constantly evolving and improving, and adaptable to individual needs. This document assumes that 1) some priority setting has already taken place; 2) few projects will start at the beginning of these standards; 3) these standards represent the ideal; 4) each project is different in potentially significant ways; 5) these standards will change over time; 6) these standards are not site specific; and 7) these standards are not divorced from strategy, tool, and indicator standards. This guide is focused on process steps toward planning, analyzing data, and completing a cycle for project completion. This is not a step-by-step linear document nor does it give examples of its principles. It represents a general overview of what tasks should be accomplished and guidance on how to accomplish them in a project.

The *Conservation Action Planning – Developing Strategies, Taking Action, and Measuring Success at Any Scale: Overview of Basic Practices* (TNC 2007) document is the most recent incarnation and synthesis of The Nature Conservancy (TNC) and other documents including *The Five-S Framework for Site Conservation: A Practitioner's Handbook For Site Conservation Planning and Measuring Conservation Success* (TNC 2000). This combines previous conservation documents into a ten-step process, though it is not meant to be a "how-to" guide for implementation. The idea is to deliberately, yet rapidly, go through the steps, develop a credible draft of the outputs, and then revise your work over time as your project changes and matures. The basic practices of this document should apply in general but will have to be adjusted to meet each project's needs, so it is expected that teams will change or adapt these as necessary. The beginning steps in this document are very similar to the *Ecological Integrity Assessment: A Framework For Conservation Planning and Measuring Success* (Parrish *et al.* 2002, 2007) and *National Resources Assessment and Ratings Methodology* (NPCA 2003) steps and follows the *Five-S Framework for Site Conservation: A Practitioner's Handbook For Site Conservation Planning and Measuring Conservation Success* (TNC 2000) approach involving systems, stresses, sources, strategies, and success. The last few steps are more oriented for resource planners after data analysis and the conditions of resources have been determined.

4.1.3. Ecological Integrity Assessment Frameworks

The United States Environmental Protection Agency –Science Advisory Board (USEPA-SAB) framework, *A Framework for Assessing and Reporting on Ecological Condition* (USEPA SAB 2002), defines six hierarchical Essential Ecological Attributes

(EEAs), each of which contains associated categories and subcategories: 1) landscape condition; 2) biotic condition; 3) chemical and physical characteristics (water, air, soil, and sediment); 4) ecological processes; 5) hydrology and geomorphology; and 6) natural disturbance regimes. One purpose of the EEA hierarchy is to provide organizational structure for the process of selecting ecological system characteristics that will be assessed. It can also be used to identify information gaps in current monitoring programs. The elements of the EEA hierarchy are derived from a conceptual model of ecological system structure and function. Once the purpose and scope of the assessment have been determined, the EEA list can be applied. Authors recommend beginning with a presumption that all of the entries in the EEA hierarchy will be included. A "thought experiment" can then be conducted to eliminate the subcategories and categories that are not relevant to the assessment. When resources are limited, authors generally recommend reducing the number of subcategories for which data are collected, rather than eliminating an entire category. Similarly, it may be preferable to limit the number of categories assessed rather than eliminating an entire EEA. Indicators/measures (metrics) associated with these categories are evaluated to assess ecologic integrity. The framework provides a scheme for combining indicators and collapsing them into a single entry. This framework separates ecologic condition indicators from stressor indicators and EEAs relate only to condition indicators. Rationale for this separation is that it more clearly differentiates natural variations from human induced variations, can aid the analysis of the causal mechanisms underlying compromised ecosystem conditions, and encourages indicator selection criteria to be based upon fundamental environmental attributes and processes rather than current data availability. Authors suggest that this

framework can be applied to a variety of aquatic and terrestrial systems at local, regional, and national scales; however, fine-tuning will be necessary as the framework is applied to various programs. This framework was designed to: 1) help assure that the required information is measured systematically by the USEPA programs; 2) provide a template for assembling information across USEPA programs and from other agencies; and 3) provide an organizing tool for synthesizing large numbers of indicators into a scientifically defensible, yet understandable, report on ecological condition. This framework focuses its efforts on ecological aspects rather than natural resources and may focus more on implementing plans to gather information than assessing current conditions from available sources of information. An issue with separating condition and stressor indicators may be that some indicators can be represented as either type, such as water quality indicators. These indicators may show pristine or degraded conditions depending on the indicator value. This approach looks at essential components of a complete assessment and then documents information gaps, instead of looking at stressors and excluding other essential aspects of an assessment.

The *Ecological Integrity Assessment: A Framework For Conservation Planning and Measuring Success* (Parrish *et al.* 2002, 2007) documents were a result of difficulties encountered with *The Five-S Framework for Site Conservation: A Practitioner's Handbook For Site Conservation Planning and Measuring Conservation Success* (TNC 2000) and expands on this framework based on: 1) the concept of "ecological integrity" as a replacement for the less appropriate concept of conservation target "viability"; 2) the concept of "key ecological factors" and their crucial roles in defining integrity for any single conservation target; 3) the identification of "critical ecological thresholds" for

individual factors that allows a standardized and rigorous means to rate key factor status; 4) the concepts of "optimal integrity threshold", "minimum integrity threshold", and "imminent loss threshold" and their use in setting conservation goals; and 5) the idea of "rating" the ecological integrity of conservation targets based on these several concepts. Several of these terms are unique to this document and are not found in other framework documents. This document assigns ranking categories of "very good", "good", "fair", and "poor" as well as incorporates ecological integrity categories from the "Five-S" framework (ibid. 2000) namely "condition", "landscape context", and "size". This document rests on the observation that there are a set of "key ecological factors" that sustain any "conservation target" and maintain its composition, structure, and function. It offers guidance on: 1) identifying the key factors for conservation targets; 2) using key ecological factors to set conservation goals for a target; 3) assessing the integrity of an individual conservation target based on the status of its key ecological factors; and 4) using key ecological factors to guide the identification of threats, the design of effective monitoring and measures of success, and the identification of critical research needs. It describes a set of "thresholds" that can be applied to these key ecological factors to determine its "ecological integrity" using textual descriptions and color schemes. The author suggests it is important that the conservation planning process maintain a clear distinction between key ecological factors and stresses for the two crucial and distinct purposes of assessing integrity and ranking threats. The document provides a scheme for weighting indicators/metrics and totaling scores into a whole resource condition; for example, if all of the key factors assigned to a category receive ratings of "good" or "very good", then that category receives a rating based on the majority among its key factors. It

provides examples for defining thresholds using qualitative reasoning when quantitative data are absent; for example, a definition of a "good" rating might include a statement saying that the key factor requires little to no human intervention to be maintained within its reference condition.

The National Parks Conservation Association (NPCA 2003) reviewed various assessment frameworks and created its own assessment framework methodology with similar purposes and objectives as this study. The NPCA (2003) mentions that *The State of the Nation's Ecosystems* (The Heinz Center, 2002) has had some success as the first holistic attempt to understand the health of America's ecosystems. The NPCA asserts that there are a number of assessment frameworks, with more being focused on conservation planning and management effectiveness rather than on resource condition assessment. They argue that no rapid, affordable, comprehensive, and authoritative framework for evaluating and rating ecosystems health is generally accepted (NPCA 2003). Therefore, the NPCA created the *National Resources Assessment and Ratings Methodology* (ibid. 2003); one specifically tailored for the NPS park units. The NPCA adopted The Nature Conservancy (TNC) *The Five-S Framework for Site Conservation: A Practitioner's Handbook For Site Conservation Planning and Measuring Conservation Success* (TNC 2000) planning approach, modified some of the definitions, and developed a different method for implementation. Their goal is to provide information on natural and cultural resource conditions for national park units. The NPCA strives to evaluate the integrity of natural systems within the parks by focusing mainly on biological integrity. Their approach is to assess ecosystem health by analyzing impacts, stressors, and mitigation efforts rather than directly measuring changes in higher-order ecosystems.

Their justification for this approach is that besides major natural events, the impacts on ecological integrity come primarily from human activities and that if no human influences were present, the ecosystems would self regulate and maintain their ecological integrity. Assessment criteria are organized into categories: 1) Ecosystem Measures (ESMs) having two sub-categories and 2) Environmental and Biotic Measures (EBMs) having five sub-categories. EBMs address air, water, soils, climate changes, and how they influence plants and animals. ESMs address ecosystem and environmental characteristics. Each sub-category is further divided into discrete elements of ratable indicators, totaling over 120, that are ranked numerically from zero (complete and irreparable loss) to three (not a problem), IND (inadequate or no data), or NA (not applicable) based on characteristics of various influences (NPCA. 2003). Once the elements are scored, a percentage of the sum of the scores over the total score possible becomes the rating. Element categories are then "rolled-up" to produce category scores and an overall score. Information adequacy or basis can also be calculated by the number of IND ratings assigned to the elements relative to the total number of applicable elements to a given category, which reflects the extent to which data requirements for the assessment are met. The NPCA expects that their methodology and rating system will evolve and require updating as new scientific information becomes available. The outline for the "Park and Resource Context" could be useful for the National Park Service (NPS) pilot program report. The ecoregion division approach used in this methodology may not be useful for this assessment because, referring back to Figure 10, the ecoregion pertaining to LIRI covers a large area and their descriptions are too general to be useful in assessment of natural resources. The framework focused more on biodiversity with little

focus on the other natural resources and environments. The framework uses numbers for scoring conditions with text descriptors rather than displaying resource conditions geospatially such as using a colored "stoplight approach". The framework provides a scheme for summing the element scores, assuming each element has equal weight in terms of overall integrity.

In summary, there are many assessment frameworks that can be adopted to assess conditions in watersheds, the ecological integrity of an area, and the success of conservation efforts. Several frameworks expressed that no one approach is likely to be adequate or universal for all areas of study; therefore the framework developed for this study will be derived from a variety of existing frameworks whose objective is to assess watershed conditions.

4.2. Review of Other Literature

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 (NatureBIB and NPSpecies), existing management objectives including available Government 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 establishment of the Preserve 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* (Greg *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.

NPS personnel at LIRI provided water quality information from an unpublished thesis study in 2001 (Belue 2001), which included bimonthly water sampling initially 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 and provides a description of vegetation mapping 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.

CHAPTER 5. RESEARCH METHODOLOGY

5.1. 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) study area. Strategies for a "comprehensive" or a "focused" approach were considered for the NPS pilot program and each offers strengths and weaknesses (Shilling *et al*. 2005a). 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 Preserve 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.* 2005a):

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.
(modified from Shilling *et al.* 2005a, p.4)

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* (TNC 2000) provided useful suggestions about using color schemes (dark green, green, yellow, red) and classification ranks (excellent, good, fair, poor) for displaying status of conditions at a site.

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. The NPS has established a format for its publications (NPS 2008a) that the assessment will implement for their pilot program report. A detailed analysis, condition assessment, and identification of threats/stressors/ disturbances to the natural resources of interest and related issues through results of the fourth step are presented in Chapters 6-8.

5.2. 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 two sources. 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 LIRI personnel for resource planning and stewardship.

5.3. 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 4) 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 and VSMP 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.* 2005a) contains a detailed section on watershed issues that provided valuable information

Table 4. Assessment framework for natural resources of interest and issues at Little River Canyon National Preserve. Source: Author, (NPS 2005e), (USEPA SAB 2002).

LEVEL 1 CATEGORY / Level 2 Category	Level 3 Category	Selected Indicator	Status*
WATER			
Hydrology	Groudwater 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)	Sedimentation Rate (by sub-watershed)	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

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)		NA
	Invasive/Exotic Animals (e.g. extent, risk factor, non-native species diversity)	Asian Clam	NA
Infestation, Disease, and Trauma	Insect Pests (e.g. extent, risk factor)	Southern Pine Beetle	NA
	Plant Disease/Trauma	Risk Factor of Ozone Sensitive Plants	NA
	Animal Diseases		NA
Visitor and Recreation Use	Visitor Use	Population Density	A
		ATV Use Trend	A
		Swimming Impacts to Water Quality	NA
		Rock Climbing Impacts 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		NA
	Community Composition (e.g. inventory of species, native species diversity, species richness)		NA
	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)		NA
	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)		NA
Species and Populations	Population Size (e.g. number of individuals in the population, breeding population size, number of individuals per habitat area (density))		NA
	Habitat Suitability (focal species) (e.g. measures of habitat attributes important to focal species)		NA

LEVEL 1 CATEGORY Level 2 Category	Level 3 Category	Selected Indicator	Status*
BIOTA (Continued)			
Fauna (Continued)			
Species and Populations (Continued)	Freshwater Invertebrates		NA
	Terrestrial Invertebrates		NA
	Birds		NA
	Herpetofauna (Amphibians & Reptiles)		NA
	Fish		NA
	Mammals (e.g. deer, bats)		NA
At-Risk Biota	Threatened & Endangered (T&E) Species and Communities		NA
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			

on potential natural resource indicators for this study. Items in Table 4 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 VSMP or 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 assessment framework contains six "Level 1" categories as follows: 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.

Although Table 4 is quite comprehensive, this study will consider the abiotic resource categories including Water, Landscape, Geology and Soils, and Threats, Stressors, and Disturbances, while the other categories will be investigated for the overall NPS pilot program report.

5.4. 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. A list of library, Internet, and state/federal agency databases as well as the list of search terms is provided in Appendix D. 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. Useful information was extracted for the assessment and summarized in a summary table (Appendix E).

CHAPTER 6. ASSESSMENT OF WATER RESOURCES

6.1. 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 5. 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 6 provides a summary of the area within each sub-watershed and its percentage of the LIRI watershed. Note that sub-watershed areas include all upstream sub-watersheds and any additional area downstream of these to the sample location. For example, the Lookout Mountain Camp (LCLR)

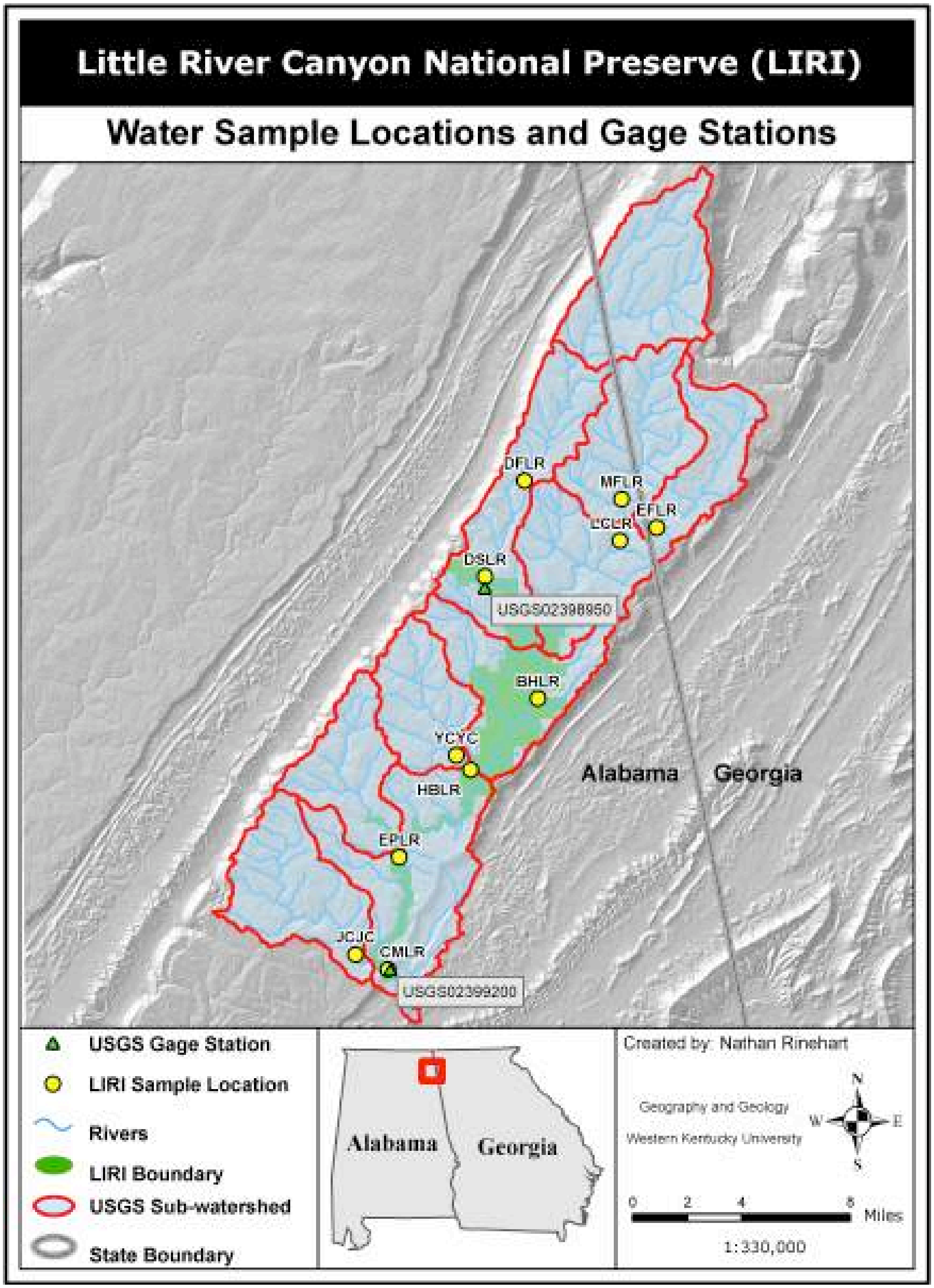


Figure 11. Little River Canyon National Preserve sample locations and gage stations. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR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

Table 5. 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 Park
DFLR	DeSoto Falls
DSLR	DeSoto State Park
EFLR	East Fork Little River
EPLR	Eberhart Point

LIRI Code	Sample Location Description
HBLR	Highway 35 Bridge
JCJC	Johnnie's Creek
LCLR	Lookout Mountain Camp
MFLR	Middle Fork Little River
YCYC	Yellow Creek

Table 6. Sub-watershed area compared to the Little River Canyon National Preserve watershed area. Source: Author, (MRLC Consortium 2007).

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%

sample location sub-watershed area includes the Middle Fork Little River (MFLR) and East Fork Little River sample location sub-watersheds as well as any area draining to the LCLR sample location. This is the reason why the last column in Table 6 does not sum to 100%.

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. Appendix F provides 11 maps showing the areas influencing each LIRI sample location. Figure 12 shows the 11 redefined sub-watershed boundaries compared to the USGS HUC-12 boundaries.

