NPS – Great Smoky Mountains National Park
U.S. Department of the Interior

Elkmont Historic District Inventory of Natural Resources

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List of Acronyms

EHD	Elkmont Historic District
GRSM	Great Smoky Mountain National Park
HBN	Hydrologic Benchmark Date Network
HI	human influence
MAL	montane alluvial forest
NADP	National Atmosphere Deposition Program
NIS	non-indigenous species
NPS	National Park Service
ONRW	Outstanding National Resource Waters
T & E	Threatened and Endangered
TDEC	Tennessee Department of Environmental Conservation
TN	Tennessee
TNC	The Nature Conservancy
USGS	United States Geological Survey
VWM	volume-weighted mean
WPC	Water Pollution Control
YOY	young-of-year

1.0 Introduction

1.1 Scope of the Natural Resource Report

This report describes the natural resources within the Elkmont Historic District (EHD) and the Little River watershed. It is based on existing information collected by personnel from the Great Smoky Mountains National Park (GRSM), the Tennessee Department of Environmental Conservation (TDEC), and from visiting scientists who have conducted research in the Park. The draft report is being submitted to the staff at GRSM for technical review. Information presented in the report includes an inventory of natural resources and statements of significance.

EHD contains a 220-site campground, 4 park residences, and about 80 unoccupied structures. Elkmont has a wastewater-treatment facility that discharges treated water into the Little River. The Little River is in one of the most accessible areas in GRSM and receives considerable tourist traffic during the summer.

Since the 1940s, GRSM has managed land in the Little River watershed primarily to restore and preserve the natural environment and to promote visitor activities at appropriate locations, levels, and times that minimize adverse impacts (NPS 1982). In 1993, 67 structures at Elkmont were placed on the National Register of Historic Places. Consequently, a third management goal was added: to identify, evaluate, and preserve significant cultural resources.

The Little River watershed drains parts of Sevier and Blount Counties in eastern Tennessee and is located entirely within the boundaries of GRSM. Access is by way of Little River Road, which parallels the main channel as far upstream as Elkmont. Secondary roads provide access to the campground and structures (Figure 1). Foot trails provide access to most other areas in the watershed, and a portion of the Appalachian Trail follows the southern basin divide.

1.2 Elkmont Historic District

The entire Little River watershed includes about 28,300 hectares (ha) (69,931 acres). EHD is located in the headwaters of the Little River (also known as the East Prong Little River). The portion of the watershed considered in this report was defined and described by the Tennessee State Historic Preservation Officer as follows:

The boundary begins on the south where Meigs Mountain Trail crosses Jakes Creek. It turns north following Jakes Creek and the 2,400-foot contour line and continues east along that line to Bearwallow Branch. The Boundary goes down the branch to the Little River and runs along the north side of Little River and then

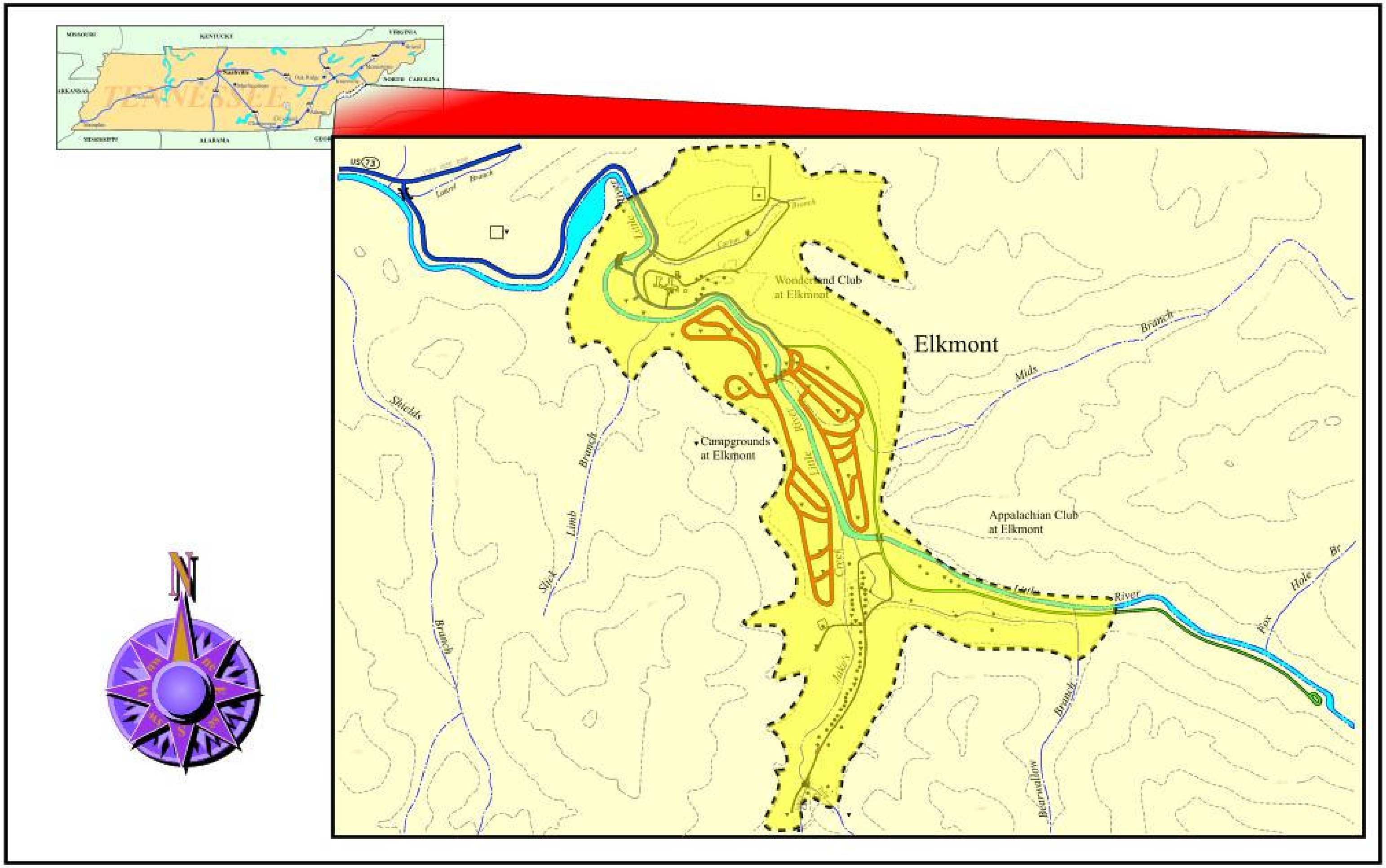


Figure 1. Elkmont Historic District Boundaries

follows the west side of the nature trail. At the point where the nature trail turns east the boundary goes north to the 2,400-foot contour line and follows that contour line across Catron Branch to the point where the contour line touches Universal Transverse Mercator Coordinates 266 Easting and 3950 Northing. The boundary runs along 3950 Northing to Pine Knot Branch and follows it to and across Little River and up the dirt road to the 2,200-foot contour line and follows that contour line to the point shown on the map at the southern end of the campground loop. From there, the boundary turns due west to the 2,400-foot contour line and follows that contour line to a point shown on the map. It then runs on a straight line south and west to Meigs Mountain Trail and follows the trial to point of beginning on Jakes Creek.

Though natural resources discussed in the report are generally within the EHD boundary, resources that operate at the watershed and regional scale are discussed at the appropriate scale. For instance, bear population dynamics are described for the watershed, and air quality is described for the region.

2.0 Geology and Soils

2.1 Regional Geology

The rocks that underlie GRSM and vicinity comprise part of the western Blue Ridge geologic province in the southern Appalachians. Complete descriptions of the geology of GRSM and detailed geologic maps can be found in King (1963) and King (1968). Most bedrock in GRSM consists of a thick mass of variably metamorphosed sedimentary rocks of late Precambrian age. The dominant units underlying the Little River watershed are the Elkmont and Thunderhead Sandstones, which are massive, thick-bedded, feldspathic sandstones composed of detrital quartz, potassium feldspar, and plagioclase and metamorphic biotite, muscovite, and chlorite. Many areas of the basin contain bedrock covered by deposits of alluvium, colluvium, and saprolite that are locally as much as 30 meters (m) [98.4 feet (ft)] thick. The bedrock underlying EHD is composed of less metamorphosed rock (slates, sandstones, and metasiltstones) of the Thunderhead formation. The sedimentary bedrock is late Precambrian, about 500 million to 1 billion years old. Processes of erosion and deposition formed the landscape at EHD. Rocks and sediments moved from higher elevations through landslides to form colluvial deposits, while alluvial deposits were formed from sediment carried and left by the flow of water. The contemporary landscape probably formed during periods of colder and/or wetter climate thousands of years ago. Movement of rock and sediment probably occurred during the late Pleistocene through middle Holocene. There is no evidence to suggest the exact mode of emplacement, but based on the data from Ravensford, debris flows sufficient to move boulders could have been fairly common during the early and middle Holocene. It is also probable that some of the mass-wasted sediment was deposited during the last glacial maximum circa under periglacial climatic conditions. Volume estimates are not possible, given the small areal focus of the project area. A study of the entire basin would have to be done in order to estimate sediment yield. The elevation of the boulders in the low terrace indicates that the streambed was slightly higher than it is now (1-2 m), and that it has incised to its present elevation during the latter half of the Holocene. However, absolute dating techniques would be necessary to confirm this hypothesis (pers. comm., D. Leigh).