6.2. 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 Park) 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,

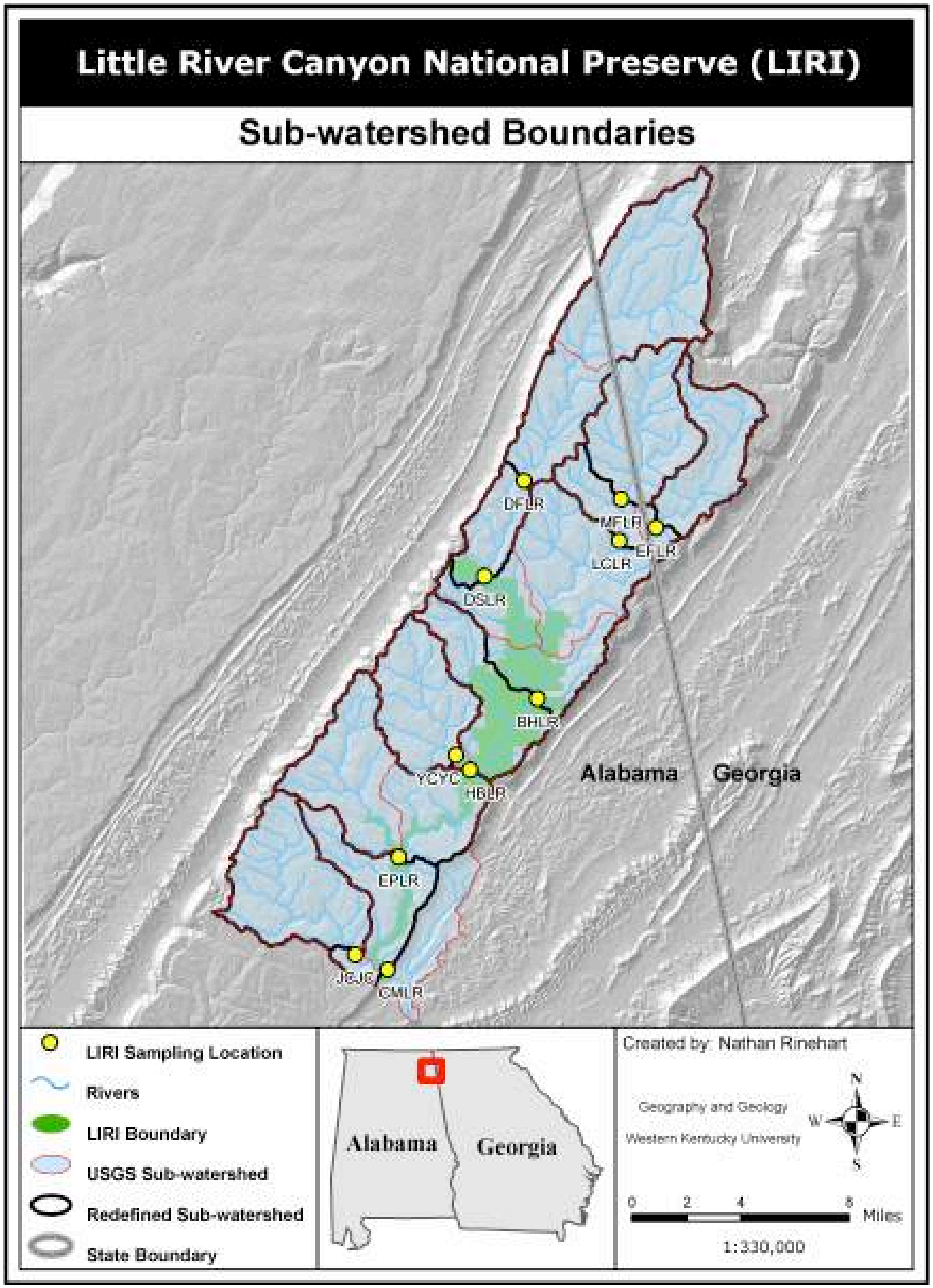


Figure 12. Redefined sub-watersheds at Little River Canyon National Preserve modified from the USGS sub-watersheds. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie's Creek, CMLR – Canyon Mouth Park. Source: Author, (USGS 2007a).

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 7 for USGS 02398950 (at DeSoto State Park) and Table 8 for USGS 02399200 (at Canyon Mouth Park) 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 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 9 for USGS 02398950 and Table 10 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 7. Mean annual statistics for gage station USGS 02398950. Cubic feet per second-cfs, feet-ft. Source: (USGS 2008).

Water Year	Gage Height (ft)	Discharge (cfs)
1998	No Data	83.7
1999	No Data	67.6
2000	2.783	54.7
2001	3.102	63.9
2002	No Data	71.8
2003	3.761	119.2
2004	No Data	78.1
2005	No Data	90.8
2006	No Data	44.2
2007	No Data	42.1

Table 8. Mean annual statistics for gage station USGS 02399200. Cubic feet per second-cfs, feet-ft. Source: (USGS 2008).

Water Year	Gage Height (ft)	Discharge (cfs)
1959	No Data	267.8
1960	No Data	412.9
1961	No Data	498.6
1962	No Data	566.2
1963	No Data	485.1
1964	No Data	562.7
1965	No Data	421.9
1966	No Data	357.7
1967	No Data	438.4
1968	No Data	No Data
1969	No Data	No Data
1970	No Data	No Data
1971	No Data	458.4
1972	No Data	459.7
1973	No Data	695.9
1974	No Data	550.2
1975	No Data	575.7
1976	3.764	555.3
1977	No Data	465.5
1978	No Data	557.8
1979	No Data	643.9
1980	No Data	547.6
1981	No Data	557.8
1982	No Data	536.7
1983	No Data	593.1
1984	No Data	633
1985	3.352	428.3
1986	3.077	191.7
1987	No Data	492
1988	3.268	237.4
1989	No Data	584.2
1990	No Data	783.7
1991	No Data	457.7
1992	3.591	438.6
1993	3.546	559.2
1994	No Data	495.6
1995	No Data	445.2
1996	4.071	640
1997	No Data	547
1998	No Data	484.5
1999	No Data	353.4
2000	3.223	251
2001	3.607	372.5
2002	3.353	373.7
2003	4.04	626.6
2004	No Data	379.4
2005	No Data	463.4
2006	3.894	200.6
2007	No Data	172.9

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

Rank	Date	Mean Daily Discharge (cfs)	Date	Mean Daily Gage Height (ft)
HIGHEST	**9/17/2004**	**4120**	**Same**	**12.04**
2nd Highest	5/6/2003	2520	Same	10.15
3rd Highest	4/3/2000	1880	Same	9.35
4th Highest	4/4/2000	1700	11/4/2004	9.12
5th Highest	1/25/2002	1700	5/7/2003	8.99
LOWEST	**9/15/1999**	**0.01**	**9/17/2000**	**1.08**
2nd Lowest	9/16/1999	0.01	9/16/2000	1.13
3rd Lowest	9/17/1999	0.01	8/21/2000	1.18
4th Lowest	9/19/1999	0.01	9/8/2007	1.25
5th Lowest	9/20/1999	0.01	9/10/2007	1.25

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

Rank	Date	Mean Daily Discharge (cfs)	Date	Mean Daily Gage Height (ft)
HIGHEST	**2/16/1990**	**27100**	**Same**	**12.73**
2nd Highest	4/13/1979	23000	3/4/1979	12.09
3rd Highest	9/17/2004	20900	7/17/1983	12.00
4th Highest	3/4/1979	19800	9/17/2004	11.43
5th Highest	7/24/1985	18900	7/18/1983	11.00
LOWEST	**7/20/1960**	**0.20**	**10/22/1976**	**1.38**
2nd Lowest	7/21/1960	0.20	10/15/1974	1.39
3rd Lowest	9/20/1999	0.27	10/21/1976	1.39
4th Lowest	9/28/1999	0.27	10/14/1974	1.40
5th Lowest	9/27/1999	0.28	10/31/1974	1.40

6.3. Water Quality

The sample locations depicted in Table 5 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 and for human consumption. The most widely used indicator bacteria are total coliform, fecal coliform, enterococci, fecal streptococci groups, and *E. coli*. *E. coli* are common to the waters of LIRI and fecal bacteria have exceeded state water quality limits for its water use classification in the past.

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 is a measurement of the scattering effect that suspended solids have on light. A high degree of scattered light will generate high turbidity values. While turbidity alone does not address the key questions about suspended solids, as turbidity is not necessarily directly correlative to the amount of material in suspension, it remains the most cost-effective measure. Turbidity has long been a parameter sampled at LIRI, which has an extensive watershed beyond its boundaries, where 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) determinations of dissolved-oxygen concentrations,

conductivity, pH, rate and equilibrium of chemical reactions, biological activity, and fluid properties rely on accurate temperature measurements.

6.3.1. 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. The date information was reformatted and a column was created and filled with each sample location's four-letter code established by the NPS. An additional column was created for *E. coli* and those values were imported from a corresponding database.

The database created from the CUPN Water Quality Program 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 conductivity" (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 11). It should be noted that most of the USEPA STORET locations

Table 11. USEPA STORET Station IDs comparable to Little River Canyon National Preserve sample locations. Source: Author.

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

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 12 shows the selected parameter codes used in the master database and their descriptions. During the 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 12. USGS water quality parameter codes used from the USEPA STORET database. Source: (USGS 2007b).

Parameter Code	Code Description
00010	Temperature, water (degrees Celsius)
00095	Specific conductance (UMHOS/CM @ 25C)
00300	Dissolved oxygen, unfiltered (mg/L)
00400	pH, unfiltered, field (standard units)
00620	Nitrate nitrogen, total (mg/L as N)
00660	Phosphate, Ortho (mg/L as PO_4)
00945	Sulfate (mg/L as SO_4)
82078	Turbidity, field nephelometric turbidity units (NTU)
	Acid neutralizing capacity – ANC, lab (mg/L)
	E. coli (colony forming units/100mL)

6.3.2. 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 13 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

Table 13. 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)	$\geq$ 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-uS/cm)	> 10 uS/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

past water quality monitoring efforts.

All water flowing through LIRI ends up at the Canyon Mouth Park (CMLR), the farthest downstream sample location (Figure 11). Making an assumption that water quality values at this sample location represent the cumulative water quality at LIRI, Table 14 was generated to provide a summary of the combined database for the Canyon Mouth Park (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 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

Table 14. Water quality summary for Canyon Mouth Park (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 (uS/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.

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 G). 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 H) 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 15) to provide a way in which to capture a holistic view of water quality in the LIRI watershed.

Table 15. 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 (uS/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.

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 13 displays a frequency chart that was generated for pH at the CMLR

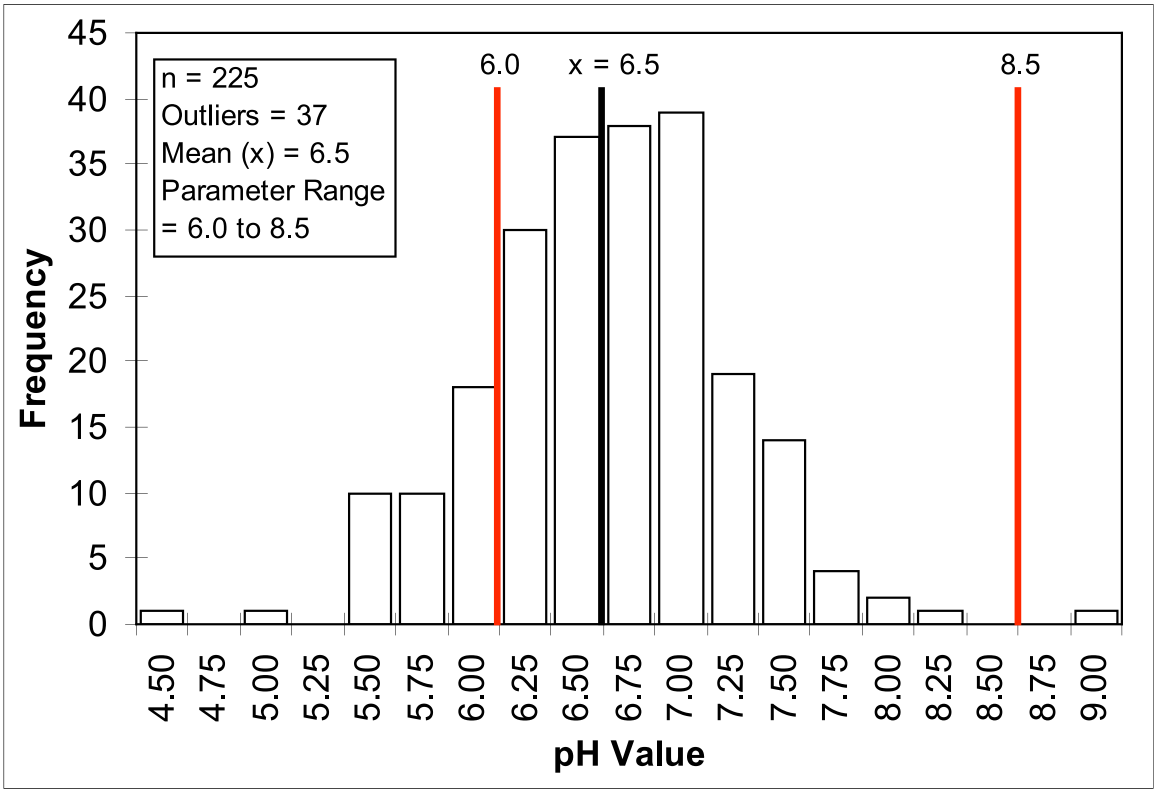


Figure 13. Histogram for pH at Canyon Mouth Park (CMLR) sample location. Source: Author.

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 Park (CMLR) sample location shows that 110 of the total 225 samples for the period of record occur during this time period (Table 16) and 16 of the total 37 lie outside the parameter limit, with 1996 being a particularly significant year for non-attainment. Table

Table 16. Summary table for pH values at Canyon Mouth Park (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%
Grand Total	**110**	**16**	

Table 17. Summary table for pH at Canyon Mouth Park (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%

17 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 record. Values of pH collected during the month of April had the lowest mean value and percent attainment for the period of record.

A summary table (Table 18) 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.

Table 18. Summary statistics by month for the period of record pertaining to E. coli at the Canyon Mouth Park (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.

To examine how *E. coli* values compare throughout the study area, Table 19 was generated showing summary statistics of each of the 11 sample locations. Yellow Creek

Table 19. Summary table comparing all sample locations pertaining to E. coli within the study area (ATN = Attainment). 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.

(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 19 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. 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 14) 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 14, which measures how

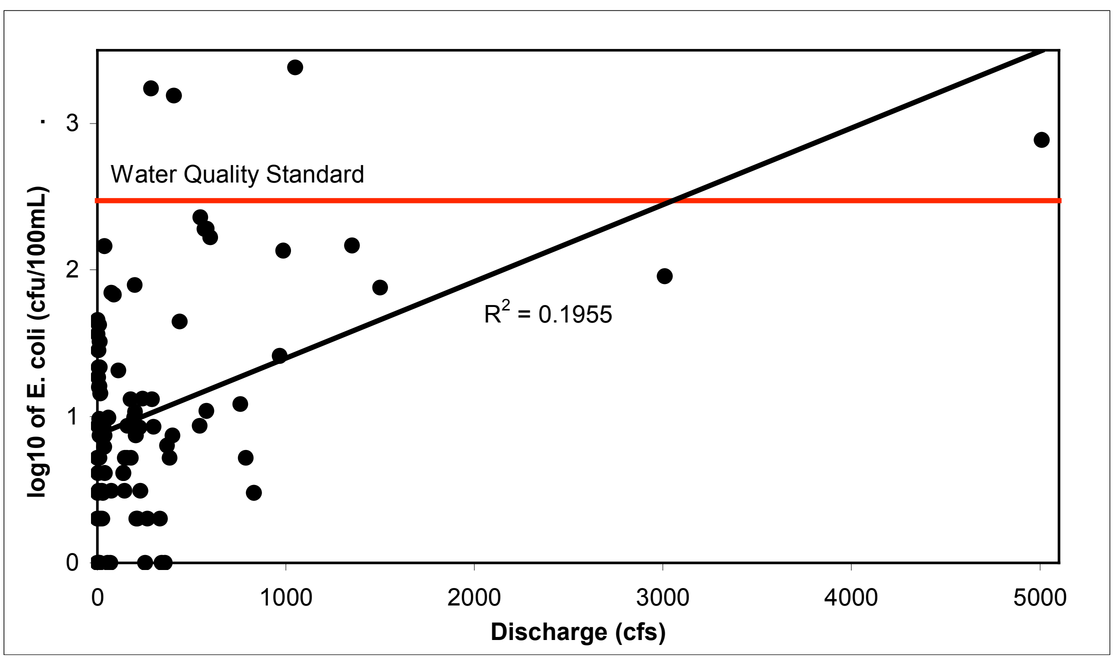


Figure 14. Scatter plot graph of E. coli and discharge values for the Canyon Mouth Park (CMLR) sample location. Source: Author, (USGS 2008).

well a regression line approximates real data points, suggests 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.

6.4. Summary and Discussion

Table 20 provides a number of ways to summarize water quality conditions in the LIRI watershed. The "condition" column shows the number of sample stations divided

Table 20. Sample location counts by condition level with overall results of water quality conditions. ATN = Attainment. Source: Author.

Parameter	Condition				n (All)	% ATN (All)	% ATN (CMLR)
ANC	11	0	0	0	161	100%	100%
Dissolved Oxygen	2	3	6	0	1133	87%	99%
E. coli	0	5	6	0	894	91%	96%
Nitrate	11	0	0	0	859	100%	100%
pH	0	1	10	0	1117	85%	84%
Phosphate	11	0	0	0	168	100%	100%
SPC	11	0	0	0	915	100%	100%
Sulfate	11	0	0	0	760	100%	99%
Water Temperature	11	0	0	0	1346	100%	100%
Turbidity	11	0	0	0	1089	100%	100%
Total	79	8	23	0	8442		
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.							

by condition level that are associated with a water quality parameter with a total number of sample stations that fall within each condition level for all of the parameters at all of the sample stations. Column "n (All)" represents the total number of observations from all the sample locations for each parameter. Table 20 also shows an overall look at the percent attainment values over the entire LIRI watershed (% ATN (All)) from Table 15

and how they compare with the Canyon Mouth Park (CMLR) sample location (% ATN (CMLR)) from Table 14. To "roll up" these parameter conditions into an overall result for water quality, a weighted result and normalized result were 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.

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 14 and Appendix H were displayed geospatially in a summary map for water quality (Figure 15). 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 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 middle and southern portions of the LIRI watershed.

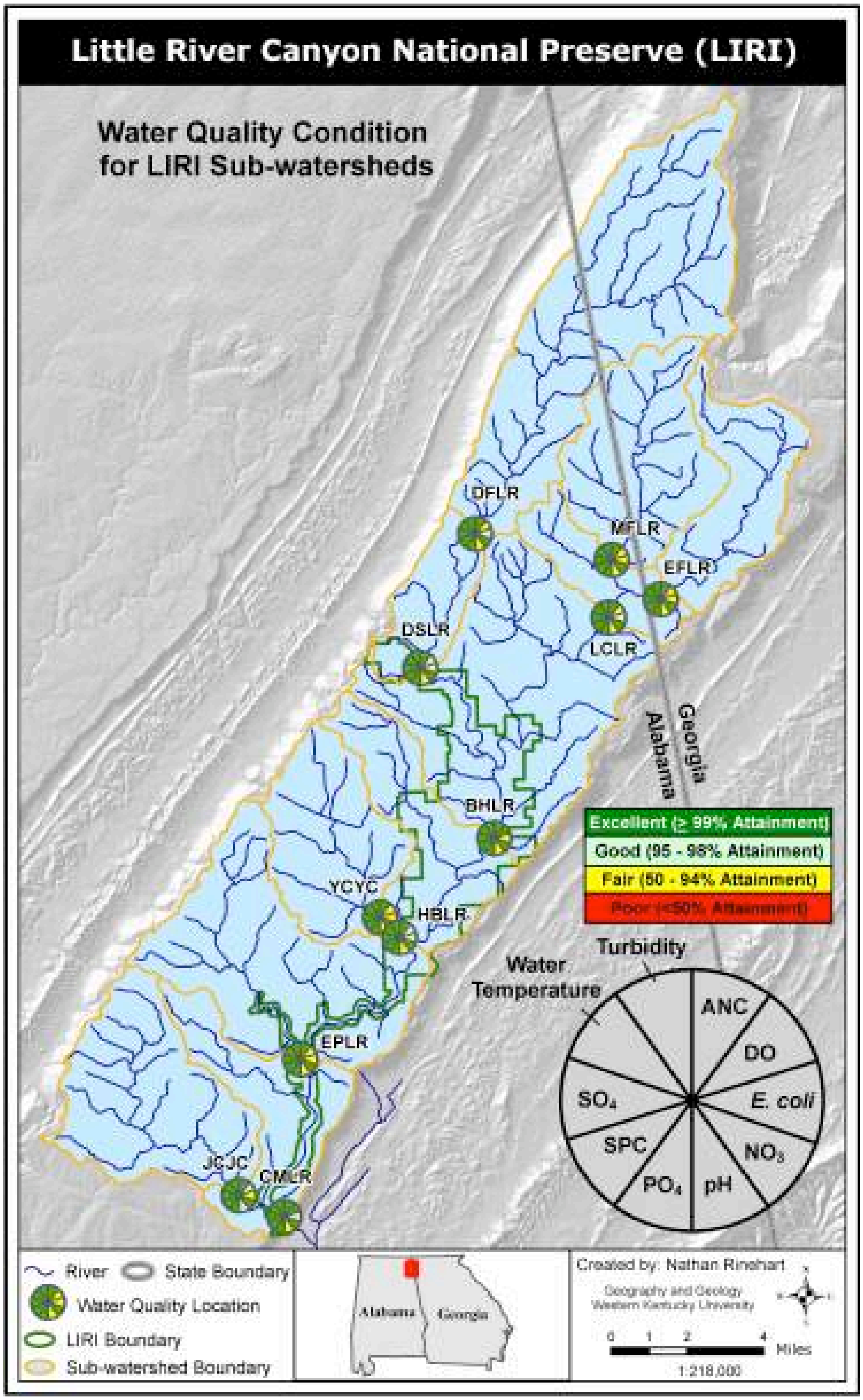


Figure 15. Water quality summary map of the Little River Canyon National Preserve watershed. DFLR – DeSoto Falls, MFLR – Middle Fork Little River, EFLR – East Fork Little River, LCLR – Lookout Mountain Camp, DSLR – DeSoto State Park, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie's Creek, CMLR – Canyon Mouth Park.

CHAPTER 7. ASSESSMENT OF LANDSCAPE RESOURCES

7.1. 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 this 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).

7.1.1. Data Preparation

Land cover for 2001 and land cover change between 1992-2001 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 sub-watershed boundary.

7.1.2. 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 16). Land cover percentage for the LIRI watershed boundary is presented in Table 21 and primarily consists of forest (~69%) followed by pasture/hay (~16%), shrub/scrub

Table 21. Percentage of land cover for 2001 within the Little River Canyon National Preserve watershed and the 400-meter buffer. Source: (MRLC Consortium 2007).

Cell Value	Land Cover Description	% of Total Area for LIRI Watershed	% of Total Area for 400-meter Buffer
11	Open Water	0.52%	0.48%
21	Developed, Open Space	2.38%	3.25%
22	Developed, Low Intensity	0.23%	0.36%
23	Developed, Medium Intensity	0.02%	0.03%
24	Developed, High Intensity	0.04%	0.01%
31	Barren Land (Rock/Sand/Clay)	0.21%	0.08%
41	Deciduous Forest	40.79%	41.85%
42	Evergreen Forest	12.26%	8.47%
43	Mixed Forest	20.75%	18.92%
52	Shrub/Scrub	4.18%	4.14%
71	Grassland/Herbaceous	4.15%	2.91%
81	Pasture/Hay	11.68%	16.45%
82	Cultivated Crops	2.45%	2.57%
90	Woody Wetlands	0.33%	0.47%
95	Emergent Herbaceous Wetlands	0.01%	0.01%

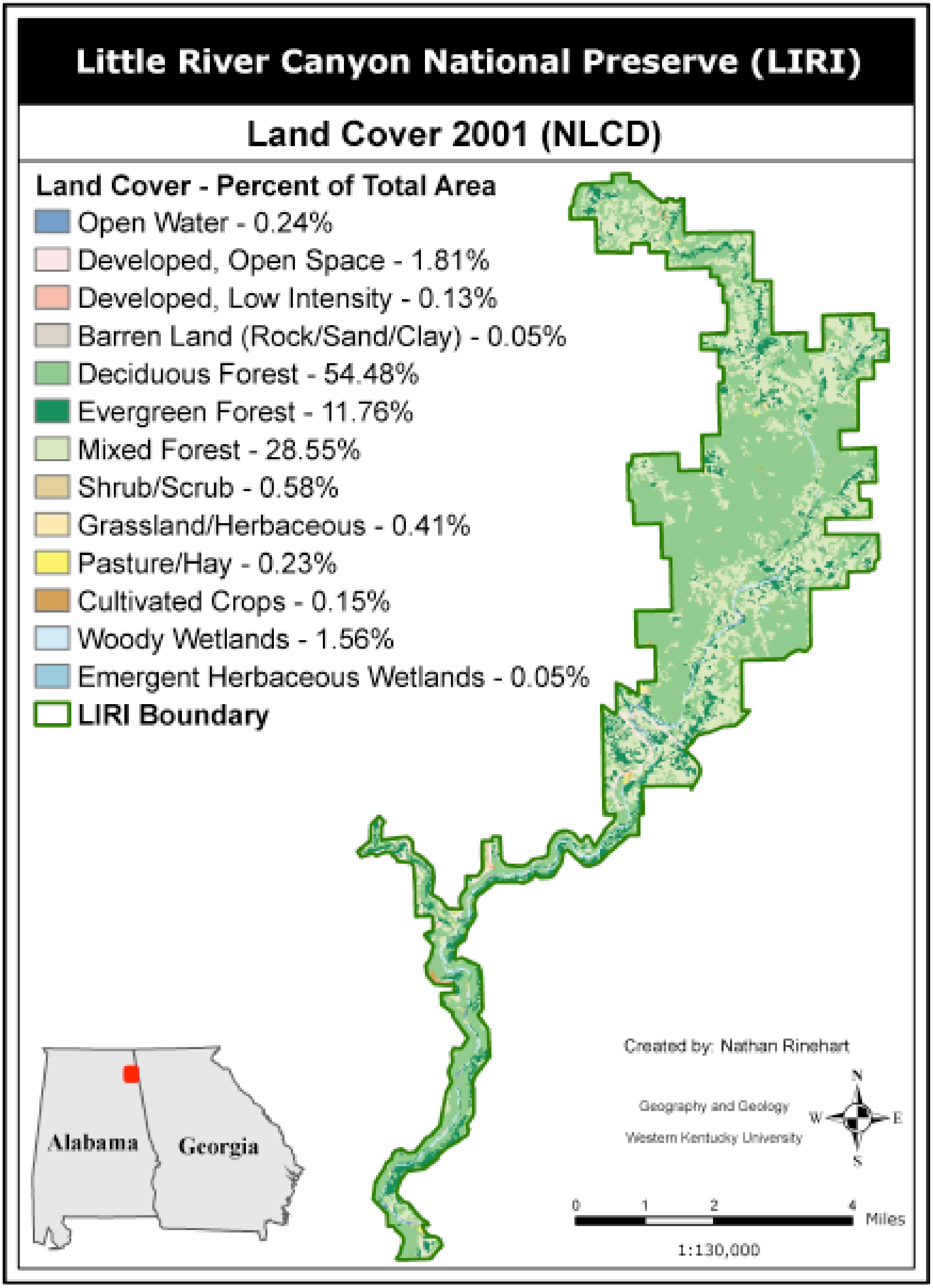


Figure 16. Land cover for the 2001 National Land Cover Database (NLCD) at Little River Canyon National Preserve. Source: (MRLC Consortium 2007).

(~4%), and developed, open space (~3%). Land cover percentage for the 400-meter LIRI buffer layer is also presented in Table 21 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 17 shows the land cover change 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 22 summarizes percentage of land cover change for each of the 11 sub-watersheds influencing LIRI. Total percent change in this table is calculated by summing the "from-to" categories starting with "Forest to Open Water". The Middle Fork Little River (MFLR) sample location shows the highest percent change (15.22%) followed by the Lookout Mountain Camp (LCLR) sample location (9.34%). In general, dominant land cover change is from "Forest to Grassland/Shrub" followed by "Forest to Agricultural Land".

7.2. 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

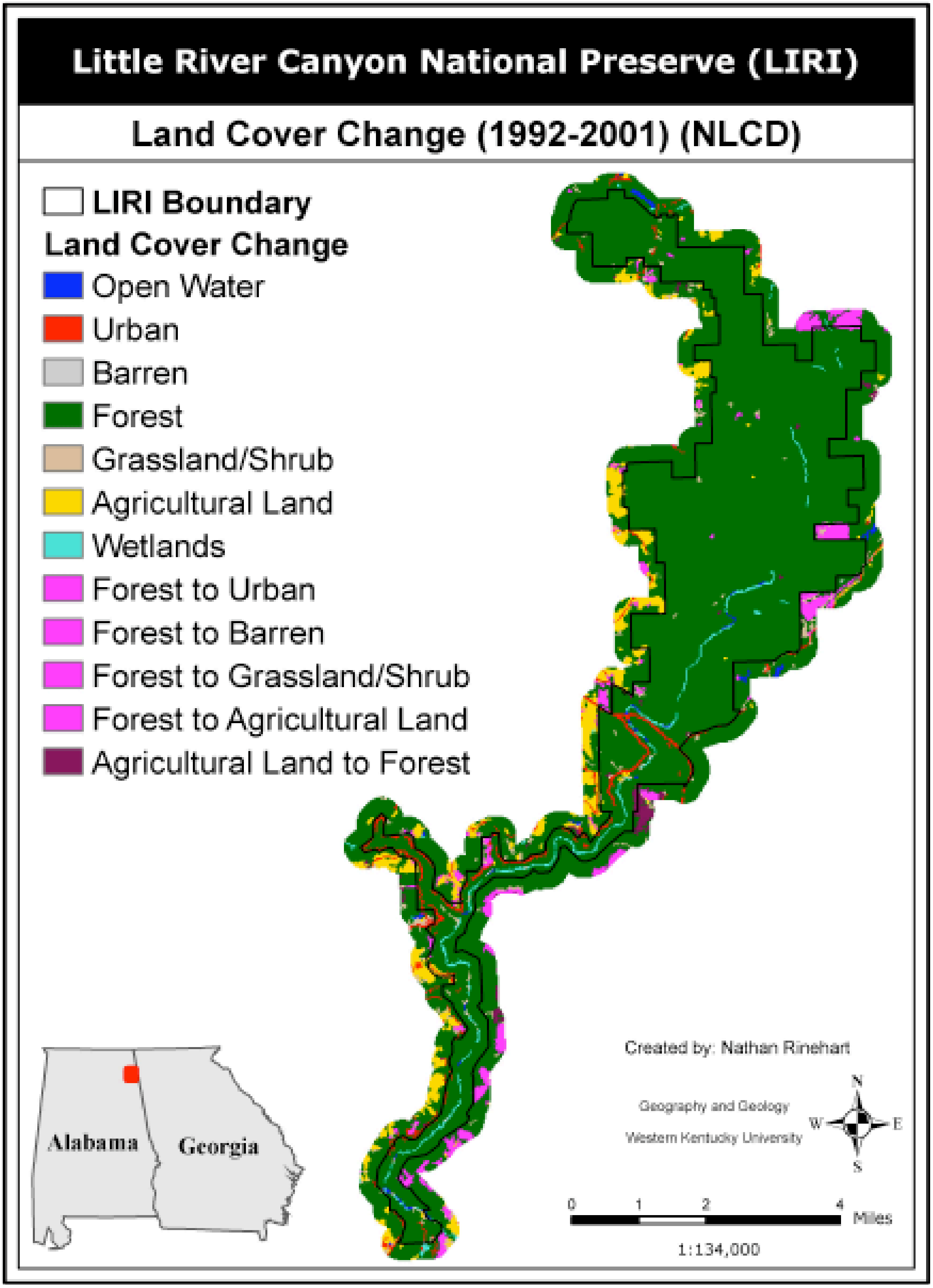


Figure 17. Land cover change between the 1992 and 2001 National Land Cover Database (NLCD) for Little River Canyon National Preserve and 400-meter buffer surrounding the Preserve. Source: (MRLC Consortium 2007).

Table 22. Land cover change summary (1992-2001) showing percent change for each of the eleven sub-watersheds influencing 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, BHLR – Burnt House Ford, YCYC – Yellow Creek, HBLR – Highway 35 Bridge, EPLR – Eberhart Point, JCJC – Johnnie's Creek, CMLR – Canyon Mouth Park). Source: (MRLC Consortium 2007).

Land Cover Change Description	BHLR	DFLR	DSLR	EFLR	EPLR	HBLR	JCJC	LCLR	MFLR	YCYC	CMLR
Forest to Open Water	0.01%	NONE	NONE	NONE	0.01%	0.01%	0.03%	NONE	NONE	NONE	0.01%
Forest to Urban	0.26%	0.16%	0.14%	0.22%	0.24%	0.25%	0.19%	0.48%	0.72%	0.24%	0.22%
Forest to Barren	0.11%	0.02%	0.01%	0.00%	0.07%	0.09%	0.03%	0.14%	0.30%	NONE	0.06%
Forest to Grassland/Shrub	4.05%	2.28%	2.12%	1.26%	3.59%	3.61%	3.93%	6.02%	10.69%	2.10%	3.81%
Forest to Agricultural Land	2.14%	3.14%	2.75%	0.87%	2.12%	2.12%	3.25%	2.18%	2.98%	2.88%	2.21%
Forest to Wetlands	0.00%	NONE	NONE	NONE	0.00%	0.00%	0.01%	0.01%	NONE	NONE	0.00%
Agricultural Land to Open Water	0.00%	NONE	NONE	0.02%	0.00%	0.00%	0.05%	0.01%	NONE	NONE	0.01%
Agricultural Land to Urban	0.00%	NONE	NONE	NONE	0.01%	0.00%	NONE	NONE	NONE	0.02%	0.00%
Agricultural Land to Forest	0.30%	0.07%	0.06%	0.43%	0.47%	0.31%	0.82%	0.50%	0.54%	0.50%	0.61%
Agricultural Land to Grassland/Shrub	0.01%	0.01%	0.01%	0.03%	0.01%	0.01%	NONE	0.01%	NONE	NONE	0.01%
Percent Change "from-to"	**6.89%**	**5.66%**	**5.08%**	**2.82%**	**6.52%**	**6.40%**	**8.31%**	**9.34%**	**15.22%**	**5.74%**	**6.95%**

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.

7.2.1. Data Analysis

Table 23 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

Table 23. 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)
8427	155	2014.66	14.70%	13.00
8430	163	1650.45	12.04%	10.13
7244	162	1409.17	10.28%	8.70
6327	145	1287.96	9.40%	8.88
2591	42	173.87	1.27%	4.14
3618	1	0.82	0.01%	0.82
3895	33	55.84	0.41%	1.69
3914	3	1.85	0.01%	0.62
4044	13	13.82	0.10%	1.06
4048	6	30.77	0.22%	5.13
4098	28	145.15	1.06%	5.18
4539	10	55.19	0.40%	5.52
4622	21	15.94	0.12%	0.76
4622x	11	14.36	0.10%	1.31
6011	45	159.99	1.17%	3.56
7119	138	728.65	5.32%	5.28
7192	1	1.15	0.01%	1.15
7330	6	14.99	0.11%	2.50
7388	4	5.46	0.04%	1.36
7443	19	82.58	0.60%	4.35
7493	56	1209.43	8.83%	21.60
7500	13	202.25	1.48%	15.56
7546	43	139.95	1.02%	3.25
8428	119	754.05	5.50%	6.34
8431	67	1158.16	8.45%	17.29
8462	60	631.65	4.61%	10.53
8488	21	219.74	1.60%	10.46
8495	34	53.77	0.39%	1.58
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**		

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 23 and include: 1) CEGL-8427 classified as “Shortleaf Pine – Mesic Oak (White Oak –Southern Red Oak – Post Oak – Black Oak) Forest” with 14.7%; 2) CEGL-8430 classified as “White Oak – (Chestnut Oak)/ Oakleaf Hydrangea – Mapleleaf Viburnum Forest” with 12.04%; 3) CEGL-7244 classified as “White Oak – (Southern Red Oak – Mixed Oak) – Pignut Hickory Forest” with 10.28%; and 4) CEGL-6327 classified as “Shortleaf Pine Early-Successional Forest” with 9.4%. CEGL-8430 contains the most patches followed by CEGL-7244. The category Water (W) contains the largest average patch size followed by CEGL-7493 classified as “Shortleaf Pine – Dry Oak (Chestnut Oak – Southern Red Oak) Forest”.

7.3. Summary and Discussion

The current condition of land cover within LIRI is 94% forested showing little land cover change (~0.71%) between 1992 and 2001. Land cover change adjacent to the Preserve may become a source of stress to resources within LIRI because a significant portion (~9.21%) of land is changing toward development. On a watershed scale, the Middle Fork Little River (MFLR) sub-watershed has the highest land cover change toward development (15.22%) 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.

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.

CHAPTER 8. 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, and potential flooding through failure of degraded dams.

8.1. ATV Use

ATV use is an emerging stressor to biological environments as users travel off the established roads and trails. Personnel at Little River Canyon National Preserve (LIRI) have identified areas where ATV use has destroyed areas of critical habitat for species, creating mud pits. One mitigation effort involves fencing off the areas so no further destruction takes place.

8.1.1. Data Preparation

NPS personnel maintain a database for ATV permits issued at LIRI. 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.

8.1.2. Data Analysis

ATV permits were counted for each year and a graph was generated to show values over time. Figure 18 shows nearly a five-fold increase in ATV permits issued at LIRI since 2000.