2.2 Geomorphology

A geomorphic reconnaissance of the Elkmont tract was conducted to identify the major landforms present. Five principal landforms were identified, including: (1) the floodplain; (2) a low terrace; (3) high terrace remnants; (4) alluvial/colluvial hillslope deposits; and (5) rocky upland slopes. Auger tests were performed within each of the landforms and profile descriptions and data from these tests are provided in Appendix A, Table A.1. Each landform type is discussed below in terms of its sedimentation history.

2.2.1 Floodplain

The floodplain is the alluvial land surface that is being constructed by the modern regime of Little River and its tributaries. It is the first distinct alluvial surface moving up from the river and stream channels. The top elevation of this surface ranges from about 0.5 to 2.0 m (1.6 to 6.5 ft) above the base flow water level of Little River and its tributaries. The floodplain tends to be a narrow corridor of land, which indicates that the river and streams have not been graded to this elevation for a very long period of time. The floodplain probably receives new sediment (historical in age) during relatively frequent overbank flood events that occur at an interval of approximately 0.5 to 5.0 years. The youngest parts of this surface consist of imbricated boulders and cobbles, whereas the older parts have a drape of sand and silt that is typically less than 50 centimeters (cm) [19.7 inches (in)] thick over the cobbles. No auger holes were drilled into the floodplain deposits, but observations were made from cutbanks along the active channel.

2.2.2 Low Terrace

The low terrace is the first widespread alluvial surface with increasing elevation above the floodplain. The average top elevation is at about 1.5 to 3.0 m (4.9 to 9.8 ft) above the baseflow water level, but it can be as high as 4.0 m (13 ft). There is considerable topographic relief on this surface since boulder bars and intervening swales are common. This is the most extensive alluvial surface in the valley at Elkmont and includes most of the area where the campground and structures are situated. Some relatively low swales on this surface are probably the only portions of this landform that have received overbank flood sediment over time. This surface contains many very large boulders [some in excess of 2.0 m (6.5 ft) in diameter], indicating that debris flows were an important sediment source for the alluvium and that larger-than-modern floods were probably responsible for sedimentation of this surface.

Auger holes 2, 3, 9, 11, and 13 were drilled into the low terrace. Each hole exhibited a silty to sandy drape of sediment less than 1.0 m thick that overlies cobbles and boulders. At some locations cobbles and boulders are at the surface and completely lack a fine-grained drape. The soil traits indicate that the low terrace is probably Holocene in age. This surface exhibits characteristics that correlate closely to those of the first terrace at the confluence of Raven Fork and the Oconaluftee Rivers on the east side of the GRSM, which has been dated at 3,000 to 8,000 calendar years old (Leigh 2002).

2.2.3 High Terrace Remnants

Small remnants of high terraces occur sporadically throughout the project area. The largest portion of a high terrace remnant occurs in the amphitheater area, but it appears to be covered with a drape of hillslope sediment. Other patches of high terrace remnants were too small to map at the scale investigated for this report. The available outcrops exposing this unit indicated a much greater degree of soil weathering than was seen in the low terrace. These high terrace remnants represent a

much higher elevation of the stream base level in the past. All available evidence (profile weathering and stratigraphic relation to the low terrace) suggests that this surface is Pleistocene in age.

2.2.4 Alluvial/Colluvial Hillslope Deposits

Alluvial/colluvial hillslope deposits are aprons of colluvium and alluvium along the sides of the valleys. They have been transported from the uplands and redeposited in the lower backslope, footslope, and toeslope positions. Many of the hillslope deposits occur as lobes of sediment that debouch from small first and second-order tributaries upon entry to the main valley of Little River and Jakes Creek. The thickness of the hillslope deposits is not well known. Cobbles and boulders were always encountered in auger holes, which restricted the depth of analysis within this unit. Auger holes 1, 4, 5, 6, 8, 10, and 12 were drilled into hillslope deposits.

These hillslope deposits are essentially identical to the Holocene hillslope sediments that were radiocarbon dated as part of the geomorphic investigations of the Ravensford Tract in the Oconaluftee drainage (Leigh 2002). Unlike the valley at Ravensford, an older phase (Pleistocene) of hillslope deposition was not identified at Elkmont, and it appeared that the majority of these deposits are Holocene in age. A buried A horizon was found in one auger hole (#4), indicating that the youngest of these deposits is historical in age. It is also apparent that some of the older Holocene hillslope sediments have been somewhat dissected and appear as low spurs of footslope deposits protruding into the valley in some localities (i.e., near holes 4, 5, and 6).

2.2.5 Rocky Upland Slopes

The rocky upland slopes are the hillslopes that consist of bedrock and saprolite with a thin veneer of colluvium. Much of this sediment is rather coarse, consisting of angular cobbles and gravel.

2.3 Soil Characteristics

Most soils in the watershed are classified as inseptisols, which are fairly deep, well-drained soils developed in residuum weathered from the underlying bedrock (Feldman et al. 1991). Chemically, these soils tend to be acidic (pH 4.1 to 5.8) and have a low organic content and low cation-exchange capacities (Daniels et al. 1987). Aluminum generally dominates the exchange complex, which is almost entirely derived from the organic matter.

The U.S. Department of Agriculture–Natural Resources Conservation Service (NRCS) is mapping soils in GRSM. Soil mapping for EHD is in draft (Figure 2) and will be transferred in to a digital overlay for the draft final report. A description of the soils found in EHD follows (A. Khiel 2002):

- The floodplain, low terrace, and alluvial/colluvial landforms are composed of Spivey-santeetlah complex soil (Sw). Slopes vary from 2 to 8 percent (SwB), 8 to 15 percent (SwC), and 15 to 30 percent (SwD). The Spivey soil series consists of very deep, well-drained, cobbly soils in long narrow areas in hollows and coves in mountainous areas. Formed in colluvium from metasedimentary rock (mostly sandstone of the Thunderhead formation), they are classified as loamy-skeletal, mixed mesic Humic Dystrudepts. The Santeetlah series consists of very deep, well-drained, moderately rapidly permeable soils on benches, fans, and footslopes in coves in mountainous areas. They formed in colluvium from metasedimentary rock (phyllite, slate, and sandstone). They are classified as coarse-loamy, mixed, mesic Humic Dystrudepts. Spivey and Santeetlah soils have thick, dark surface layers, and are very deep. Spivey soils also have more than 35 percent rock fragments in the subsoil and make up about 20 percent of the map unit.

- The high terrace landform is composed of Lonan loam, with 15 to 30 percent slope (LoD). This map unit consists of deep to very deep Lonon soils on sloping colluvial benches and fans. This soil is well drained. Mapped areas are remnants of once larger colluvial deposits from the surrounding mountains. Permeability is moderate, with very little runoff in forested areas where leaf litter has not been fully or partially disturbed. Runoff is rapid in non-forested areas. The water table is greater than 6 feet below the surface.

- The rocky upland slopes are composed of Soco-stecoah complex, with 30 to 95 percent slopes (SoF). This complex consists of moderately deep Soco soils and deep Stecoah soils on very steep south-to-west facing side slopes in the intermediate mountains. Both soils are well drained. Mapped areas are irregularly shaped and range from 2 to 20 ha (5 to 50 acres). These soils are too intricately mixed and small in size to separate them in mapping. Permeability is moderately rapid. Surface runoff is slow where forest litter has not been disturbed and rapid where litter has been removed.

Figure 2. Draft Soil Map of the Gatlinburg USGS Quadrangle in the Vicinity of Elkmont (USDA–NRCS)

3.0 Water Resources

3.1 General Description of Surface Waters

The Little River is a northwest-flowing tributary of the Tennessee River with a channel length of about 36 kilometer (km) [22.4 miles (mi)] within GRSM boundaries and stream gradients that range from 16 m/km (52.5 ft/mi) downstream from Elkmont to as much as 110 m/km (361 ft/mi) in the steep headwater tributaries (Figure 3). The main channel is perennial, and mean monthly discharge ranges from about 3.5 cubic meters (m^3)/ second (s) (123.6 cubic feet (ft^3)/s) during base-flow conditions in September to 14.8 m^3/s (522.6 ft^3/s) during high flow in March. Average annual runoff from the basin was 93 cm (36.6 in) from 1964 through 1995 (U.S. Geological Survey, Water Resources Data, Tennessee). The site on Little River sampled by Tennessee Department of Environmental Conservation (DEC) is typical of the middle reaches of the watershed. It varies from 7.6 to 12 m [25 to 40 feet (ft)] wide, with a maximum depth of 0.7 m (2.4 ft). The site is approximately 85 percent canopy-covered with a streambed substrate comprised predominantly of boulders (60 percent), cobbles (30 percent), and gravel (10 percent). Pools contain some bedrock and silt.