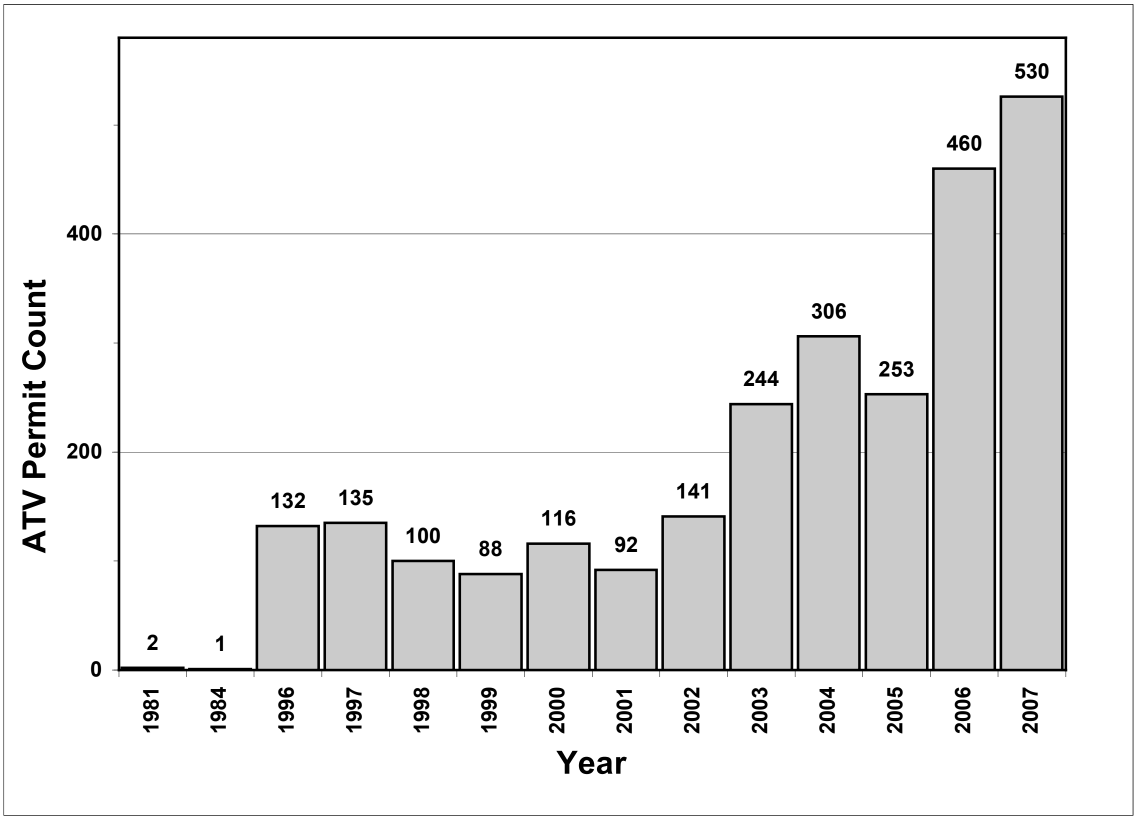


Figure 18. All-terrain vehicle (ATV) permits issued by year for Little River Canyon National Preserve. Source: (NPS 2008c).

8.2. 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 19). 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:

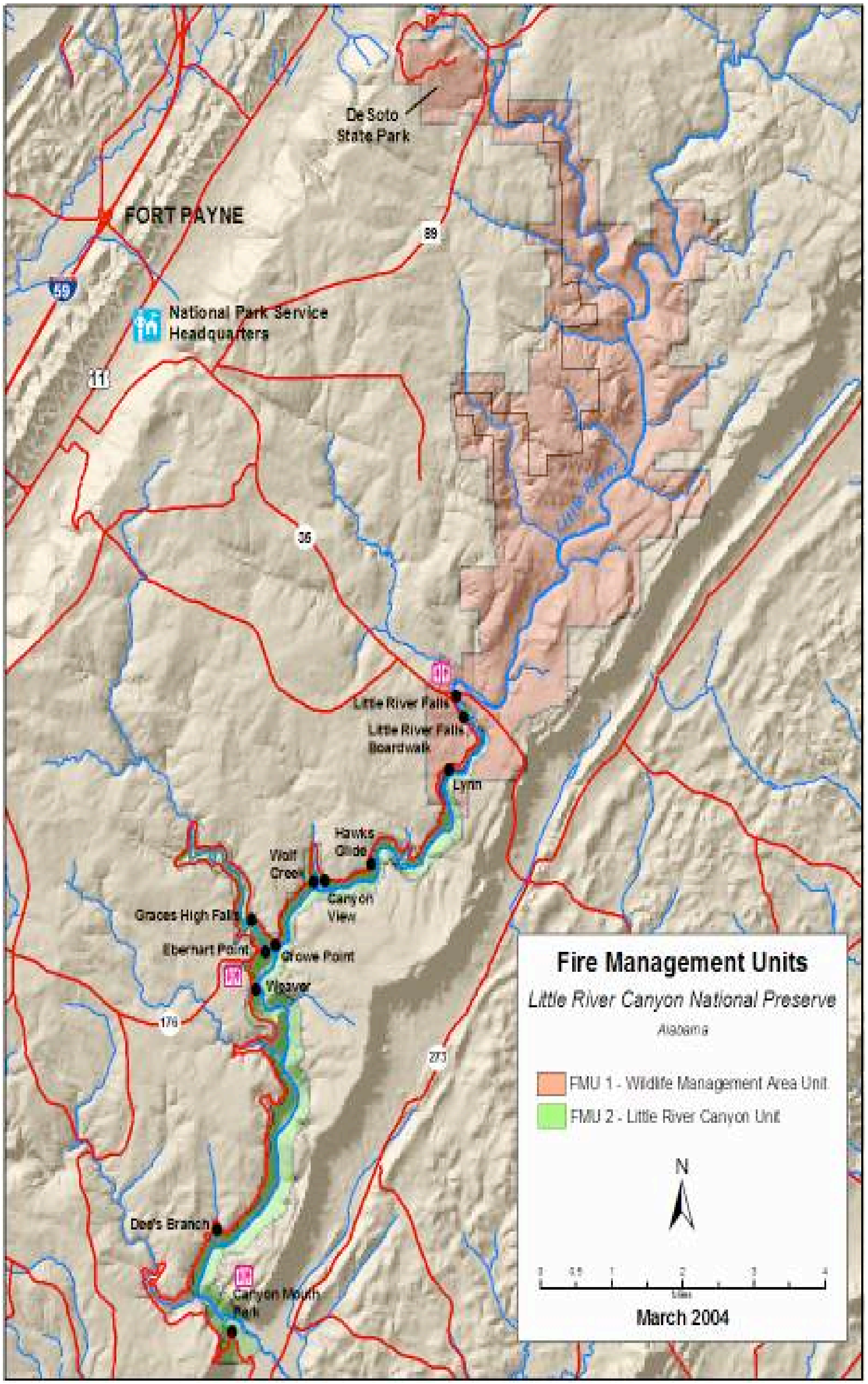


Figure 19. Fire Management Units (FMUs) for Little River Canyon National Preserve. Source: modified from (NPS 2005b).

> 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 results in 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, p.8)

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).

8.2.1. Data Preparation

The NPS maintains a database for tracking fires and park personnel keep individual fire reports at individual 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 LIRI 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 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.

8.2.2 Data Analysis

Figure 20 provides a summary of fire frequency and extent information from the combined fire report database. The upper graph in Figure 20 shows that 202 documented

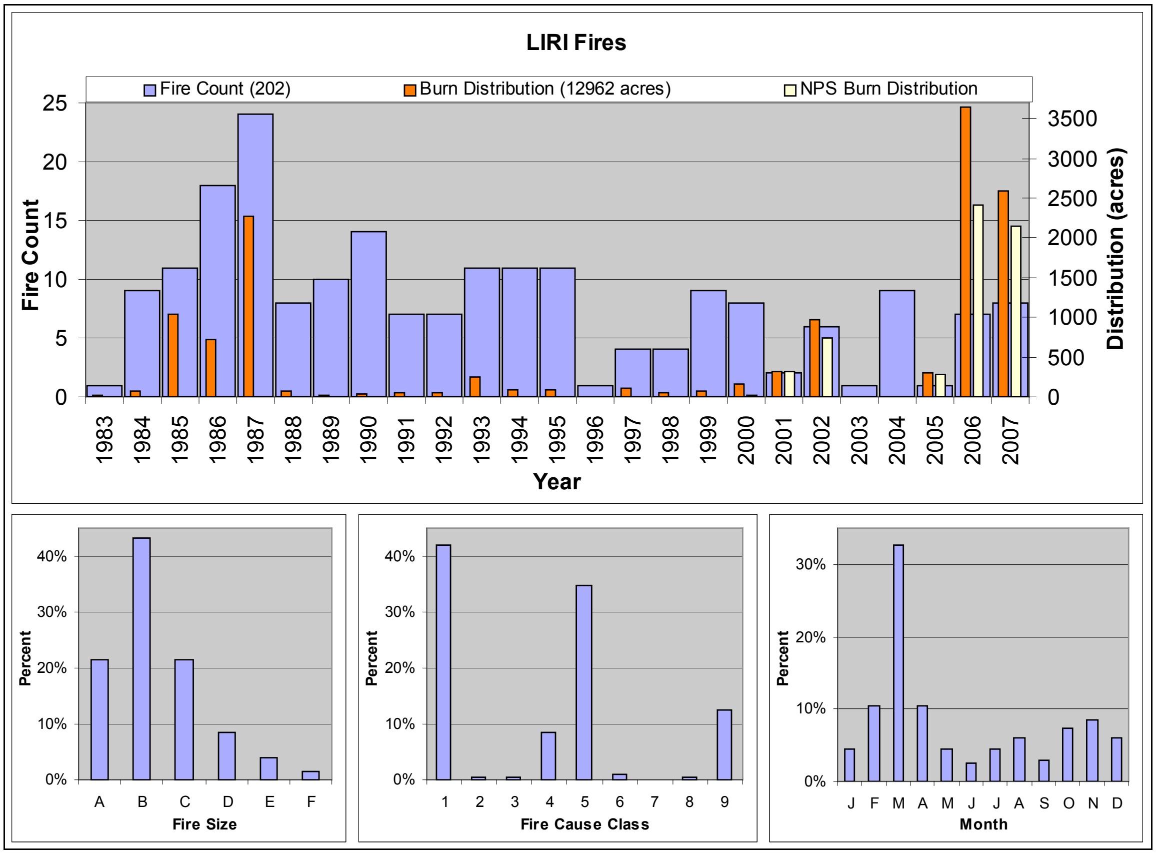


Figure 20. Summary of the fire report database for Little River Canyon National Preserve. Fire size: A (0.1-0.25 acres); B (0.26-9.9 acres); C (10-99.9 acres); D (100-299.9 acres); E (300-999.9 acres); F (1000-4999.9 acres). Fire cause class: 1 (natural); 2 (camp campfire); 3 (smoking); 4 (fire use); 5 (incendiary); 6 (equipment use); 7 (railroads); 8 (juveniles); 9 (miscellaneous). Source: (NPS 2005b; 2008d).

fires are represented in the combined fire report database between 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 20 (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 20 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 20 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 20 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 21 shows, geospatially, 57 of the 202 fire locations at LIRI. These 57 records are all that contained usable locational coordinates from the combined fire report database. Figure 21 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" occur near heavily used roadways in and adjacent to LIRI. Fires with the class of "4-Fire Use" are dispersed throughout LIRI

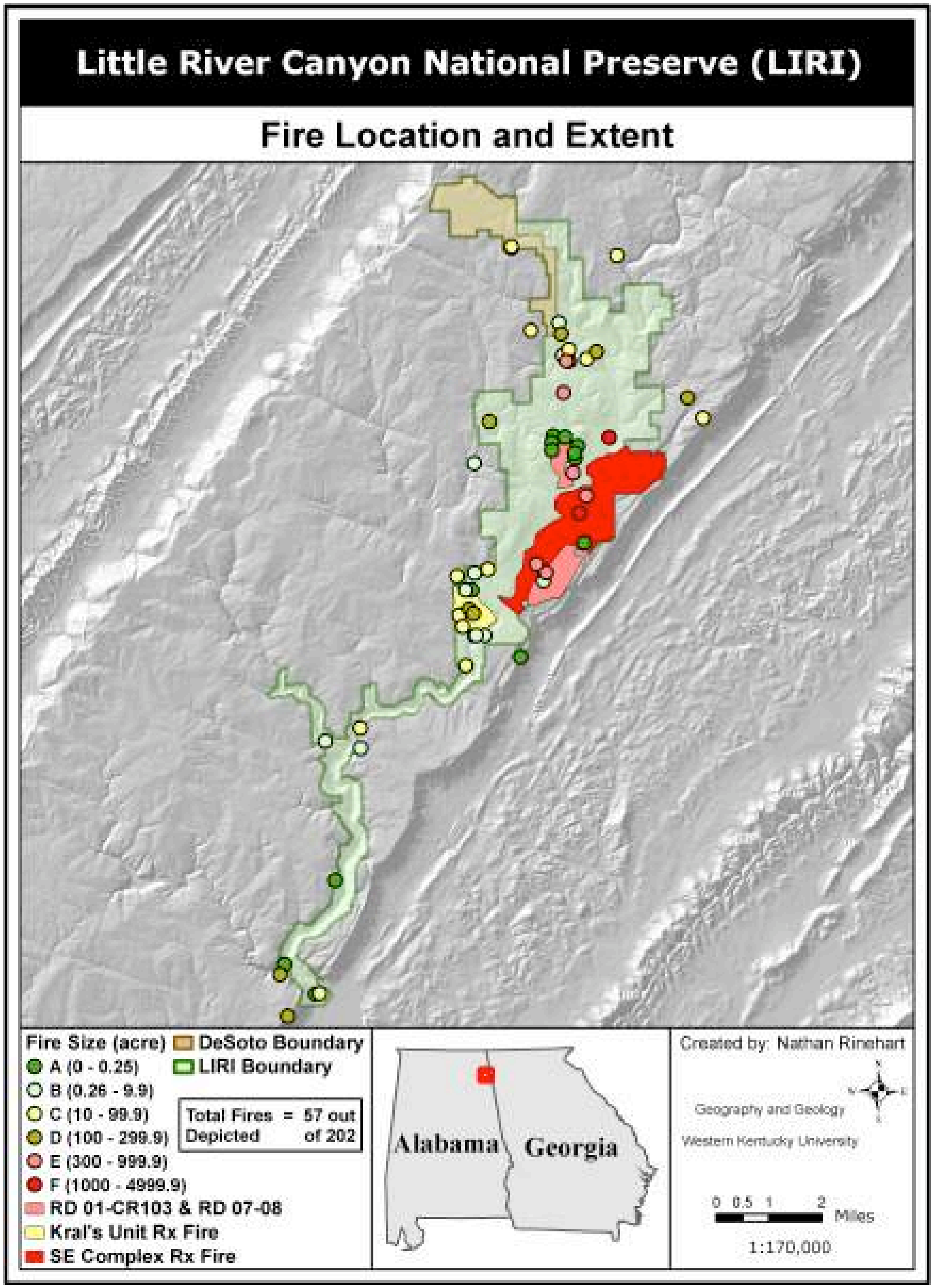


Figure 21. Location, fire size, and extent of selected fires at Little River Canyon National Preserve. Source: (NPS 2008d; USGS 2007c).

and include several prescribed burn events. The one instance of fire caused by "3-Smoking" occurred near Canyon Mouth Park.

In general, the number of burned acres was 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.

8.3. 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. 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.

8.3.1. 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 Chatooga 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 are 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.

8.3.2. Data Analysis

Census block level population density within the LIRI watershed for 2000 is shown in Figure 22. 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, though parcel data for Alabama are not easily available online without a purchasing fee. A database for housing permits, purchases,

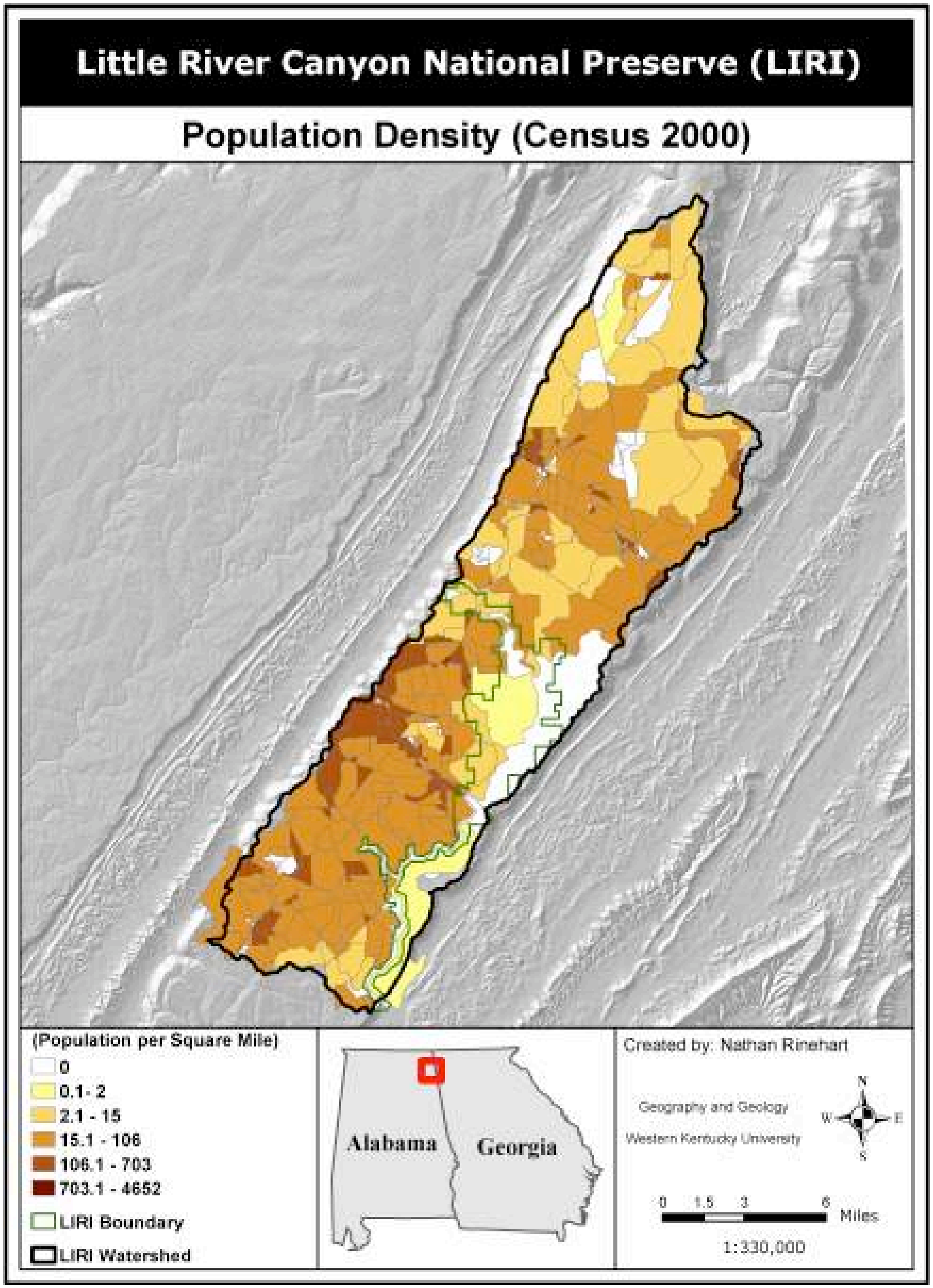


Figure 22. Census block level population density for 2000 at Little River Canyon National Preserve. Source: (ESRI 2008a).

and taxes could be used to obtain the houses built near LIRI for a specified time period.

8.4. Impervious Surface

According to the Center for Watershed Protection (Schueler, 2000), less than 10% impervious surface facilitates minimal impact to the environment, greater than 10% and less than 25% facilitates moderate impacts to the environment, and greater than 25% facilitates serious severe impacts to the environment. Accordingly, impervious surface proportions were not an issue within LIRI (less than 2%) or within the LIRI watershed (less than 3%) with land cover change to urban being less than 4%, so no further analysis was conducted.

8.5. 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.

8.6. 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, two abandoned surface/underground mines, four unknown type mines, and six active mines adjacent to LIRI and within the LIRI watershed (OSM 2008; GeoCommunity 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 mines within the LIRI watershed (NPS 2008e). Four of these active 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 23 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.

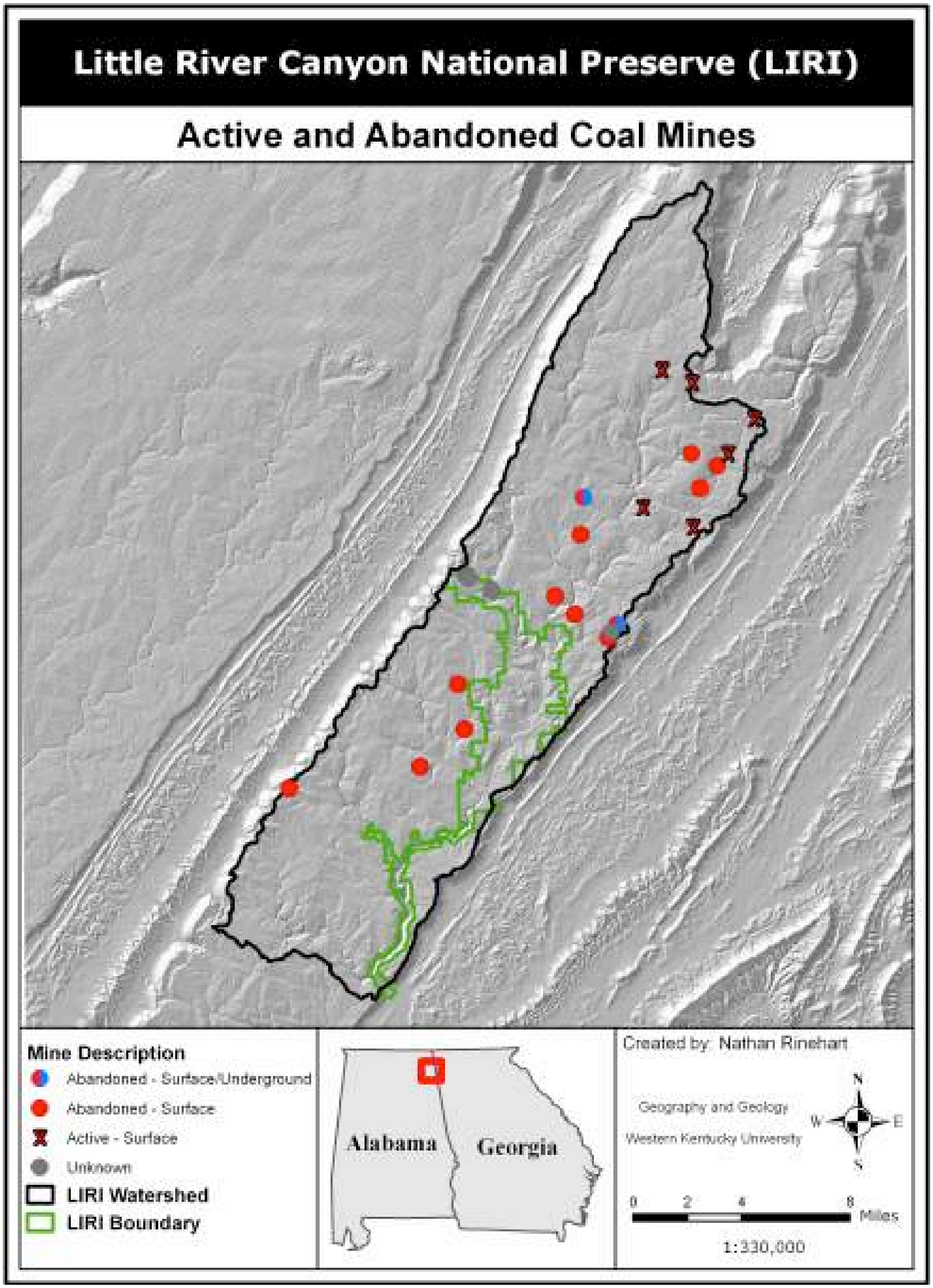


Figure 23. Abandoned and active mines within the Little River Canyon National Preserve watershed. Source: (NPS 2008e; OSM 2008; GeoCommunity 2008).

8.7. 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.

8.8. 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 current information in the National Inventory of Dams and National Performance of Dams Program (NPDP), there are eight dams identified within the LIRI watershed. All of these dams are considered 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 24 displays locations of the eight known dams

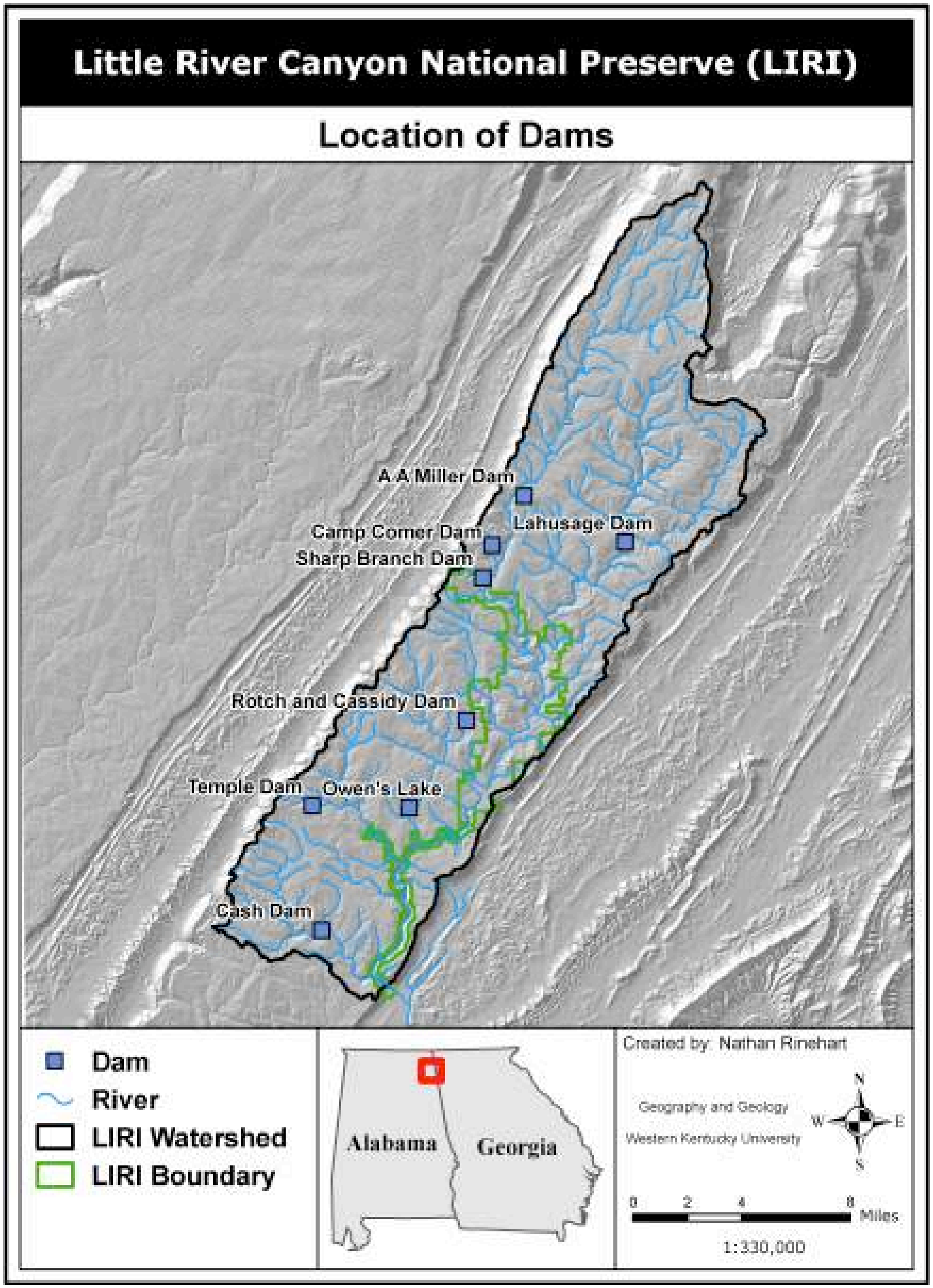


Figure 24. Location of dams within the Little River Canyon National Preserve watershed. Source: (NPDP 2008).

within the LIRI watershed.

8.9. 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 Park (CMLR, see Figure 15) and fair (yellow) for an accumulation of all sample location data values for *E. coli* for the period of record (see Table 20). Refer to Figure 15 for individual sample location conditions throughout the LIRI watershed.

8.10. Summary and Discussion

Table 24 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

Table 24. 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	--
E. coli contaminants	Unk	EP	PP	--
Degradation of dams	PP	PP	PP	--
Impervious surface	OK	PP	PP	--

Extent of problem: OK = OK, EP = Existing problem, PP = Potential problem, Unk = Unknown
Knowledge base: Light blue = Good, Pink = Fair, Grey = Poor

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 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. 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.

CHAPTER 9. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

9.1. 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 abiotic resources at LIRI.

Objective one, to identify natural resources of interest and related issues at LIRI, 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 (Section 5.2). 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 5.4, Table 4).

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 (Appendix D, Appendix E). Searches yielded numeric and descriptive information. Descriptive information is provided in the "Park and Resources Context" sections (Chapter 2) of this document. Numeric information is presented in the data analysis portions of this document (Chapters 6-8).

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 25.

Table 25. 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 Preserve 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
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
*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. Figure 4 provides the framework for assessment developed for this study. Methods for assigning a status condition for these category levels were established where possible. Water quality conditions were assessed using a knowledge-based modeling approach to compare the observed conditions to existing standards at the state or federal level. Each water quality parameter was given a condition status according to percent attainment over the period of record (Table 20, Figure 15). In the case of land cover (Chapter 7), the assessment was based on calculating the percent change toward development between two time slices namely 1992 and 2001. It was not possible to place a condition status on these values. Little data were available for geology and soil characteristics at LIRI, but available information for these are discussed in Chapter 2. No information for defining a condition status was available for geology or soils at LIRI. Information was identified for threats, stressors, and disturbances that could impact conditions for natural resources (Chapter 8). Best judgment was used to indicate the knowledge base and current extent of threats, stressors, and disturbances according to available data (Table 24).

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

9.2. 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) are outside the NPS influence to change.

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 26 summarize the status of natural resource conditions, watershed characteristics, and ratings for threats/stressors/ disturbances based on existing information from documentary sources and NPS commissioned studies. The "Resource or Issue" column comes from the assessment

framework developed in this study (Table 4) and each is identified by its rank as a "Level 2 category" or "Selected Indicator" attribute. The "Evidence" column in Table 26 provides evidence supporting the "Status" column.

Table 26. Condition status summary of natural resources and related issues for Little River Canyon National Preserve. Source: Author.

Resource/Issue	Status	Evidence
Hydrology (Level 2)	Unknown	
Water Quality (Level 2)	Good	Majority 100% attainment of water quality limits, although *E. coli*, dissolved oxygen, and pH are a concern (Table 20, Figure 15, Appendix H).
Landscape Pattern and Fragmentation (Selected Indicator)	Unknown	One time inventory (2008).
Soil Quality (Level 2)	Unknown	
*Land Cover Change (Selected Indicator)	Good	Land cover change toward development within LIRI is ~0.7%, within the watershed is ~7% (between 1992-2001).
*Land Cover Change - Adjacent Land (Selected Indicator)	Caution	Adjacent land cover change of ~9% within a 400m buffer of LIRI (between 1992-2001).
*Impervious Surface (Selected Indicator)	Good	Minimal impact to environment: Less than 2% within LIRI, less than 3% within LIRI watershed, less and 4% land cover change to urban (2001).
*Fire and Fuel Dynamics (Level 2)	Good	More prescribed burns, implementing Fire Management Plan (FMP) objectives.
*Silviculture (Selected Indicator)	Unknown	
*Mining (Selected Indicator)	Unknown	
*Viewscape (Level 2)	Caution	Visual evidence of houses built on canyon rim.
* Human Population Density (Selected Indicator)	Unknown	
*ATV Use Trend (Selected Indicator)	Caution	Trend of issued permits is increasing.
*Poaching Risk Factor (Selected Indicator)	Unknown	One instance of poaching in 14 years since establishment.
*Issues include threats, stressors, and disturbances		

9.3. 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 25 enabling the NPS resource managers to achieve a more comprehensive assessment of natural resources. A similar study addressing biotic natural resources of interest can provide additional knowledge and useful products. 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 Plant (GMP), NPS reporting goals, and Resource Stewardship Strategy (RSS) documents.

Recommendations 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.
    - Monitor additional sample locations, especially on the East Fork Little River where higher land cover change occurs and active mines potentially affect water quality, to identify and isolate sources of contaminants.
    - Monitor flood events for their potential impacts to landscape and species of concern.
2. Landscape Resources:
    - Review existing land development regulations and coordinate efforts to enforce the prevention/reduction of contaminants from roads and developing lands.
    - Present a bill to U.S. Congress allowing the expansion of the LIRI boundary to establish a viewscape buffer.
    - 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:
    - Conduct an inventory of cliff species, maintain climbing management plan efforts, and more closely monitor for climbing violations.
    - Maintain natural soils classified by the USDA NRCS.
4. Threats, Stressors, and Disturbances
    - Increase education and public awareness concerning wildlife poaching and more closely monitor for poaching violations.
    - Press to state to enact dam safety regulations and update the inventory of dams.
    - Ensure that state and federal listed threatened and endangered species and their habitats are protected and sustained
    - Ensure that invasive species are reduced in numbers and area, or eliminated.
    - More closely monitor for ATV violations and establish a restriction 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 concern.

ACRONYMS

ADEM	Alabama Department of Environmental Management
AEMA	Alabama Emergency Management Agency
AFC	Alabama Forestry Commission
ANC	Acid Neutralizing Capacity
ATN	Attainment
ATV	All-Terrain Vehicle
BHLR	Burnt House Ford
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 Park
CRMS	Center for Remote Sensing and Mapping Science
CSI	Cultural Sites Inventory
CUPN	Cumberland-Piedmont Network
DFLR	DeSoto Falls
DO	Dissolved Oxygen
DRG	Digital Raster Graphics
DSLR	DeSoto State Park
EBM	Environmental and Biotic Measures
EEA	Essential Ecological Attribute
EFLR	East Fork Little River
EPLR	Eberhart Point
ESM	EcoSystem Measures
ESRI	Environmental Systems Research Institute
F & W	Fish and Wildlife
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
HUC	Hydrologic Unit Code
I & M	Inventory and Monitoring Program
IDEA	Inventory Data Evaluation and Analysis
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
MFLR	Middle Fork Little River
MRLC	Multi-Resolution Land Characteristics
NA	Not Applicable
NHD	National Hydrography Dataset
NLCD	National Land Cover Database (2001) or Dataset (1992)
NPCA	National Parks Conservation Association
NPS	National Park Service
NRC	Natural Resource Challenge
NRCS	National Resources Conservation Service
NTU	Nephelometric Turbidity Units
NVCS	National Vegetation Classification System
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
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
SAB	Science Advisory Board
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
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
VSMP	Vital Signs Monitoring Plan
WED	Western Ecology Division
WCA	Watershed Condition Assessment
WRD	Water Resource Division
YCYC	Yellow Creek

APPENDICES

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 Macroinvertebrates	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	
		Marine Features and Processes	
		Stream/River Channel Characteristics	
		Lake Features and Processes	

Ecological Monitoring Framework			
Level 1 Category	**Level 2 Category**	**Level 3 Category**	**Comments**
Geology and Soils	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	
	Non-point Source Human Effects	Non-point Source Human Effects	

Ecological Monitoring Framework			
Level 1 Category	**Level 2 Category**	**Level 3 Category**	**Comments**
Human Use	Consumptive Use	Consumptive Use	
	Visitor and Recreation Use	Visitor Use	
	Cultural Landscapes	Cultural Landscapes	
Landscapes (Ecosystem Pattern and Processes)	Fire and Fuel Dynamics	Fire and Fuel Dynamics	
	Landscape Dynamics	Land Cover and Use	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. List of search terms and databases.