3.2 Water Quality

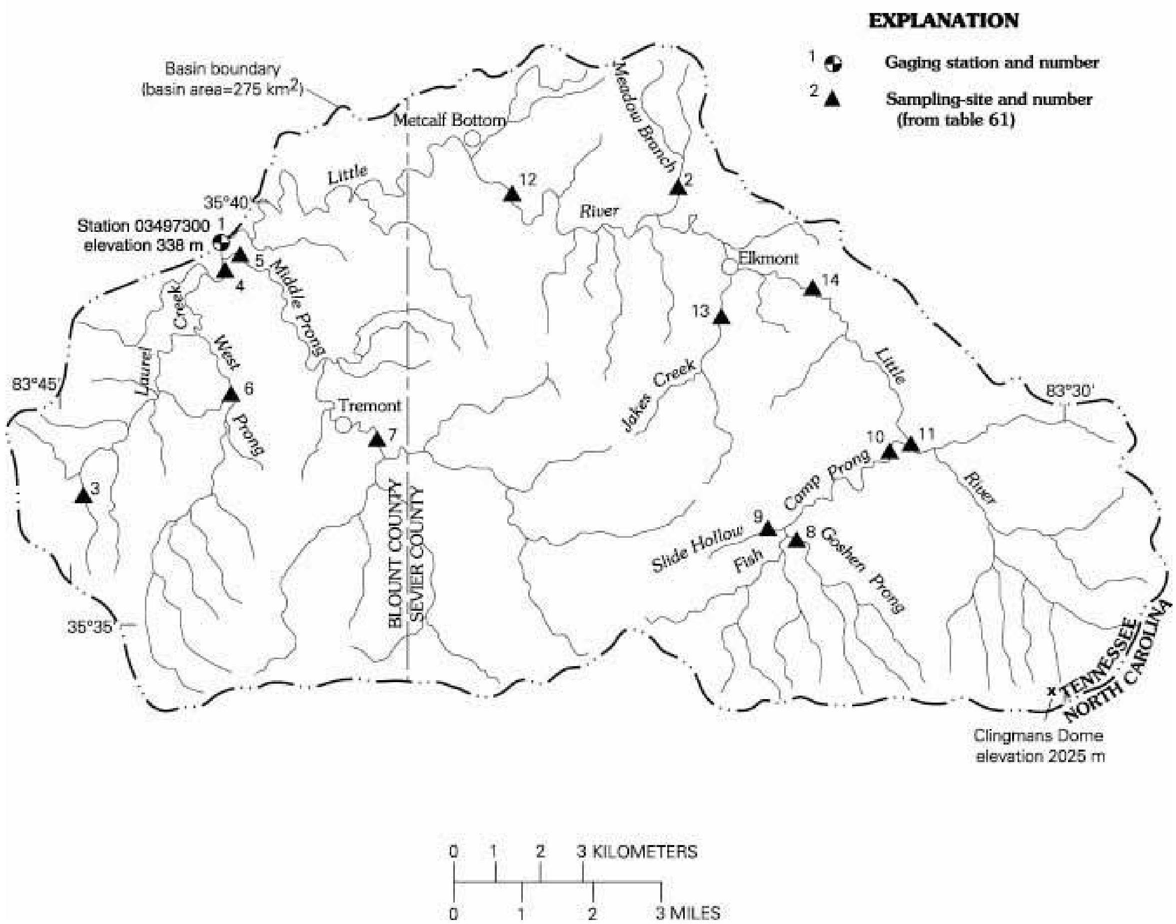
One of the responsibilities of TDEC, Division of Water Pollution Control (WPC) is the formal adoption of water quality standards, including the adoption of water quality criteria. Criteria establish the level of water quality protection for each of the designated uses, which in Tennessee include fish and aquatic life protection, recreational use, domestic water supply, industrial water supply, irrigation, wildlife and livestock watering, and navigation. Regulations give the highest level of water quality protection to streams and lakes designated Outstanding National Resource Waters (ONRW). Streams are nominated for ONRW status because they

(1) have important habitat for ecologically significant populations [including rare, threatened and endangered (T&E) species],
(2) offer specialized recreational opportunities,
(3) have outstanding scenic or geologic values, and
(4) have very high existing water quality.

Tennessee's Water Quality Control Act also contains an anti-degradation statement that protects existing uses of all surface waters as established under the Act.

In 1997, four streams within GRSM were nominated and subsequently designated as an ONRW. They include Little River (whose entire watershed is within Park boundaries), Abrams Creek, West Prong Little Pigeon River and Little Pigeon River. Only 10 streams in Tennessee have this designation.

Figure 3. Sampling Stations for the Hydrologic Bench Network in the Little River Watershed (USGS)



These streams have more than local significance. With U.S. Environmental Protection Agency assistance, WPC personnel are subdelineating ecoregions within the State and characterizing water quality at carefully selected reference streams (Arnwine et al. 2000). A water quality sampling site on the Little River within EHD was selected as a reference site as part of the Ecoregion Reference Stream Monitoring program to help establish water quality standards. Information from the stream will help set clean water goals for other streams in the Blue Ridge Mountains ecoregion.

The EHD sampling site is located near the gate across Little River Road. Data is available at http://oaspub.ea.gov/storpubl/legacy (STORET number ECO66G05). Habitat assessments, physical measurements, and chemical and biological samples were collected beginning in 1996. Biological samples including semi-quantitative kick sampling and using rapid bioassessment field techniques were collected twice per year during the low-flow period (August–October) and high-flow period (March–May). Chemical samples were collected on a quarterly basis. Ten habitat parameters were evaluated, including epifaunal substrate/available cover, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, riffles frequency, bank stability, vegetative protection, and riparian zone vegetative width. Each habitat parameter is given a numeric ranking from 0 to 20, with 20 being the highest level. The top score possible is 200; the Little River sampling site scores ranged from 193–197. Some points were lost because there is very little slow velocity/shallow depth habitat on the stream and occasional low flow. Data were collected for three consecutive years through May 1999 (Arnwine and Denton 2001).

Mast and Turk (1999) collected and analyzed 61 water-quality samples as part of the Hydrologic Benchmark Data Network (HBN) by the U.S. Geological Survey (USGS). Samples were collected bimonthly from October 1985 through December 1995. Twenty samples were collected from August 1963 through August 1968, prior to 1986 when the site was added to the HBN. Daily discharge records for the Little River (station 03497300) are available beginning in October 1933. Figure 3 shows the Little River Watershed, the location of the USGS gauging station, and the location of 14 HBN sampling sites within the watershed. Site 13 is within EHD boundaries, Site 14 is just upstream from the boundary. Records of daily water temperature at the gage are available for October 1963 through January 1982, and daily precipitation amount was measured at the gage from 1991 through 1995.

Table 1 lists median concentrations and ranges of major constituents in stream water collected at the gage and volume-weighted mean (VWM) concentrations in wet-only deposition measured at the National Atmospheric Deposition Program (NADP) station near the Elkmont campground. Atmospheric deposition of sulfate, nitrate, and hydrogen in the Southern Blue Ridge Province is among the highest reported in the Eastern United States (Elwood et al., 1991). The VWM pH of wet precipitation measured at the Elkmont NADP station was 4.5 during the 15 years of record. The dominant cations in precipitation were hydrogen, which contributed 63 percent of the total cation charge, and ammonium, which contributed 20 percent. The dominant anions were sulfate and nitrate, which accounted for 65 and 29 percent of the total anions, respectively.

Table 1. Values of Physical Properties and Major Ion Concentrations from Little River, 1985–1995, and Wet Precipitation Collected at the Elkmont Station (from Mast and Turk 1999)

[Concentrations in units of microequivalents per liter, discharge in cubic meters per second, specific conductance in microsiemens per centimeter at 25°C, pH in standard units, and silica in micromoles per liter; n, number of stream samples; VWM, volume-weighted mean; inst., instantaneous; spec. cond., specific conductance; <, less than; --, not reported]

Parameter	Stream Water						Precipitation VWM[a]
	Minimum	First quartile	Median	Third quartile	Maximum	n	
Discharge, inst.	1.0	2.8	5.1	8.5	20	57	--
Spec. cond., field	9.6	14	17	20	61	56	--
pH, field	6.4	6.8	6.9	7.2	7.7	56	4.5[b]
Calcium	48	65	75	87	190	59	4.5
Magnesium	23	30	34	38	70	59	1.4
Sodium	19	39	44	48	61	59	2.7
Potassium	7.7	13	13	15	26	59	.9
Ammonium	<.7	<.7	<.7	1.4	3.6	59	10
Alkalinity, laboratory	60	96	120	140	260	59	--
Sulfate	25	35	42	58	130	59	34
Chloride	8.5	11	14	17	49	59	3.1
Nitrite plus nitrate	<3.6	9.7	11	14	31	56	15[c]
Silica	83	90	95	110	120	58	--

[a]Values are VWM mean concentrations for 1980-94

[b]Laboratory pH

[c]Nitrate only

Stream water in the Little River is dilute and weakly buffered. Specific conductances ranged from 10 to 61 microsiemens (µS)/cm, and alkalinities were generally between 40 and 260 millequivalent (meq)/L. The major cations in stream water were calcium and sodium, and the dominant anion was alkalinity. The low concentrations of the weathering-derived solutes, particularly alkalinity, reflect the slow-weathering sandstones and quartzites of the underlying Precambrian bedrock. The median chloride concentration in stream water was 14 meq/L, which is about four times larger than the VWM concentration of chloride in precipitation. Based on the difference between average annual runoff and precipitation, evapotranspiration can account for about a twofold increase in the concentration of precipitation. This suggests that as much as half of stream-water chloride may be derived from sources other than wet deposition. Considering the combined effects of evapotranspiration and additional inputs of sulfate in dry deposition, these data suggest that a substantial portion of atmospherically deposited sulfate is retained in the basin. The most likely mechanism for retention is sulfate adsorption on clays and organic matter in the soil environment. Based on the smaller concentrations of both nitrate and ammonium in stream water compared to precipitation, the basin also is an important sink for nitrogen species. By contrast, many higher elevation streams in the park have been found to have nitrate concentrations similar to those in precipitation (Nodvin et al. 1995). Retention of both sulfate and nitrate in the Little River Basin is probably an important process that buffers stream water from the effects of acidic deposition (Cosby et al. 1991) at low elevations in the Park.