<u>SEARCH TERMS</u>

General Terms
Little River Canyon
Alabama
Desoto State Park
Cherokee county
DeKalb county
Fort Payne
Lookout Mountain
Natural resources
Watershed
Wildlife management
Coosa
Basin
Coosa basin
Tribal land

Landscape Context
Viewshed
View shed
Viewscape
View scape
Land development
Landuse
Land use
Silviculture
Silvicultural
Impervious surface
Mining
Mines
Coal
Fire
Fuel dynamics
Fuel potential

Geology and Soils
Soil
Soil moisture
Geology
Hydrogeology
Geomorphology
Formation
Lithology
Lithologic
Fault

Human Use
Population density
Population
Recreation
ATV
Kayak
Swimming
Rock climbing
Poaching
Visitor
Visitor use

Biotic Condition
Green Pitcher Plant
Exotic
Exotic plants
Species
Exotic species
Native
Nonnative plants
Threatened species
Endangered species
Vegetation
Communities
Vegetation communities
Habitat
Habitat type
Plants
Plant diversity
Ozone plants
Ozone injury
Ozone sensitive plants
Benthic macroinvertebrates
Indicator species
Avian
Birds
Herpetofauna
Herpetofaunal
Amphibian
Frog
Reptile
Snake
Fish
Blue Shiner fish
Forest pests
Southern pine beetle
Deer
Wildlife

Water Condition
Water
Wetland
Hydrology
Water quality
Acid neutralizing capacity
ANC
Dissolved oxygen
E. coli
Nitrate
pH
Phosphate
Specific conductance
Sulfate
Water temperature
Turbidity
Water flow

Air Condition
Climate
Climatology
Temperature
Precipitation
Air quality
Visibility
Particulate matter
Ozone

SEARCH DATABASES

Library Databases

MarciveWeb
Worldcat
FirstSearch
- Economic Literature
- GEOBASE
- SIRS Researcher

GeoScience World
- Georef

EBSCOHost
- Academic Search Premier
- AGRICOLA
- MasterFILE Premier
- Newspaper Source
- TOPICsearch

Project MUSE
- JSTOR

Jacksonville State University Library

Internet Search Engines

Google.com
- Scholar
- U.S. Government Search

Altavista.com

Federal and State Agencies

National Park Service (NPS)
United States Department of Agriculture (USDA)
United States Environmental Protection Agency (USEPA)
United States Geological Survey (USGS)
United States Fish and Wildlife Service (USFWS)
Natural Resources Conservation Service (NRCS)
The Nature Conservancy (TNC)

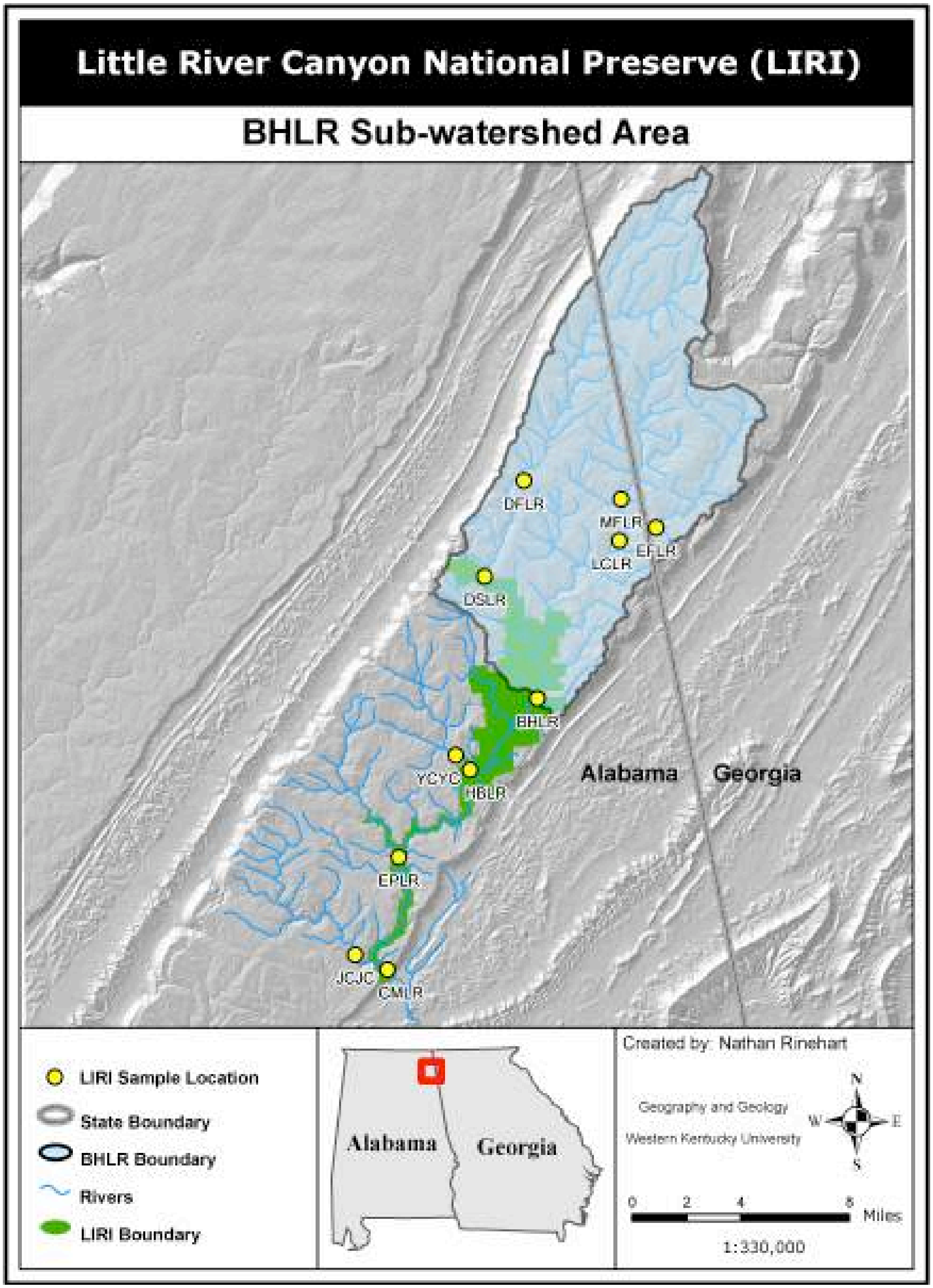
Geological Survey of Alabama (GSA)
Alabama Department of Environmental Management (ADEM)
Georgia Environmental Protection Division (GA EPD)
Southeast Regional Climate Center (SERCC)

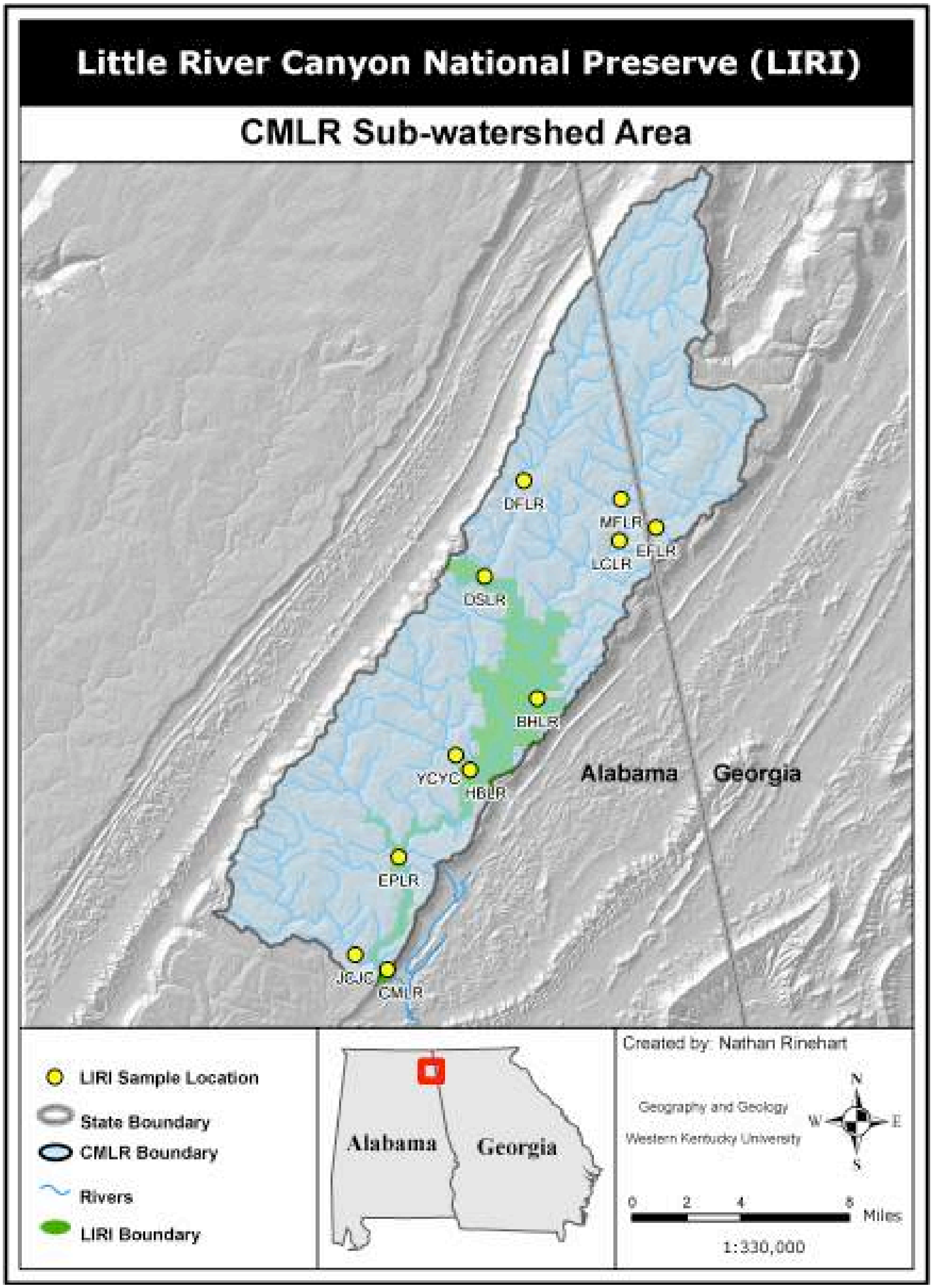
Appendix E. Data summary sheet from literature search.

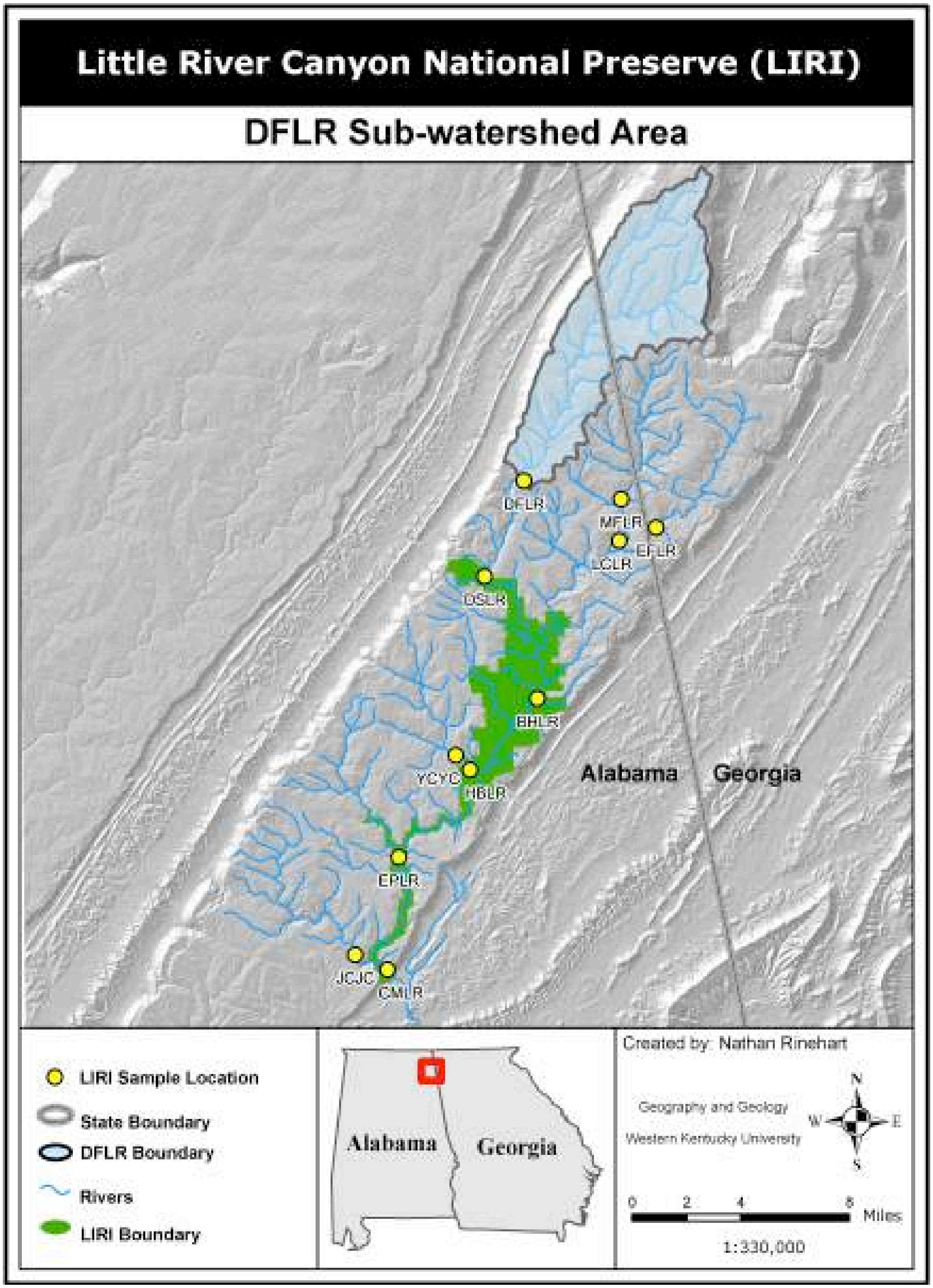
Resource	Coverage Area	Time Frame	Data Source/Access	Data Format	Scale/Resolution/ Accuracy	Sampling Technique	Attributes Used	Description
Digital Geologic Map	Alabama	2006	Geological Survey of Alabama (Website)	Vector	1:250,000	Created from scanned copy of hardcopy 1988		Base Map
Digital Park Boundary	LIRI	2001	LIRI Personnel (Mary Shew)	Vector	1:24,000	Digitized from DRGs		Base Map, LIRI Area
Digital Census Data	LIRI Watershed	2000	http://arcdata.esri.com/data/tiger2000/tiger_download.cfm	Vector	1:100,000	Census every 10 years	Population, Area	Population Density
National Elevation Dataset	LIRI Watershed	1999	http://seamless.usgs.gov/	Raster	10m Resolution	Seamless layer of best available elevation data	Elevation	Hillshade
Digital Topographic Maps (DRG)	LIRI Watershed	Varies	http://seamless.usgs.gov/	Raster	1:24,000, 1m cell size	Created from scanned hard copy	Elevation contours	Base Map
Digital Fire Locations	LIRI	1983-2007	http://fam.nwcg.gov/fam-web/weatherfirecd, http://burnseverity.cr.usgs.gov/show_list.php, LIRI personnel	Vector, Excel Database	NPS fire report methodology	NPS fire report methodology	Date, Location, Fire distribution, Fire perimeter	Fire frequency, Fire distribution
Digital Land Cover	LIRI Watershed	2001	http://www.mrlc.gov/	Raster	30m Resolution	Created from satellite imagery	Area, Land cover class	Percent land cover
Digital Land Cover Change	LIRI Watershed	1992-2001	http://www.mrlc.gov/	Raster	30m Resolution	Created using from to matrix analysis	Area, Land cover class	Percent land cover change
Digital Soils (SSURGO)	LIRI	2005	http://soils.usda.gov/).	Vector	1:24,000	Determined by field observations and remote sensing data	Soil series class	Base Map
Digital Vegetation Map	LIRI	2006	http://crms.uga.edu	Vector	1:12,000	Delineated from color aerial photographs	Patch number, Patch size	Current Condition
Digital Vegetation Buffer Map	400m LIRI Buffer	2006	http://crms.uga.edu	Vector	1:12,000	Delineated from color aerial photographs	Vegetation class	Current Condition
Digital Water Sample Locations	LIRI Watershed	2005	CUPN Vital Signs Monitoring Plan - Appendix S: Water Quality Monitoring Protocol Cumberland Piedmont Network	Vector	+/- 20-30 ft	Hand held GPS unit	Location	Base Map
USEPA STORET Database	LIRI Watershed	Pre-1997	http://www.epa.gov/storet/dbtop.html	Excel Database	NA	Any agency could input data into database	Location, Water parameter values	Water Quality
JSU Water Quality Analysis	LIRI Watershed	1996-2006	Accessed from LIRI Personnel (Mary Shew)	Excel Database	NA	Various methods and protocols were used for sampling and analysis	Location, Water parameter values	Water Quality
NPS CUPN Water Quality Program Database (NPSTORET)	LIRI Watershed	2006-2007	NPS CUPN Inventory & Monitoring	Excel Database	NA	CUPN Water Quality Monitoring Protocol	Location, Water parameter values	Water Quality
Water Quality Parameter Limits for Water Use Classifications	LIRI Watershed	1986-2008	CUPN, ADEM 2008); (GA EPD 2008); (USEPA 1986); (USEPA 1999)	Report	NA	NA	Water quality parameter limits	Water Quality

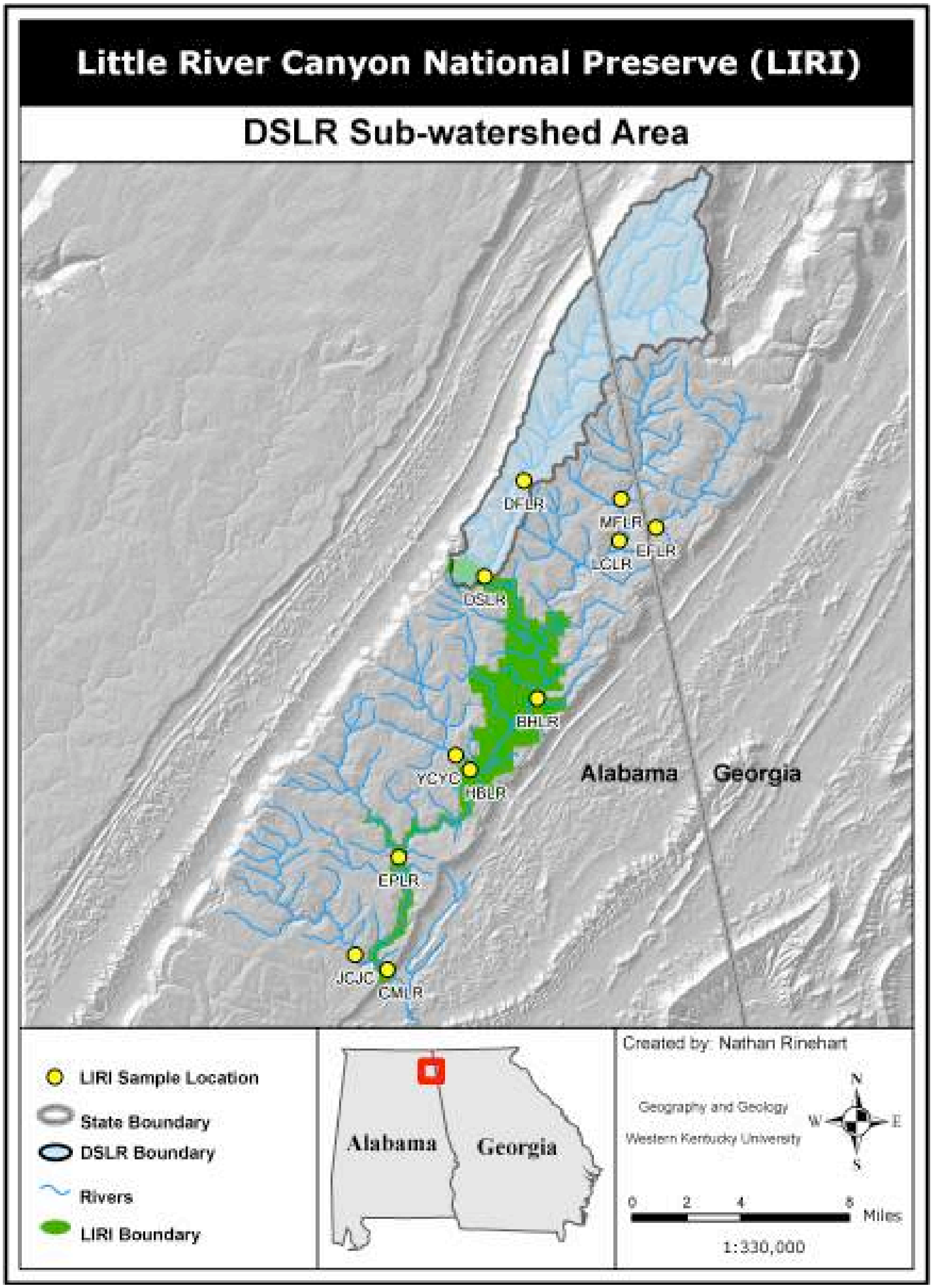
Resource	Coverage Area	Time Frame	Data Source/Access	Data Format	Scale/Resolution/ Accuracy	Sampling Technique	Attributes Used	Description
Water Use Classifications for Little River and Tributaries	LIRI Watershed	2006-2008	(Roy 2006), (ADEM 2008)	Report	NA	NA	Water use classifications	Water Quality
USGS Gage Station Data	LIRI	1958-2007	http://waterdata.usgs.gov/al/nwis/rt	Excel Database	NA	Automated recorders and manual field measurements	Location, Discharge, Gage height	Base Map, Water Quantity
USGS HUC Boundaries	LIRI Watershed	2003-2005	http://nhd.usgs.gov/	Vector	1:250,000 to 1:2,000,000		Boundaries, Names, Area	Base Map, Redefine Sub-watersheds
USGS NHD Data (Rivers)	LIRI Watershed		http://nhd.usgs.gov/	Vector			Location, Names,	Base Map
ATV Database	LIRI	1981-2007	NPS LIRI Database	Excel Database	NA	Permit sign up	Date, Quantity	ATV Use
NPS Park Index	LIRI	2005-2007	The National Parks: Index 2005-2007	Document	NA	NA	Park unit acres	Size reference, Nat. Preserve vs. Park
Park Establishment document	LIRI	1992	Public Law 102-427 October 21, 1992	Document	NA	NA	Establishment date, Purpose	Legislative background
Fire Report Form Instructions	NA	2007	NPS Wildland Fire Report Form Instructions 2007	Document	NA	NA	Reference to various number codes in fire report database	Reference of number codes
CUPN Vital Signs Monitoring Plan	NA	2005	(Leibfreid et al. 2005)	Document	NA	NA	Background, Resources of interest, Potential threats and stressors	Background, Reference
Digital Mine Locations	LIRI Watershed	1983-2005	(NPS 2008e; AMLIS 2008; GeoCommunity 2008)	Vector	1:24,000		Location, Mine type, Active or abandoned	Base Map

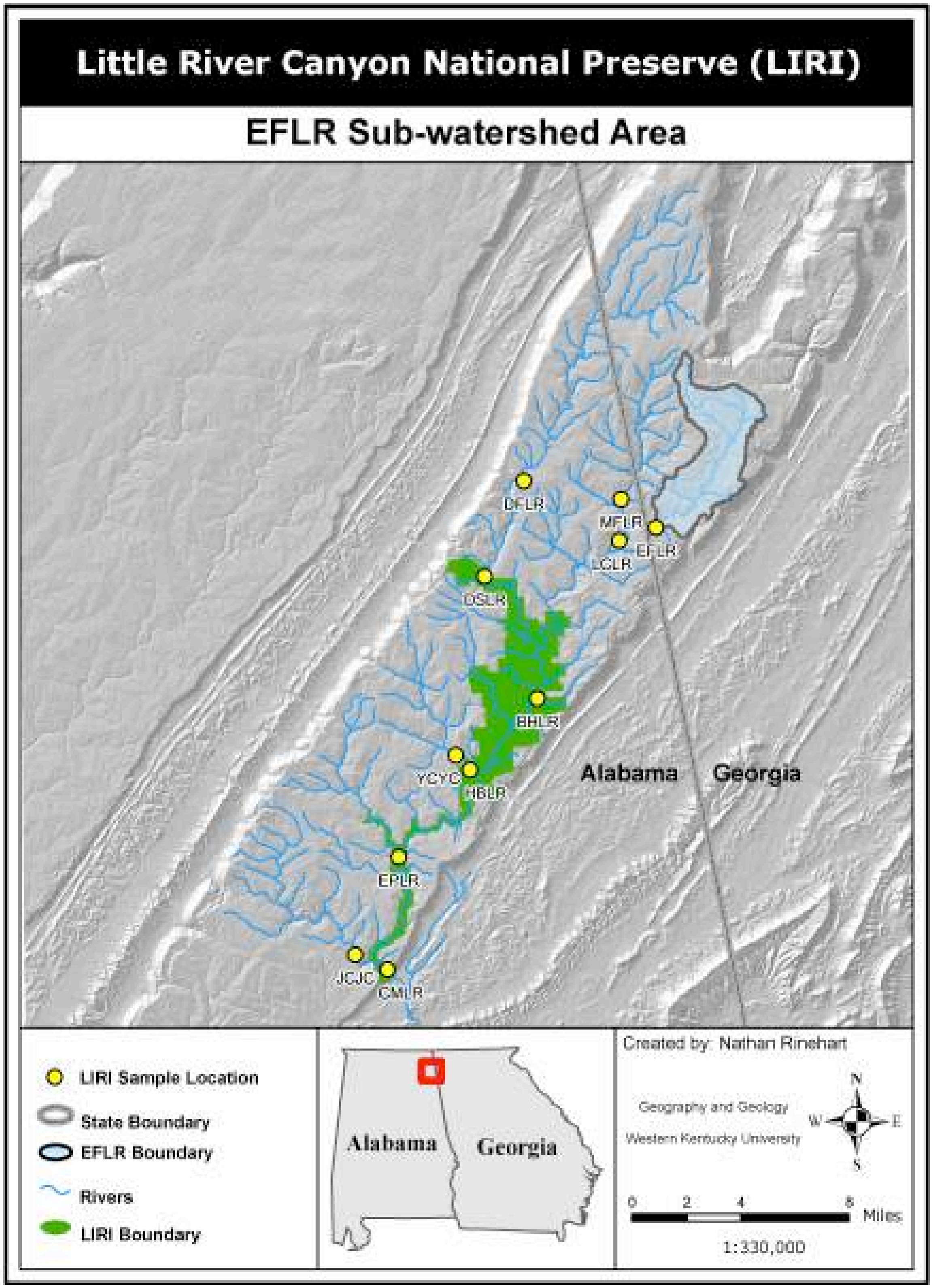
Appendix F. Sub-watershed area for sample locations within the Little River Canyon National Preserve watershed.

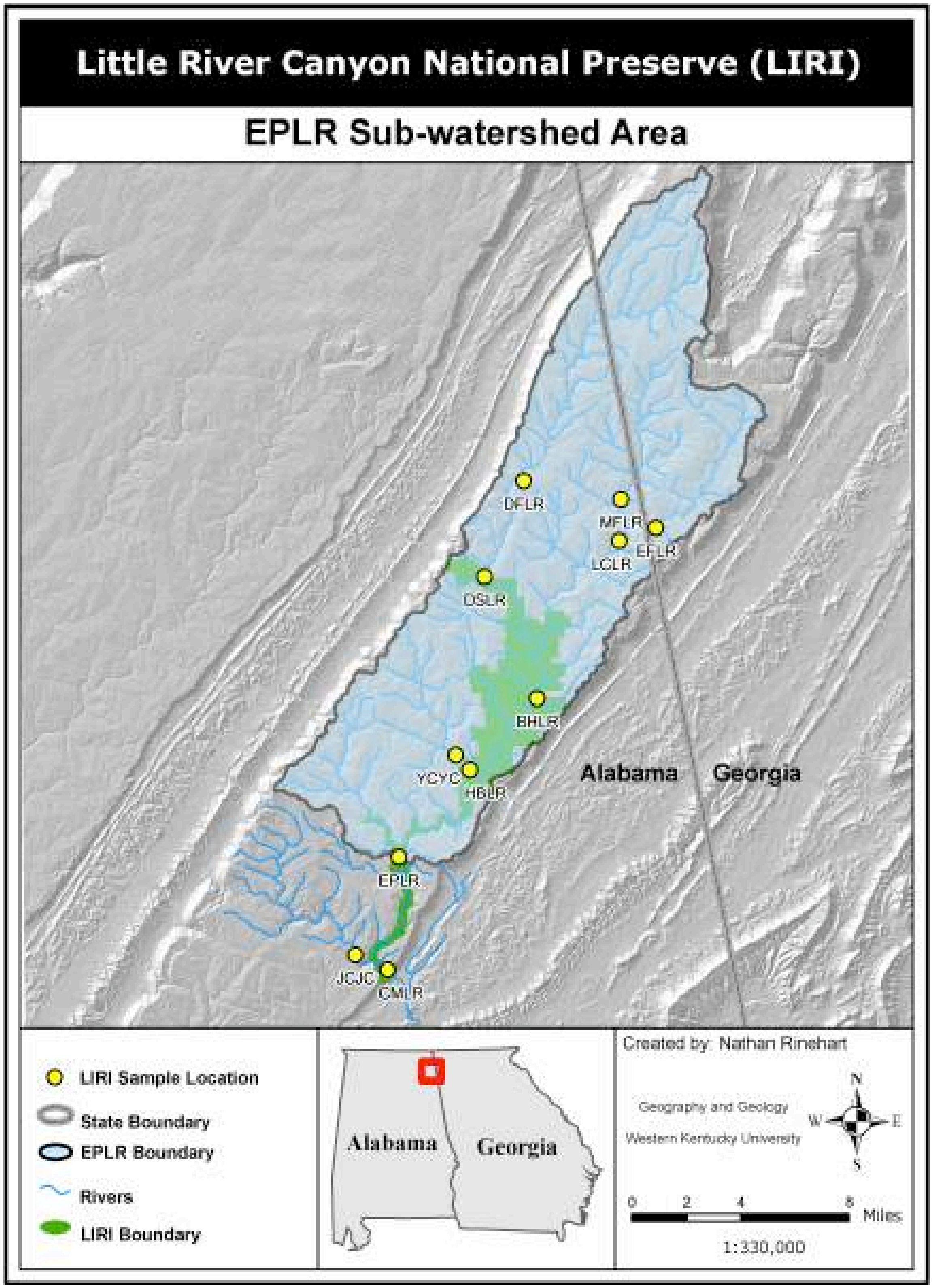


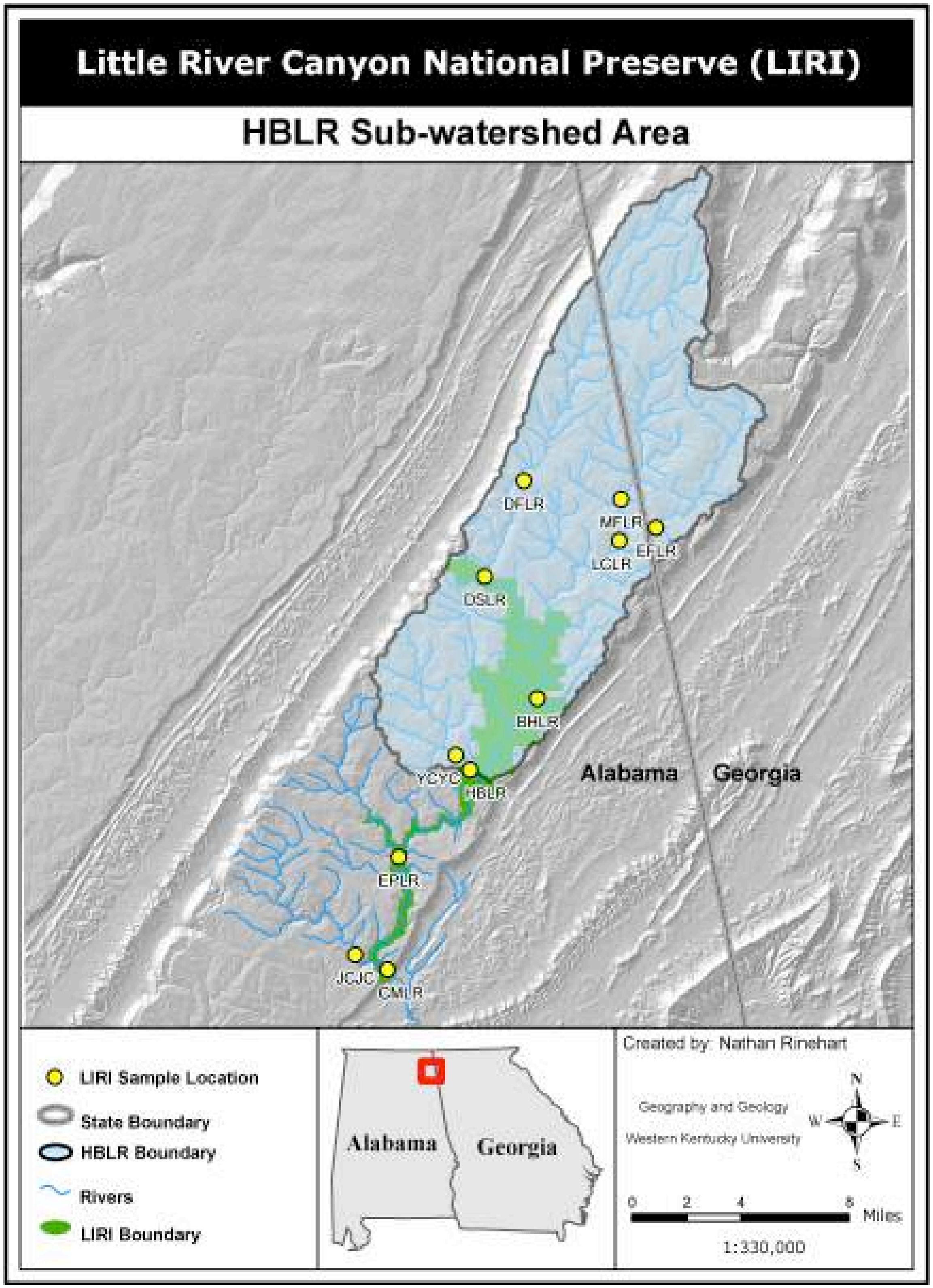

Little River Canyon National Preserve (LIRI)
CMLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
CMLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0 2 4 8
Miles
1:330,000

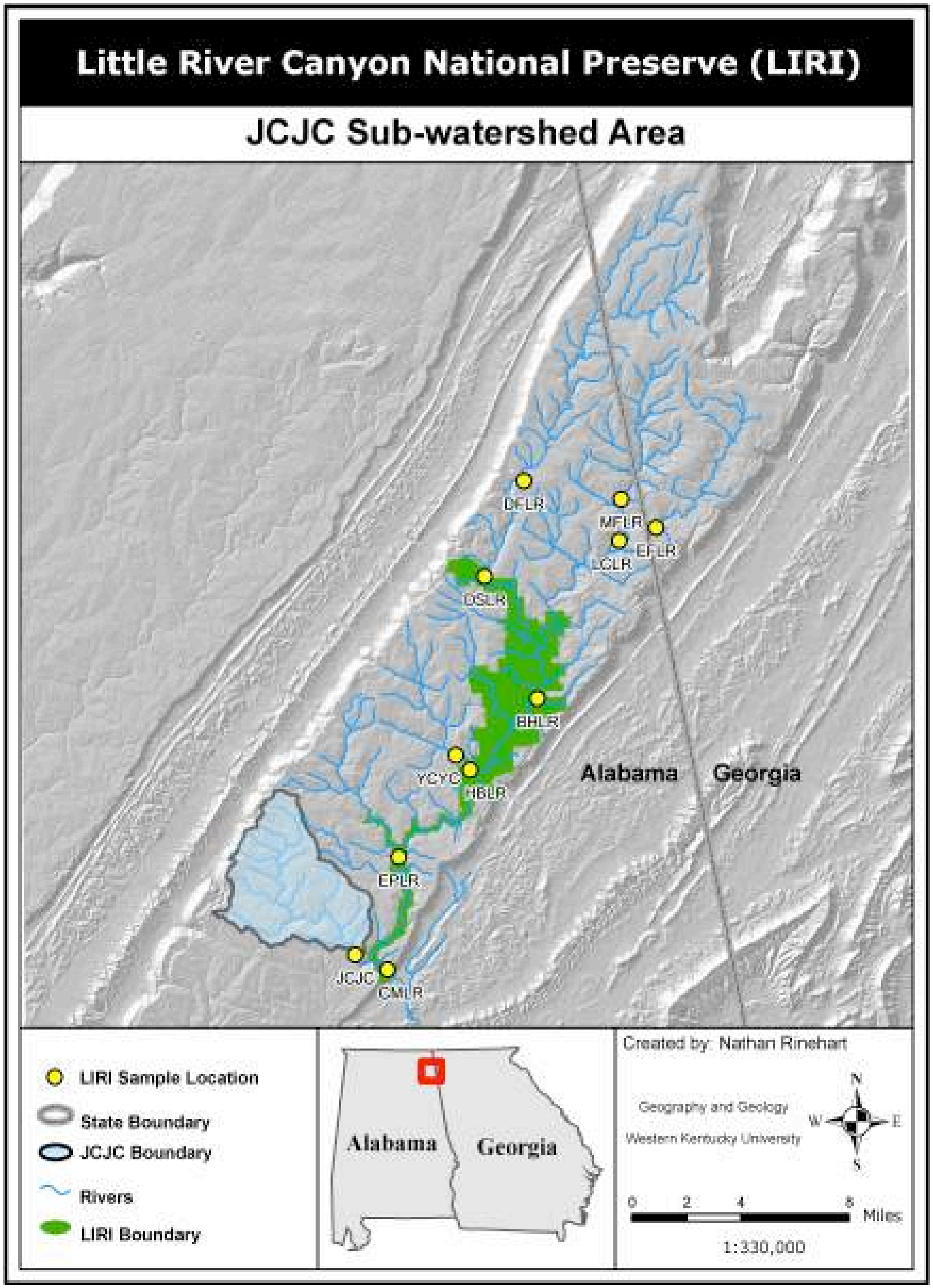

Little River Canyon National Preserve (LIRI)
DFLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
DFLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0 2 4 8
Miles
1:330,000