Neither chloride nor nitrate concentrations were elevated in stream waters downstream from Elkmont and Tremont (sites 5 and 12), indicating that the wastewater facilities do not affect water quality during periods of low visitor use in the Park. Nitrate concentrations in tributary streams were lower than the long-term median concentrations at the gage, which may reflect the time of year the samples were collected. Silsbee and Larson (1982) observed that stream-water nitrate concentrations in GRSM varied seasonally, with the highest concentrations in winter and spring and the lowest concentrations in autumn. Low autumn concentrations may result from uptake of nitrogen by microorganisms during the initial stages of leaf fall (Silsbee and Larson 1982).

4.0 Aquatic Ecology

4.1 Benthic Invertebrates Surveys

GRSM personnel conduct Benthic invertebrate surveys on Little River on an annual basis. The sample site is located approximately 3 miles upstream from Elkmont, along the Little River trail. Researchers follow the Rapid Bioassment Protocols of North Carolina's Department of Environment/Water Quality. They assess species numbers, and determine a Biotic Index score (ranging from poor to excellent) for each stream site that is intended for later trend analysis. Results are listed in the following table.

Little River Site 2

Year	# Species	BI score
2000	63	good
1999	64	excellent
1998	52	good
1997	72	good
1996	no data	
1995	76	excellent
1994	82	excellent
1993	no data	

4.2 Fish Surveys

The ongoing fishery management program was initiated in the mid-1980s by the Fisheries Division of the Natural Resources Branch of the Division of Resource Management and Science at GRSM. Overall program objectives are to assess fish communities and annual variation in both population density and biomass in large and small stream sites that best represent in-stream habitat. Sampling sites were selected to provide elevational profiles typical of montane streams in GRSM, and data are generally collected on an annual basis. Specific program objectives include: monitoring native brook trout distribution, monitoring large stream fish communities and evaluating angler use, restoration of selected streams to native brook trout, and monitoring atmospheric and geological deposition throughout GRSM. Four sites on the Little River are sampled, and two of them are applicable to this study. The two sites are on Jakes Creek, both within EHD.

Data from three large streams in GRSM is collected in a large stream monitoring study. Since 1986, population estimates have been conducted at sampling sites on Cataloochee Creek, Little River, and Abrams Creek. Little River had the second highest number of species (12). Abrams Creek supports 18 species, and Cataloochee Creek supports 7 species. Species diversity increases in a downstream direction. Species diversity and composition are indicative of coldwater and coolwater ecosystems (Moore and Kulp, 1994).

Mean salmonid biomass was greatest in Cataloochee Creek [37.29 kilogram (kg)/ha] [82.2 pounds (lbs)/acre] followed by Little River (33.60 kg/ha) [74lbs/acre] and Abrams Creek (32.85 kg/ha) [72.4lbs/acre]. Mean salmonid density followed the same trend. Of the three large streams sampled, Abrams Creek supported 14 species of nongame fish, Little River supported 10 species, and Cataloochee Creek 5. Non-game species comprise 50.3 percent of the biomass in Little River. The major factors influencing these populations are droughts and floods. Major droughts occurred in 1987–1989 and 1999–2001, whereas a major flood [>1,000 cubic feet per second (cfs)] [>28.3 cubic meters per second (cms)] occurred in 1994.

4.2.1 Trends

Little River is a fourth-order montane stream with mean monthly discharges ranging from 2.8 to11.3 cms (100–400 cfs). From 1986 to 1994, peak discharge during the annual peak flow period of January to May ranged ~28.3 to 113.3 cms (~1000 to 4000 cfs). On March 26, 1994, the USGS gauging station on Little River at the Park boundary estimated the peak discharge at 736.2 cms (26,000 cfs). Game species were affected most by the flood. There was very poor survival of young-of-year (YOY) rainbow trout, while no YOY brown trout were collected in 1994. However, the 5-year drought from 1986 to1990 appears to have had a greater effect on the populations than the major flood event.

Little River trends from 1986 to 1994 show a decline in the density of rainbow trout during the drought years of 1986 to 1990 and a rebound to pre-drought levels in 1991. A flood in 1994 resulted in a decline in rainbow trout densities in 1994, primarily due to loss of the 1994 year class. Densities did not decline to the 1988 to1990 levels (Figure 4).

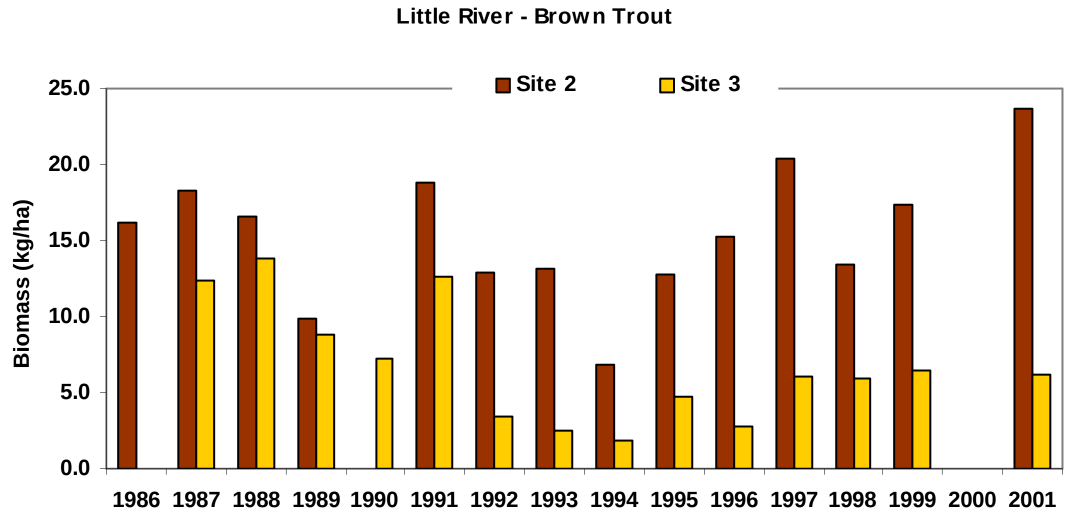
Non-game fish trends show considerable variation from 1986–1994. All non-game fish declined between 1988–1990. The 1994 flood affected each species differently, reflecting site-specific changes due to alteration of habitat.

Four sampling sites are within or near EHD boundaries. The one at Little River is just below Elkmont junction with US 73 at elevation 603.5 m (1,980 ft). The upstream site is up Little River truck road from the old metal gate and to the turnaround [elevation 701 m (2,300 ft)]. The two sites on Jakes Creek are above the cabins; the downstream site begins at the pumphouse and ends 100 m (328 ft) below it [elevation 707.1 m (2,320 ft)]. The upstream site begins at the stream crossing on Meigs Mountain trail [elevation 755.9 m (2,480 ft)]. Data collected in 2001 on Little

River show biomass trends for brown and rainbow trout are consistent with data from previous years (Figure 4). Jakes Creek data show a decrease in brown trout biomass at both sampling locations and a substantial increase in rainbow trout (Figure 5). Nongame species biomass data trends appear to be consistent with previous years (Figure 6) (Moore and Kulp 2002).

The State sampled game fish species on January 23, 1997, and found that rainbow trout accounted for 94 percent of the biomass at the site and brown trout for 7 percent. They also sampled nongame species; longnose dace accounted for 30 percent of the biomass and mottled sculpin 70 percent.

Figure 4. Biomass (kg/ha) of Brown Trout and Rainbow Trout at Two Sites on the Little River (1986–2001) [updated from Moore and Kulp (1994, 1996)]



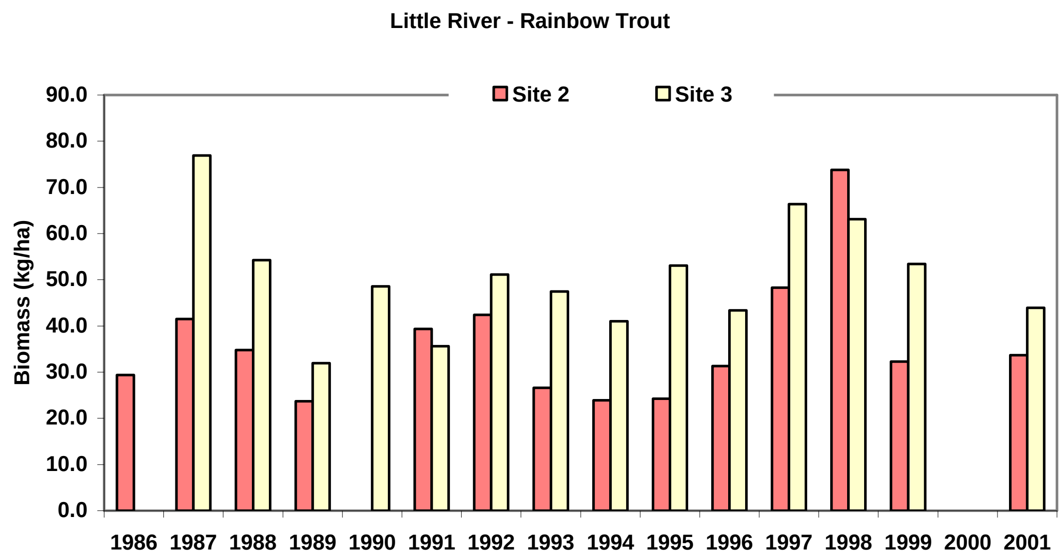
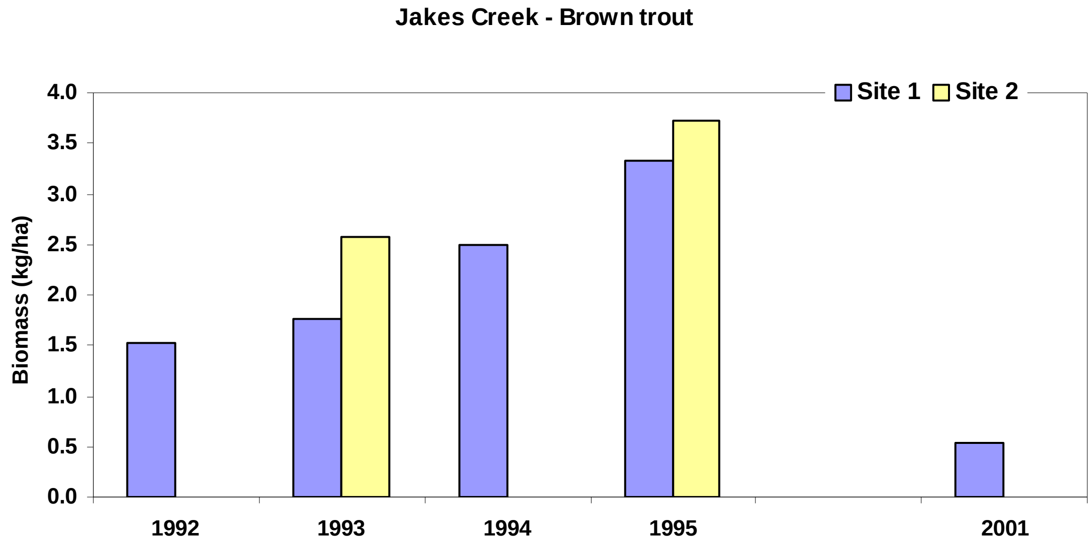