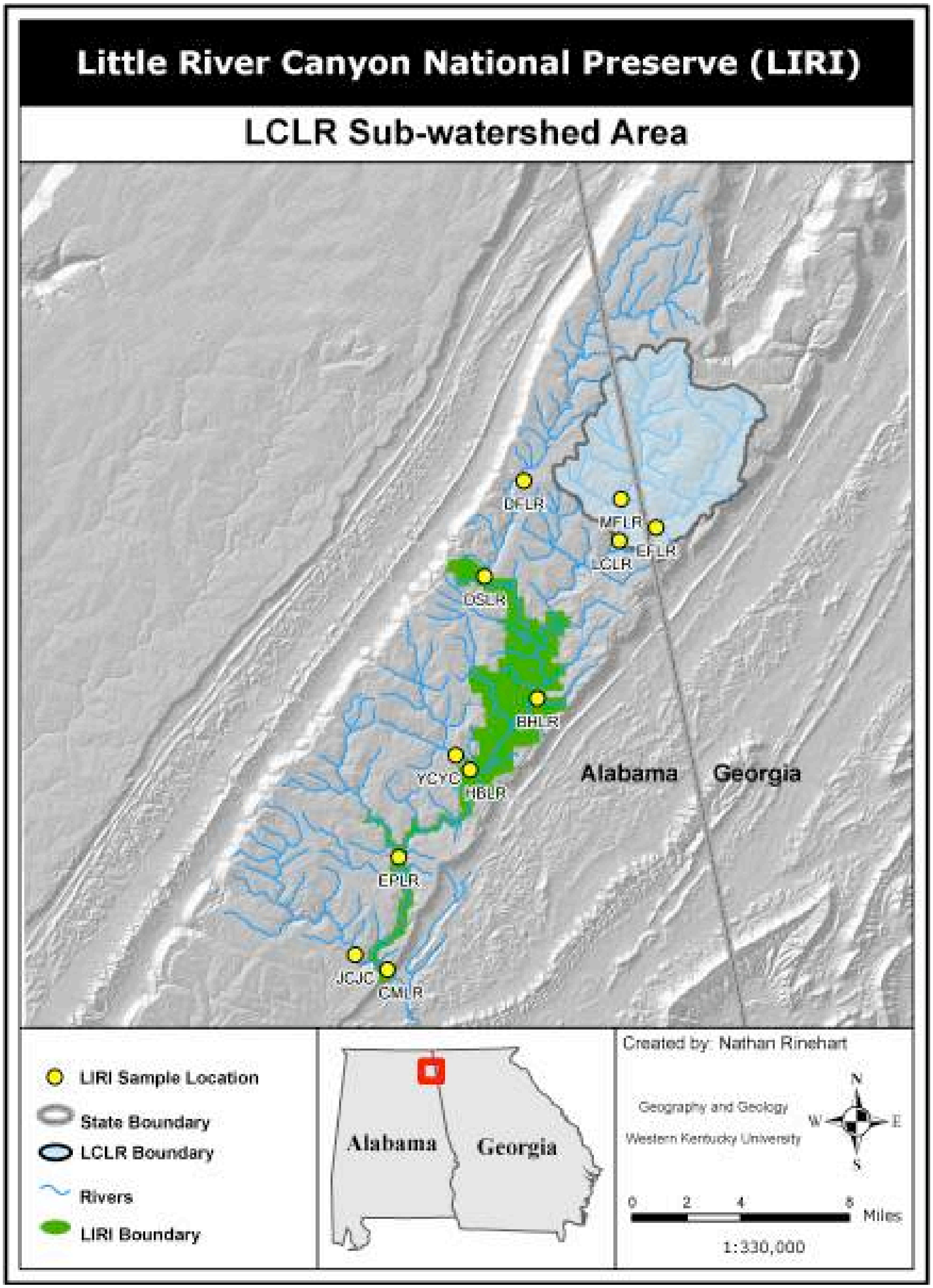

Little River Canyon National Preserve (LIRI)
DSLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
DSLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0
2
4
8
Miles
1:330,000

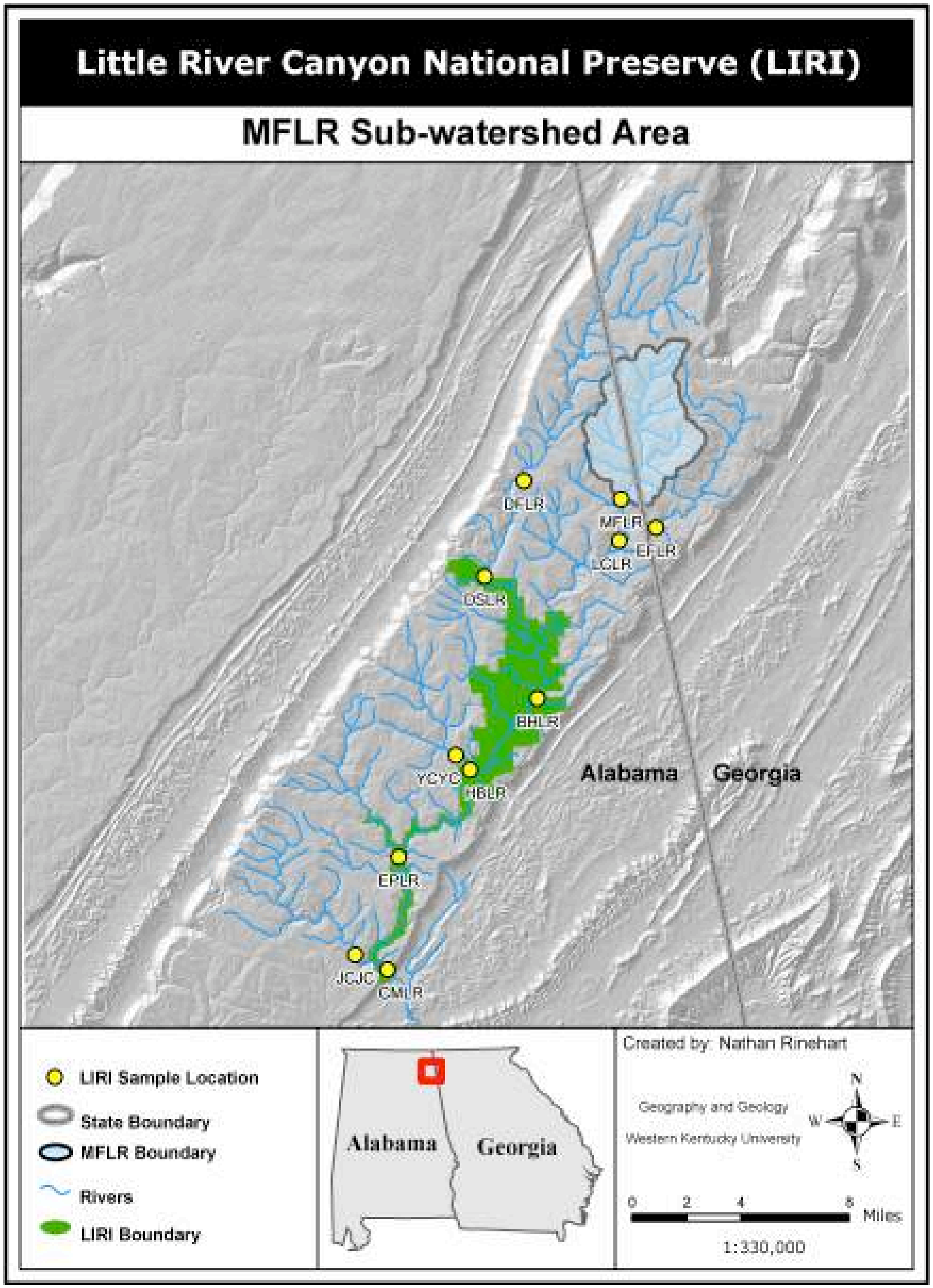

Little River Canyon National Preserve (LIRI)
EFLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
EFLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0
2
4
8
Miles
1:330,000


Little River Canyon National Preserve (LIRI)
EPLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
Alabama
Georgia
EPLR
JCJC
CMLR
LIRI Sample Location
State Boundary
EPLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0 2 4 8
Miles
1:330,000


Little River Canyon National Preserve (LIRI)
HBLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
HBLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0
2
4
8
Miles
1:330,000


Little River Canyon National Preserve (LIRI)
JCJC Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
JCJC Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
0 2 4 8
Miles
1:330,000


Little River Canyon National Preserve (LIRI)
LCLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
LCLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
S
E
W
0 2 4 8
Miles
1:330,000


Little River Canyon National Preserve (LIRI)
MFLR Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
Alabama
Georgia
EPLR
JCJC
CMLR
LIRI Sample Location
State Boundary
MFLR Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
N
W
E
S
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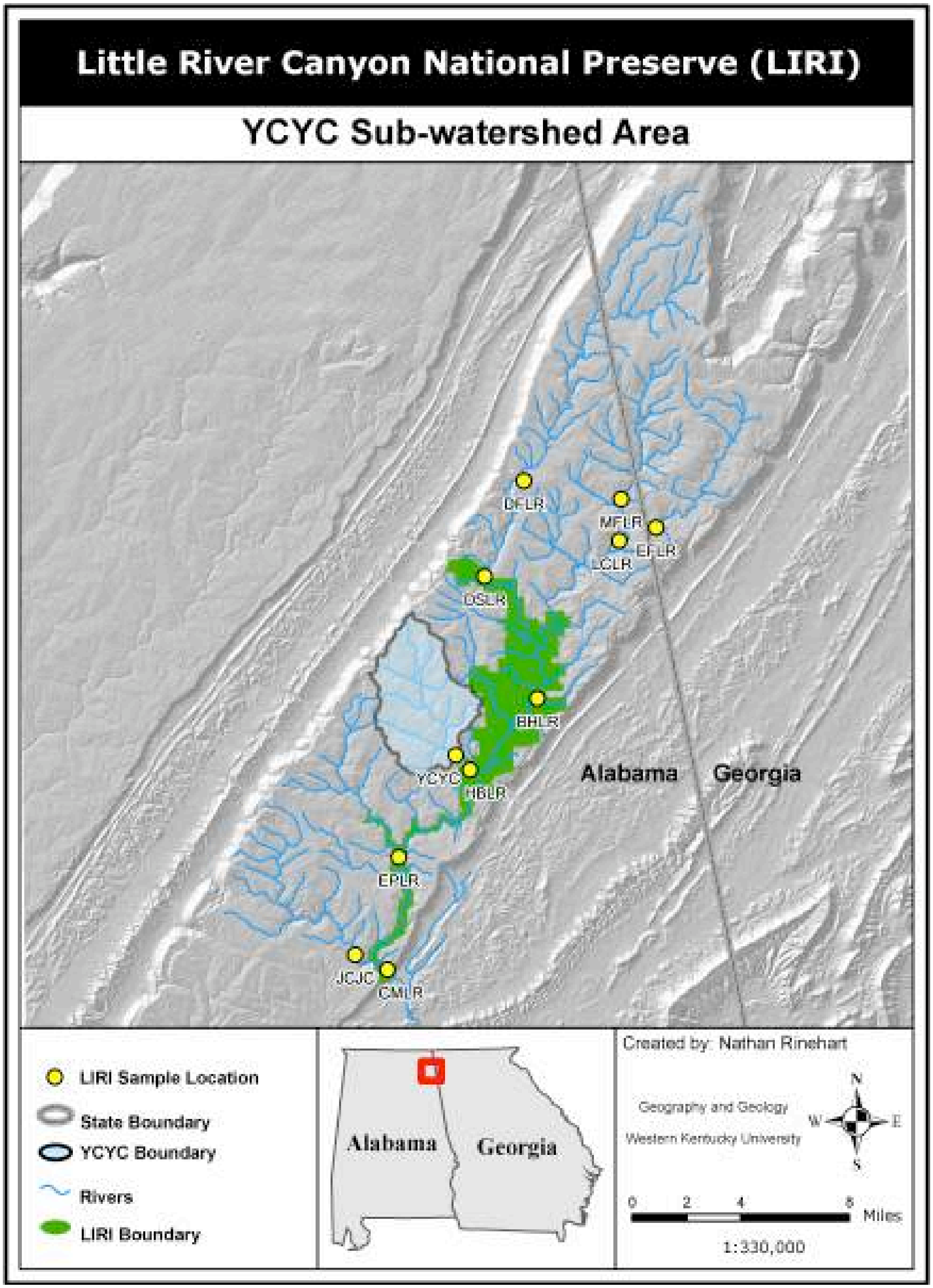
4
8
Miles
1:330,000


Little River Canyon National Preserve (LIRI)
YCYC Sub-watershed Area
DFLR
MFLR
EFLR
LCLR
DSLR
BHLR
YCYC
HBLR
EPLR
JCJC
CMLR
Alabama
Georgia
LIRI Sample Location
State Boundary
YCYC Boundary
Rivers
LIRI Boundary
Alabama
Georgia
Created by: Nathan Rinehart
Geography and Geology
Western Kentucky University
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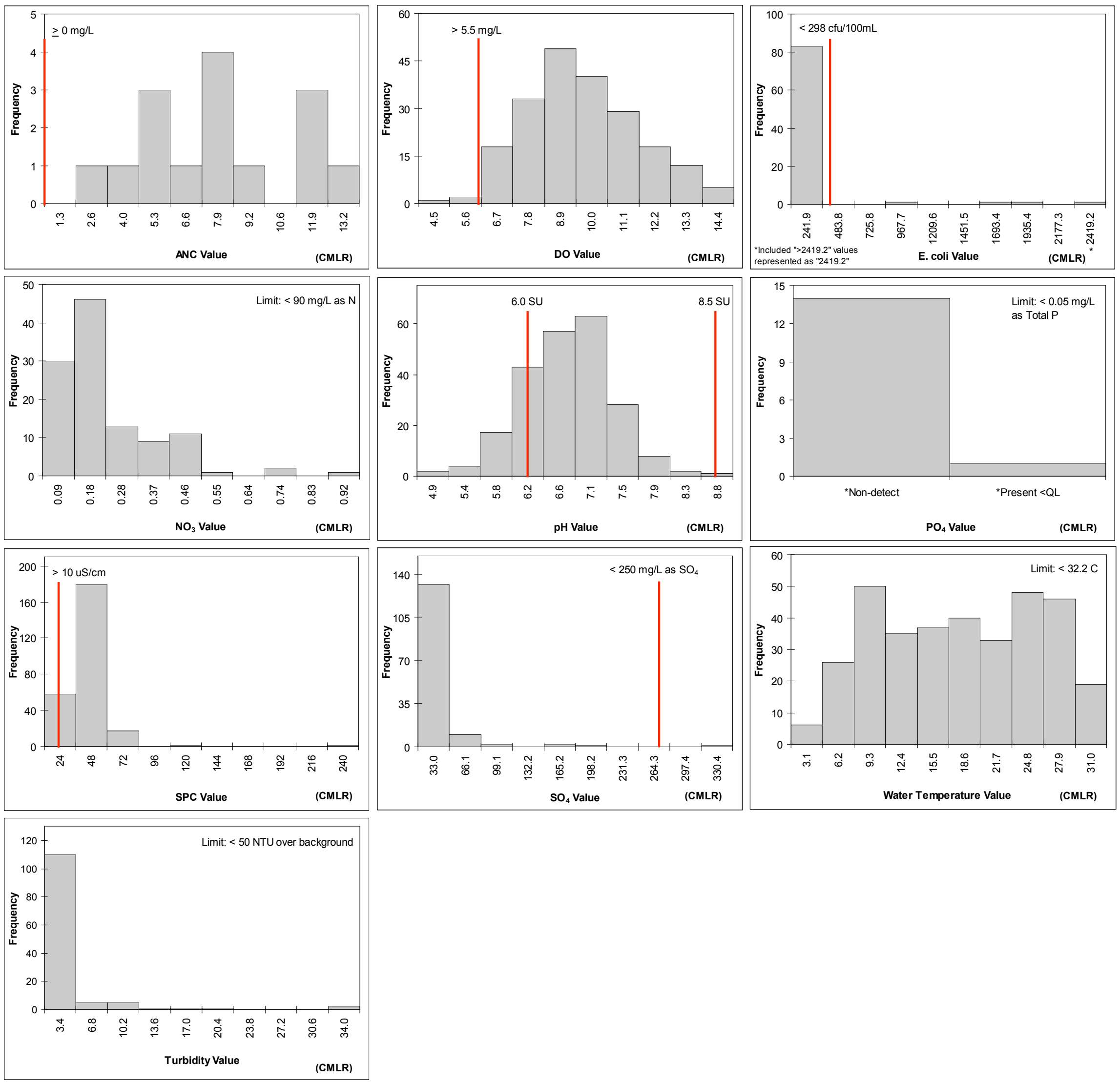
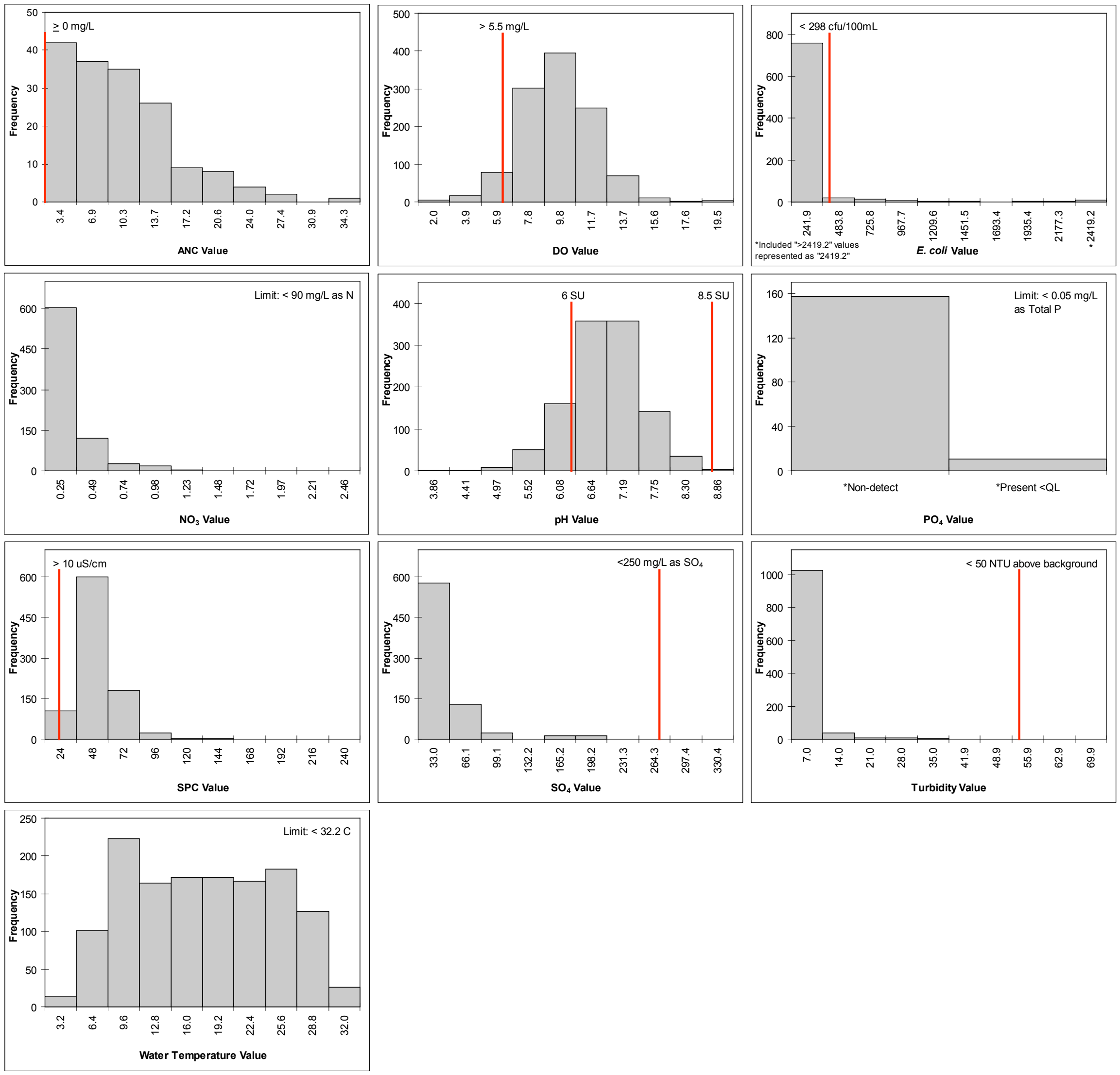
Appendix G. Histograms for the ten water quality parameters at Canyon Mouth Park (CMLR) sample location and charts for the ten parameters from the accumulation of all sample location values.




Frequency
≥ 0 mg/L
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 H. 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 (uS/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. (°C)	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 (uS/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. (°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.

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 (uS/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. (°C)	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 (uS/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 (uS/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 (uS/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 (uS/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 (uS/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 (uS/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 (uS/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 (uS/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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