Figure 5. Biomass (kg/ha) of Brown Trout and Rainbow Trout at Two Sites on Jakes Creek (1992–2001) [updated from Moore and Kulp (1994, 1996)]



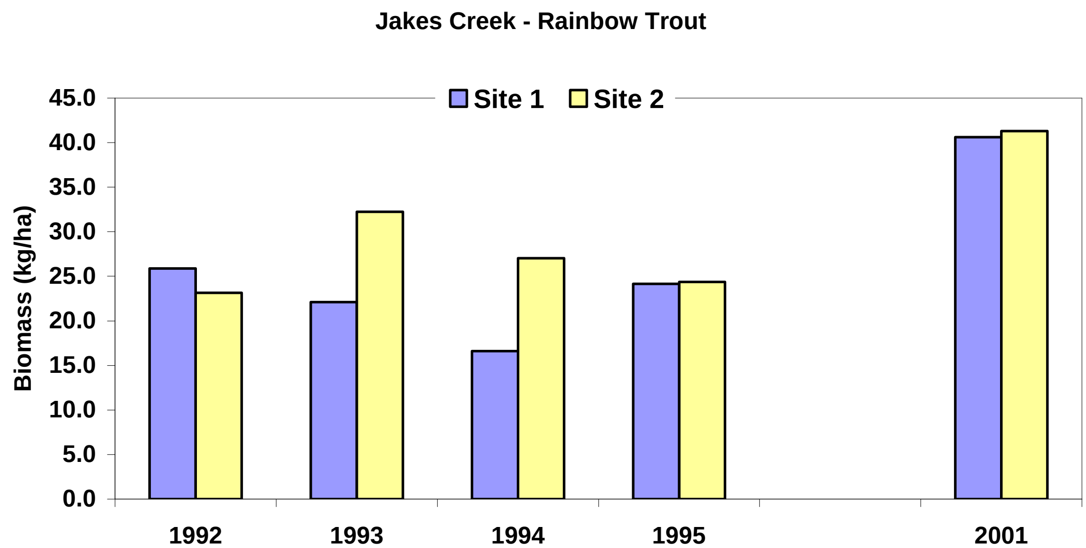
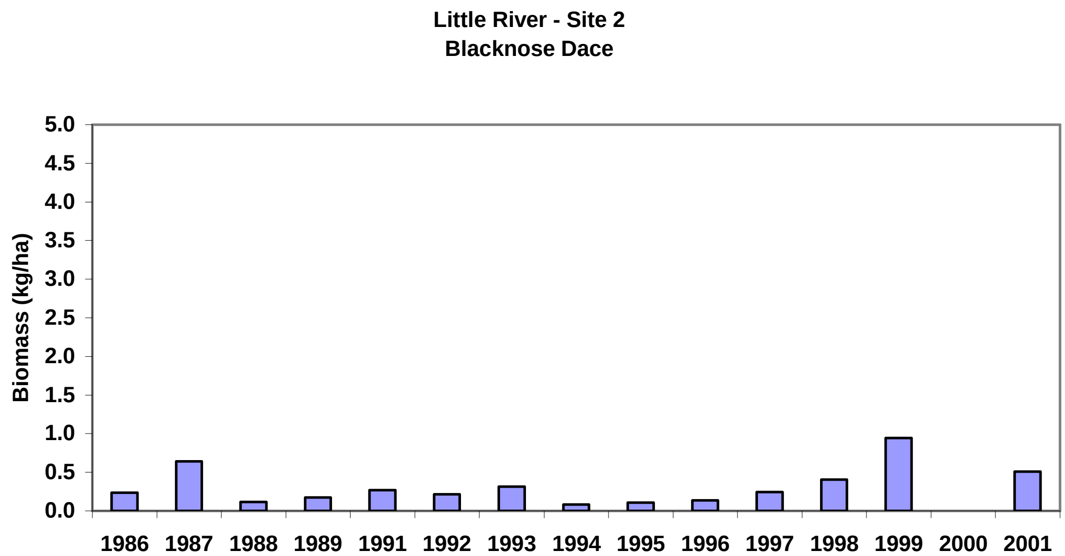


Figure 6. Biomass (kg/ha) of Nongame Species for Two Sites on Little River (1986–2001) [updated from Moore and Kulp (1994, 1996)]



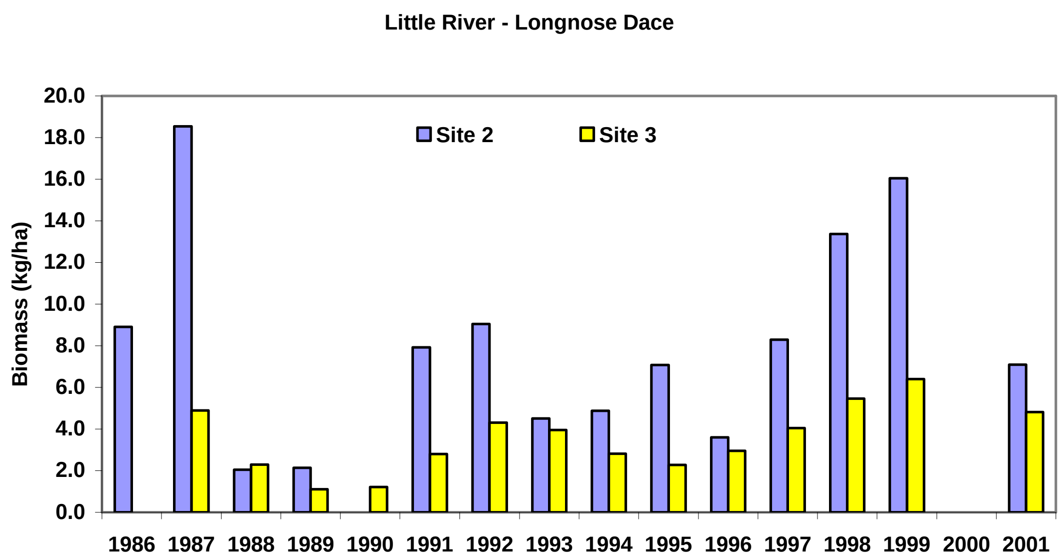
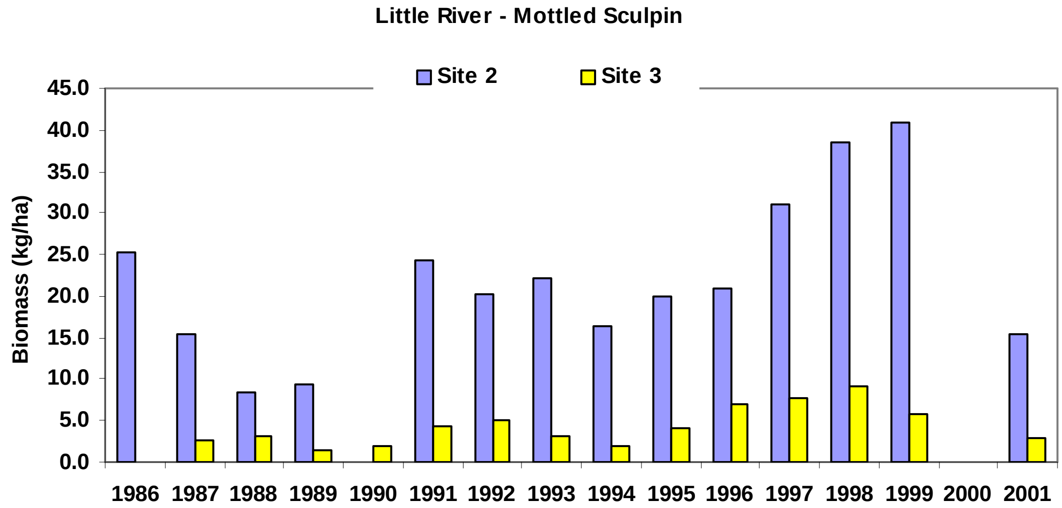
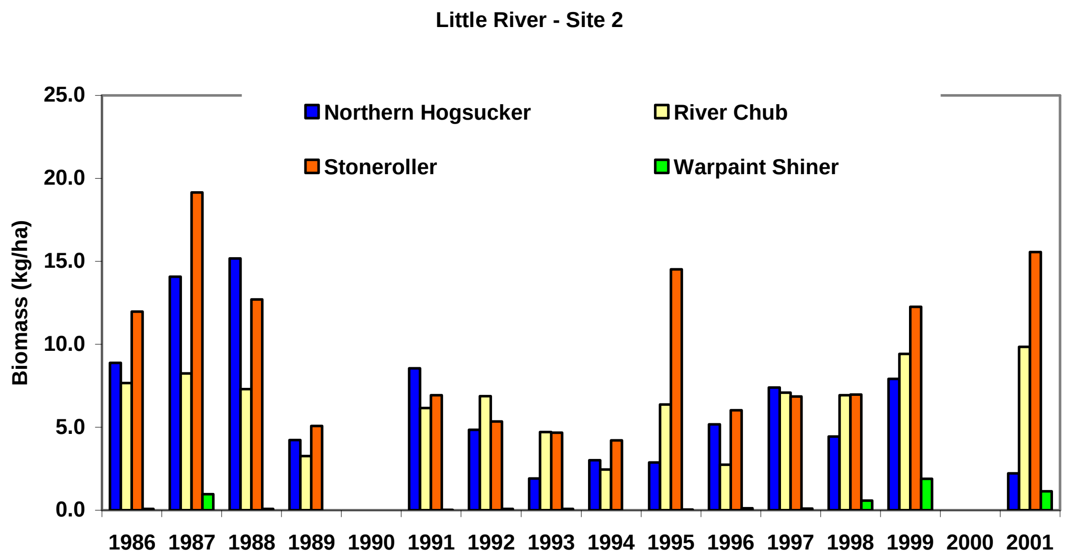


Figure 7. Biomass (kg/ha) of Nongame Species for Two Sites on Little River (1986–2001) [updated from Moore and Kulp (1994, 1996)] (continued)





5.0 Terrestrial Resources

5.1 Vegetation

The Little River watershed drains 275 square kilometers (km^2) [106.2 square mile (mi^2)] of steep mountainous terrain that ranges in elevation from 338 m (1109 ft) at the HBN gaging station to 2,025 m (6643.7 ft) at the summit of Clingman's Dome (Figure 3). The watershed is covered by hardwood-hemlock forest types at elevations below 1,450 m (4757.2 ft). The most common tree species are red maple (*Acer rubrum*), yellow poplar (*Liriodendron tulipifera*), black locust (*Robinia pseudoacacia*), white oak (*Quercus alba*), black oak (*Quercus velutina*), sweet birch (*Betula lenta*), and eastern hemlock (*Tsuga canadensis*), with lesser amounts of white pine (*Pinus strobus*), shortleaf pine (*Pinus echinata*), pitchpine (*Pinus pungens and P. rigida*), dogwood (*Cornus florida*), and sumac (*Rhus sp.*). Rosebay rhododendron (*Rhododendron maximum*) and mountain laurel (*Kalmia latifolia*) are locally abundant as a dense understory. Above 1,450 m (4757.2 ft), vegetation is dominated by red spruce (*Picea rubens Sarg*.) and Fraser fir (*Abies fraseri*) forests that are locally interrupted by beech stands and open areas covered by mountain laurel and blueberries (*Vaccinium sp.*).

5.1.1 Land Use History

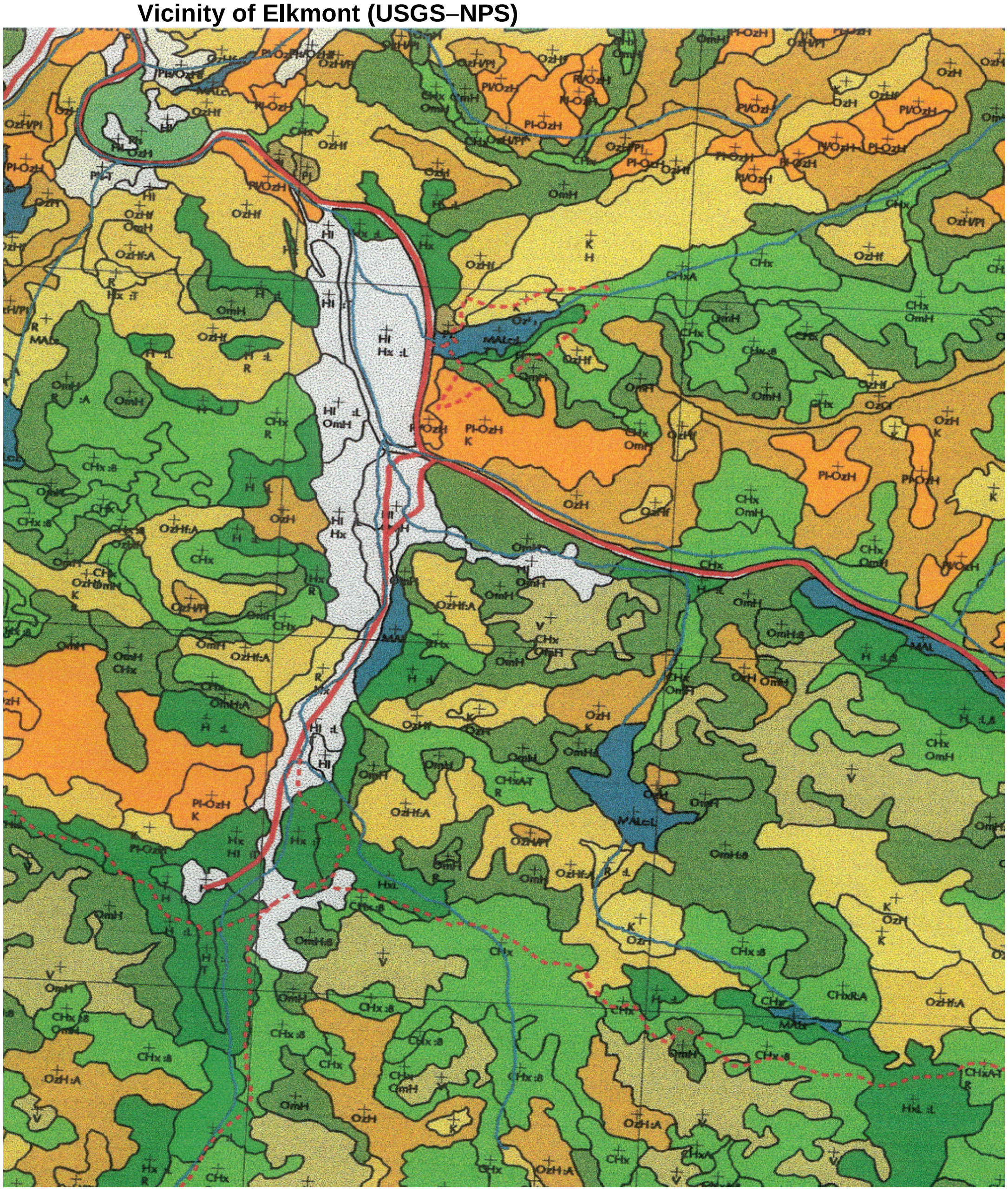
Significant landscape disturbance occurred due to logging, farming, and fire prior to GRSM's establishment in 1933 (Pyle, 1985; Lambert, 1957, 1960). The Little River Basin was first settled by Europeans in the 1830s, but landscape disturbance was limited primarily to farming activities and selective logging at lower elevations in the basin. The early 1900s was the most intense period of human disturbance as a result of large-scale logging operations and severe forest fires. The largest single logging operation in GRSM was run by the Little River Lumber Company, which logged in the Little River Basin from 1904 to 1939. Most drainages in the basin were penetrated by logging railroads, many of which were eventually converted to trails and roads, including Little River Road through the Little River Gorge.

Since the establishment of the Park, flat, alluvial sites have continued to be preferentially selected for development. Most roads, Civilian Conservation Corps camps, administrative areas, visitor centers, and recreational sites (including 8 of the 10 campgrounds) are located on flat, rich, alluvial land. Because of past land use, most of EHD is maturing second-growth forest. Forest populations range from young saplings to mature trees (50–60 years old). Native shrub and herbaceous layers are sparse and absent where there is intense recreational usage. Development in the EHD has altered surface drainage and drainage ditches in wetter sites. In many areas, it has also resulted in loss the normally diverse and abundant herbaceous layer, loss of younger and mid-story canopies, and introduction of more than 20 aggressive, non-native (exotic) plant species (GRSM 1999).

5.1.2Forest Communities, Wetlands/Floodplains

The USGS–National Park Service (NPS) Vegetation Mapping Program is not complete for the quadrangle on which EHD is located, i.e., the Gatlinburg quadrangle. Sampling strategy, field methods, and data analysis used to map the vegetation types within GRSM are described online at http://biology.usgs.gov/npsveg/grsm/methods.html. The EHD portion of the mapped quadrangle is in Figure 8. This information will be digitized as an overlay for the EHD base map.

Figure 8. Draft Forest Community Map of the Gatlinburg Quadrangle in the Vicinity of Elkmont (USGS–NPS)



Distribution of plant communities in the EHD is a result of interactions of slope, elevation, soil types, and previous land use. Forest communities in EHD can be grouped according to water availability, i.e., xeric associations on drier sites, mesic associations on intermediate sites, and alluvial associations on wetter sites.

Most of Elkmont campground is on the alluvial/colluvial flats and benches below the confluence of Little River and Jakes Creek. This area was coded as "human influence (HI)" in the ongoing USGS-NPS vegetation mapping effort [The Nature Conservancy (TNC) 1999], but it would be more accurate to identify the forest as "human influence/montane alluvial forest" community type [HI/montane alluvial forest (MAL)]. Forest communities on drier sites include pine-xeric oak/hardwood (PI-OzH) and xeric oak/hardwood (OzH). Sites with intermediate water availability include mixed hardwoods (H) and mesic oak hardwood (OmH).

The MAL narrows as it extends up Jakes Creek and was not identified along Little River within EHD boundaries. Forest communities located adjacent to the montane alluvial forest along Jakes Creek are the same types that are adjacent to the campground, with the addition of a rhododendron (R) thicket. Forest communities along Little River upstream from the confluence with Jakes Creek, include montane cove hardwoods (CHx), mesic oak hardwood (OmH), and mixed hardwoods (H) in the areas with more available water, and pine-xeric oak/hardwood (PI-OzH) and xeric oak/hardwood (OzH) on dry slopes.

NPS personnel provided vegetation survey results to the appropriate state government personnel in North Carolina, Tennessee, and the regional office of TNC in Chapel Hill, North Carolina. TNC ecologists tentatively classified the montane alluvial forest, G2, meaning globally imperiled. TNC scientists state, "This community is naturally uncommon in the southern Blue Ridge. Well-developed examples are rare due to clearing for agriculture and development. This community is threatened by road building and other hydrologic altering disturbances. Examples are known from Nantahala Gorge, Linville Gorge, Slickrock Creek, and the South Toe River." Within the park, the montane alluvial forest (large river type) is rare because it occupies flat, low elevation sites, uncommon in GRSM (less than 1 percent of the total acreage). The forest is dominated by sycamore (*Platanus occidentalis*), tuliptree (*Liriodendron tulipifera*), Yellow Birch/ Sweet Birch (*Betula alleghaniensis/Betula lenta*), smooth alder (*Alnus serrulata*) and dog hobble (*Leucothoe fontanesiana*). The montane alluvial forest at Elkmont does not fit the published standard and may be an even rarer, higher elevation variant of it. The alluvial forest community is rich in available elements and nutrients and soil water; this translates into a diverse flora and associated fauna.

The Tennessee Heritage Program in TDEC is responsible for ranking rare species and communities in the State. In a letter to GRSM staff, the State considers the montane alluvial forest located on the EHD, "… a significant occurrence, both for the Park, as well as for Tennessee and for the Southeast Region." The State is concerned about maintaining and restoring the connectivity of the community with adjacent communities.

The North Carolina Department of Environment, Health, and Natural Resources found records for montane alluvial forest at 16 sites in fair or better condition remaining in the State. Only four are on protected lands.

Wetlands/Floodplains

The wetland/floodplain investigation will be performed in two phases:

Phase I: Preliminary Wetland Assessment
The first phase would include gathering of existing information as a means of determining potential wetland impacts for discussion in the EA. A cursory review of previously conducted studies (*e.g.*, available site-specific wetland reports, floodplain maps, wetland inventory maps, soil surveys, aerial photographs and other planning maps) would be examined. This information would be used to determine the approximate wetland boundaries within EHD. This information would be used in the EA as part of the existing condition description and in determining environmental consequences of all action alternatives.

Phase II: Field Delineation
Once the preferred alternative has been selected based on preliminary wetland data and other project information, the preliminary wetland boundary determined in Phase I would be field verified. Field verification would consist of three tasks, as described below:

1. Wetland Field Investigation — Methods described in the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987—*Corps Manual*) will be used in non-shoreland areas to delineate and flag wetland boundaries during the field investigation. Plant lists for each delineated wetland community and adjacent upland area will also be compiled. The goal of this task is to identify the limits of wetlands that are under the jurisdiction of the U.S. Army Corps of Engineers (Corps), the NPS and/or other state and local agencies.

2. Agency Coordination — Meet with jurisdictional agency personnel for a site review of wetland boundaries. Concurrence of wetland boundaries will be sought from the Army Corps of Engineers during this site visit.

3. Letter Report Preparation — A letter report will be prepared which documents the results of the field investigation. This report may be used as a future reference to define existing jurisdictional wetland boundaries, and as an attachment to permit applications, if required for implementation of the proposed action. The report will contain an introductory paragraph describing the site location and stating the purpose of the investigation. Descriptions of wetland delineation and assessment methods will follow. Appendices will include three maps: (i) Site Location Map; (ii) Wetland

Boundary Plot Map; and (iii) National Wetland Inventory Map (excerpt). Other appendices may include selected aerial photographs, completed data forms that document observations of all three wetland criteria (hydrology, vegetation and soils) at each completed sample point; and plant lists.

5.2 Non-indigenous Species (NIS)

Summer residents at Elkmont planted many shrubs, vines, and perennials not native to GRSM. Some of the NIS, especially the shade-tolerant species, have been very successful at out-competing and replacing native vegetation. These species can be extremely persistent once established, and may hybridize with native species.

Japanese barberry (*Berberis thunbergii*) is the most invasive species in EHD and has received the largest control effort. From 1994–1995, 1,764 shrubs, representing about approximately 60 percent of the total shrub count, were removed. These efforts have been curtailed pending a resource management decision about EHD. Because seeds of the shrub are widely dispersed by birds, the seed bank (seeds laying dormant in the soil) is expected to produce new shrubs for many years to come.

5.3 Wildlife

Wildlife in the study area includes most animals common at middle to low elevations of GRSM. White-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes fulva*), grey fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), and turkey (*Meleagris gallopavo*) are present.

Sugarland Mountain has a high black bear (*Ursus americanus*) density and bear / human encounters occur. However, the first known fatality in the Park occurred in 2001, when a hiker encountered a female bear with a cub in the Elkmont area. Data from the GRSM *Bear Management Report* number of reported bear incidences and number of captures that have occurred from 1975 to the present will be included in the final report. Data is also available on bear population trends in the watershed and will be included in the final report.

River otters (*Lutra canadensis*) were released in the Park from 1986 to 1994. Fourteen individuals were released from 1988 to 1990, and in 1994, three were released into the Little River watershed. Anecdotal evidence, i.e., sightings of juvenile otters, supports a finding that the species has been successfully reintroduced.

The non-native European wild boar (*Sus scrofus*) is common in the study area. Data that show the number of individuals removed from the watershed each year are available and will be included in the draft final report.

A study of the rodent population in EHD detected the presence of Hantavirus in the population. Fifteen mice from the cabin area were tested for Hantavirus; one mouse tested positive. This equates to approximately 7 percent of the population tested as

being infected. Recent studies have confirmed that infected rodents are present in every habitat type--from desert to alpine tundra. The Center for Disease Control believes that any rodent has the potential to carry the virus, so precautions must be taken when dealing with any species of rodent. It is not possible to distinguish whether a rodent carries Hantavirus by observation

Hantavirus can be transferred to humans where it affects the respiratory system. The disease is contracted primarily from breathing infected rodent excreta particles that have become airborne or ingesting excreta particles that cling to hands or clothing. It can also be contracted from rodent bites or transferred through broken skin.

5.4 Birds

Alsop (1995) lists 29 commonly occurring species of birds in hardwood forests at middle and low elevations in GRSM and another 21 that are common in fields and pastures. Most of these species are probably found in EHD. Species commonly seen in openings, oldfields, and forest edges include northern cardinal (*Cardinalis cardinalis*), indigo bunting (*Passerina cyanea*), American crow (*Corvus brachyrhynchos*), Carolina wren (*Thryothorus ludovicianus*), song sparrow (*Melospiza melodia*), rufous-sided towhee (*Pipilo erythrophthalmus*), eastern phoebe (*Sayornis phoebe*), and northern bobwhite (*Colinus virginianus*). Commonly seen forest-dependent species include hooded warbler (*Wilsonia citrina*), black and white warble (*Mniotilta varia*), worm-eating warbler (*Helmitheros vermivorous*), black-throated green warbler (*Dendroica virens*), northern parula (*Parula americana*), ovenbird (*Seiurus aurocapillus*), red-eyed vireo (*Vireo olivaceous*), wood thrush (*Hylocichla mustelina*), black-capped (*Parus atricapillus*) and Carolina chickadees (*Parus carolinensis*), blue-gray gnatchatcer (*Polioptila caerulea*), yellow-billed cuckoo (*Coccyzus americanus*), tufted titmouse (*Parus bicolor*), and pileated woodpecker (*Dryocopus pileatus*).

5.5 Amphibians

Common amphibians in the area include the American toad (*Bufo americanus*), several salamanders (*Desmognathus sp., Plethodon sp., Eurycea sp.*), and several species of frogs, such as the northern cricket frog (*Acris crepitans*), tree frogs (*Hyla sp.*), upland chorus frog (*Pseudacris triseriata*), green frog (*Rana clamitans*), and wood frog (*Rana sylvatica*).

The eastern box turtle (*Terrapene carolina*) is common in the area. Other widespread reptiles are the northern fence lizard (*Sceloporus undulatus hyacinthinus*), skink (*Eumeces sp.*), water snake (*Nerodea sipedon*), eastern garter snake (*Thamnophis sirtails*), northern ring-neck snake (*Diadophis punctatus*), eastern worm snake (*Carphophus amoenus*), black rat snake (*Elaphe obsolete*), northern copperhead (*Agkistrodon contortrix mokesson*).

5.6 Synchronous Fireflies

The mowed field between the confluence of Jakes Creek and Little River provides habitat for the synchronous firefly (*Photinus carolinus*), which display from early to mid-June. These synchronous fireflies are the first ones fully documented in North America (Copeland 1995), although others have been reported. The species is found most often at about 670.5 meters (2,200 feet). Each individual performs five to eight flashes at a rate of about two a second for about three seconds, followed by a rest. The flashes come not only in unison, but also in waves of light coming down the slope. The wave effect is a result of the restricted line of sight for the fireflies on the steep hillsides (Copeland 1995). Copeland believes that the males flash together and then stop so they can see the female response. The females do flash in return, but the flash is much smaller.

5.7 Threatened & Endangered Species

5.7.1 Plants

The Natural Heritage Program in TDEC maintains a list of federally and state-listed rare species. The list is available at http://www.state.tn.us/environment/nh/vascular.htm. This list was reviewed to identify species that could be present in EHD. Seasonal field surveys will be conducted to locate the following species:

- Climbing fumitory (*Adlumia fungosa*) is found in rich mesic woods, flowers from June–September, listed as Threatened in TN.
- Blunt-lobed grapefern (*Botrichium oneidense*) is found in moist forests; sporulation occurs from July-October, listed as Special Concern in TN.
- Pink lady's slipper (*Cypripedium acaule*) is found in pine woods, flowers from April-June, listed as Endangered in TN.
- American marsh pennywort (*Hydrocotyle americana*) is found in wet soils and pools, flowers in June and July, listed as Endangered in TN.
- Small whorled pogonia (*Isotria medeoloides*) is found in mid-elevation dry woods, flowers from May-June, listed as Endangered in TN and Threatened on the federal list.
- Butternut (*Juglans cinerea*) is found in rich woods and hollows, has been identified in EHD, flowers in April and May, listed as Threatened in TN.
- Fraser's loosestrife (*Lysimachia fraseri*) is found in dry open woods, flowers from June-August, listed as Endangered in TN.
- American ginseng (*Panax quinquefolius*) is found in rich woods, flowers from April–July, fruit is visible from May-October, listed as Special Concern in TN.
- Virginia spirea (*Spiraea virginiana*) is found in gravely or rocky stream bars, flowers in June–July, is listed as Endangered in TN and as Threatened on the federal list.

5.7.2 Mammals

Habitat is available in EHD for the Indiana bat (*Myotis sodalis*), a federally listed endangered species, and Rafinesque's big-eared bat (*Plecotus rafinesquii*), a species of special concern.

Two caves within the Park serve as hibernacula for the Indiana bat. The U.S. Fish and Wildlife Service lists one of the caves as critical habitat for the largest known hibernating colony of Indiana bats in Tennessee as well as one of the largest known hibernating colonies in the United States. Until recently, most known summer roosts were located to the north of hibernation sites, but in recent years, several colonies have been located in the vicinity of the hibernacula. In 1999, a preliminary summer survey for Indiana bats revealed two reproductively active females on the western end of the Park. Based on the capture of these individuals, it is presumed that summer maternity colonies exist in the Park, although their locations are unknown. During summer, Indiana bats roost in trees and forage for insects primarily in riparian and upland forests. The forest type and elevation at EHD meets their summer habitat requirements, and it is possible that the Indiana bat could roost there during the summer. Although unlikely, they could roost within the structures. A survey conducted during June 2000 by Michael J. Harvey did not locate any bats or evidence (guano accumulations) that the buildings had ever been used as roost sites (GRSM 1999).

Rafinesque's big-eared bat is the best known of all bats in the eastern United States. Two mines within the Park serve as hibernacula for colonies of this species. Summer maternity colonies are usually found in abandoned buildings and consist of few to several dozen adults. Females give birth around mid-May in the south, and the young reach adult size by August or early September. Males are generally solitary during summer, roosting in buildings or large trees. Although it is possible that Rafinesque's big-eared bats roost in the Elkmont structures during the summer, a survey conducted in June 2000 did not locate any of these species.

6.0 Air Quality

The climate of the region is broadly classified as humid continental and it is characterized by abundant precipitation and moderate temperatures. The Cumberland Mountains to the northwest help shield the region from cold air masses during winter months. In summer, tropical air masses from the south provide warm and humid conditions that often produce thunderstorms. Elevation affects the temperature and precipitation over the region, with higher elevations of the Park generally experiencing cooler temperatures and greater precipitation. For example, average annual precipitation in GRSM increases from 147 cm (57.9 in.) at an elevation of 445 m (1460 ft.) to 231 cm (90.9 in.) at an elevation 1,920 m (6299 ft.) (Shanks 1954)

The nearest location for which climatic data are available is Gatlinburg [(elevation 443m (1454 ft)]. The elevation of EHD is 609.6 m (2,000 ft). The watershed divide is at 617.2 m (2,025 ft). Average annual temperature in Gatlinburg is 55.7°F. The coldest month is January, averaging 36.5°F. The temperature falls below freezing on an average of 115 days per year with approximately 90 percent of those days occurring from November to March. Daytime temperatures rise above 90°F on an average of 24 days per year. The annual average precipitation at Gatlinburg is 144.6 cm (56.9 in). Average monthly precipitation amounts do not vary greatly over the course of the year, ranging from 7.95 cm (3.13 in.) in October to 15.37 cm (6.05 in.) in July at Gatlinburg (Gale Research Company 1985).

The primary concerns with air quality in GRSM are visibility (sulfur dioxide), acid deposition (sulfates and nitrates) and low-level ozone. Consequently, GRSM has one of the most comprehensive air-quality-monitoring programs in the National Park System. The current monitoring system includes nine weather stations, three atmospheric deposition sites, and seven air-quality-monitoring stations. Many pollutants contribute to reductions in visibility, but sulfur dioxide ($SO_{2)}$ is the primary contaminant of concern. The most recent estimate of visibility indicates that the annual median visual range is about 39 km (24 miles). Summer visibility is around 19 km (12 miles) (Shaver, Tonnessen and Maniero 1994). A view of Little River Watershed from Clingman’s Dome is provided on Figure 9.

Figure 9. View of Little River Watershed from Clingmans Dome (1/91; A. Mast)

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Appendix A

Table A.1 Soil Profile Descriptions from Auger Holes Drilled within EHD (discussed in Section 2.2)

Profile No.	Depth (cm)	Horizon or Zone	Moist Munsell Matrix Color	USDA Texture	Additional Remarks (Mottles, Clay Films, Cultural Features, etc.)
1	0-12	A	10YR 3/3	gravelly loam	
1	12-18	AB	10YR 4/6	gravelly loam	
1	18-35	Bw	10YR 5/6	gravelly silty clay loam	
1	35+	2C	nd	cobble/boulders/rock	refusal
2	0-15	A	10YR 3/4	loam	
2	15-40	Bw	10YR 4/4	fine sandy loam	
2	40-60	C	2.5Y 4.5/3	fine sandy loam	
2	60+	2C	nd	cobble/boulder/rock	refusal
3	0-15	A	10YR 4/2	sandy loam	
3	15-60	Bw	10YR 4.5/4	sandy loam	
3	60-95	C	2.5Y 4/4	pebbly sandy loam	
3	95+	2C	nd	cobble/boulders/rock	refusal
4	0-5	A	10YR 4/4	silt loam	
4	5-40	C	2.5Y 5/4	silt loam	
4	40-95	Ab	2.5Y 3/2	silt loam	few medium 10YR 5/8 mottles, lots of charcoal
4	95+	2C	nd	cobble/boulder/rock	
5	0-10	A	10YR 4/2	silt loam	
5	10-40	Bw	10YR 5/5	silt loam	
5	40-50	C	2.5Y 5/4	v. gravelly silt loam	debris flow matrix
5	50+	2C	nd	cobble/boulder/rock	refusal
6	0-20	A	10YR 4/2	silt loam	
6	20-50	Bw1	10YR 5/5	silt loam	
6	50-60	Bw2	10YR 5/4	gravelly silt loam	charcoal fleck at 50 cm
6	60+	2C	nd	cobble/boulder/rock	refusal
7	0-20	A	10YR 3/2	silt loam	
7	20-30	AB	10YR 4/3	silt loam w/ few pebbles	
7	30-50	Bw	10YR 4/5	silt loam w/ few pebbles	
7	50-80	BC	10YR 5/4	gravelly silt loam	
7	80+	2C	nd	cobble/boulders/rock	refusal
8	0-30	A	10YR 4/2	silt loam	
8	30-60	Bw1	10YR 5/5	pebbly silt loam	
8	60-70	Bw2	10YR 5/4	v. gravelly silt loam	
8	70+	2C	nd	cobble/boulder/rock	refusal
9	0-20	A	10YR 3/3	silt loam (few pebbles)	
9	20-37	Bw	10YR 4/4	silt loam (few pebbles)	
9	37+	2C	nd	cobbles/boulders/rock	refusal
10	0-20	A	10YR 3/2	silt loam	
10	20-50	Bw	10YR 5/5	silt loam	
10	50+	2C	nd	cobble/boulder/rock	refusal
11	0-38	A	10YR 2/1	sandy fine gravel	anthropic soil
11	38-80	2Bw	10YR 5/5	silty clay loam	
11	80-90	2BC	2.5Y 5/4	silt loam	
11	90+	3C	nd	cobble/boulder/rock	abrupt refusal
12	0-5	A	10YR 4/3	silt loam	
12	5-40	Bw	10YR 5/5	silt loam (pebbly)	
12	40+	2C	nd	cobble/boulder/rock	refusal
13	0-10	A	10YR 3/2	sandy silt loam	
13	10-25	Bw1	10YR 4/4	sandy silt loam	
13	25-80	Bw2	10YR 5/5	sandy silt loam	pebbly near base
13	80+	2C	nd	cobble/boulder/rock	refusal