



Long-term Large Stream Fish Community Trends in Great Smoky Mountains National Park

Depletion Sampling Results 1986-2011

Natural Resource Data Series NPS/GRSM/NRDS – 2012/xxx



ON THE COVER: (Clockwise from top-left) A local angler with a nice brown trout caught on Little River (Charity Rutter photo). A young volunteer holding a white sucker during fish processing on Abrams Creek (NPS photo). A group of NPS biologists sorting, weighing and measuring fish on Little River (NPS photo). NPS staff, cooperators and volunteers electrofishing a sample site during a large stream survey on Little River (NPS photo).

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

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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Executive Summary

Great Smoky Mountains National Park (GRSM) is an International Biosphere Reserve and a World heritage Site located at the southern half of the boundary between Tennessee and North Carolina. GRSM covers more than 2,108 km², includes more than 3,400 km of streams and has the highest visitation of any of the National Parks, with more than 9 million visits annually. There are 58 fish species native to GRSM, including three federally threatened and endangered (T&E) fish species found only on Abrams Creek within GRSM; the Citico darter, Smoky madtom and yellowfin madtom. The GRSM Fisheries Management Plan identified monitoring of federally T&E fishes as a critical objective. The widespread declines of native fish species in the southeastern United States highlights the importance and urgency of understanding trends in fish assemblages from undisturbed habitats.

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1 – Introduction

The southeastern United States has the highest diversity of freshwater fishes and the largest number of endemic species in North America (Warren *et al.* 2000), but also the highest number of imperiled fishes (Warren and Burr 1994). With approximately 290 species, Tennessee has the greatest number of described fishes within the United States, including approximately 83 taxa of indigenous fishes needing designation under protective status (Etnier and Starnes 1993). In particular, endemic species of Percidae (i.e., darters) and Ictaluridae (i.e., madtoms) are in greatest jeopardy of imperilment (Etnier and Starnes 1993). Similar to the southeastern United States (Folkerts 1997), a large percentage of imperiled species in Tennessee are small, native minnows and darters (Etnier and Starnes 1993), which are currently threatened by impoundment, various land use practices (i.e., agriculture, urbanization, and deforestation), invasive species and poor water quality.

Great Smoky Mountains National Park (GRSM) is home to nearly 60 fish species, three of which are currently listed by the U.S. Fish and Wildlife Service (USFWS) as Federally Threatened or Endangered. Historically, fisheries survey work in Great Smoky Mountains National Park began shortly after the park was formed. However, the majority of these efforts prior to the 1970's were focused on sport fisheries and their management. These data have been important in establishing baseline data to assess changes in sportfish distribution, however little emphasis was ever placed on non-game fish populations.

1.1 Our Mission

The mission of the National Park Service (NPS) is “*to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations*” (NPS 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation's natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Natural Resource Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

Great Smoky Mountains National Park (GRSM) is part of the Appalachian Highlands Network (APHN) and was one of the first parks brought into the former Inventory and Monitoring program back in 1993. Large stream fish community monitoring was identified as a vital sign in the original 1993 monitoring plan (GRSM 1993) and continued from 1993 through 2003. In addition, large stream monitoring on many of the same streams had already been in place prior to the establishment of a formal I&M program dating back to 1986. In many cases, these

records provide unique and invaluable 18-22 year datasets for evaluating long term trends and status of GRSM fish communities (Table 1).

1.2 Long Term Monitoring Objectives

The objectives of this long term monitoring program are to (1) provide an index of annual variation in game and non-game fish abundance, and (2) monitor threatened and endangered fish reintroduction in Abrams Creek and rare fish populations across the park.

Table 1. Year's historical fish monitoring sites were sampled. X indicates sampling events.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Abrams Creek																											
ABC-1	.	x	x	.	.	.	.	x	x	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.
ABC-2	.	x	x	.	.	.	.	x	x	x	x	x	x	x	x	.	.	.	.	.	.	x	.	.	.	.	.
ABC-3	.	x	x	.	.	.	.	x	x	x	x	x	x	x	x	.	x	.	.	.	.	x	.	.	.	.	x
ABC-4	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	x	.	.	x
Anthony Creek																											
ANC-1	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	.	.	x	.
Cataloochee Creek																											
CAT-1	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	x	.	.	.	.
CAT-2	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	x	.	.	.	.
CAT-3	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	x	.	.	x
CAT-4	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	x	.	.	.	.
E.P. Little River																											
LRV-1	.	x	x	x	x	x	x	x	x	.	x	x	x	x	.	x	x	x	.	.	x	x	.	.	.	.	.
LRV-2	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	.	.	.	.	.	.	.	.	.
LRV-3	.	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
LRV-3N	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	x	x	x	.	.	.	.	.	.	.	.	.

2 – Study Area

Great Smoky Mountains National Park (GRSM) is located on the Tennessee/North Carolina border in the Southern Appalachian Mountains and encompasses more than 2,108 km² and contains more than 3,400 km of streams. There are 58-native fish species found in GRSM, as well as several non-native species. Large-stream inventory and monitoring sampling has been used in GRSM to identify fish communities found in Abrams Creek, Anthony Creek, Cataloochee Creek, and the East Prong of Little River since 1986 (Figure 1). These locations were used to correspond with historic United States Fish and Wildlife Service sampling sites. Additional information on the location of each of these sampling sites is included in appendix I. Information regarding physical and chemical characteristics of historic large stream monitoring sites is listed in Table 2 and detailed habitat characteristics are found in Table 3.

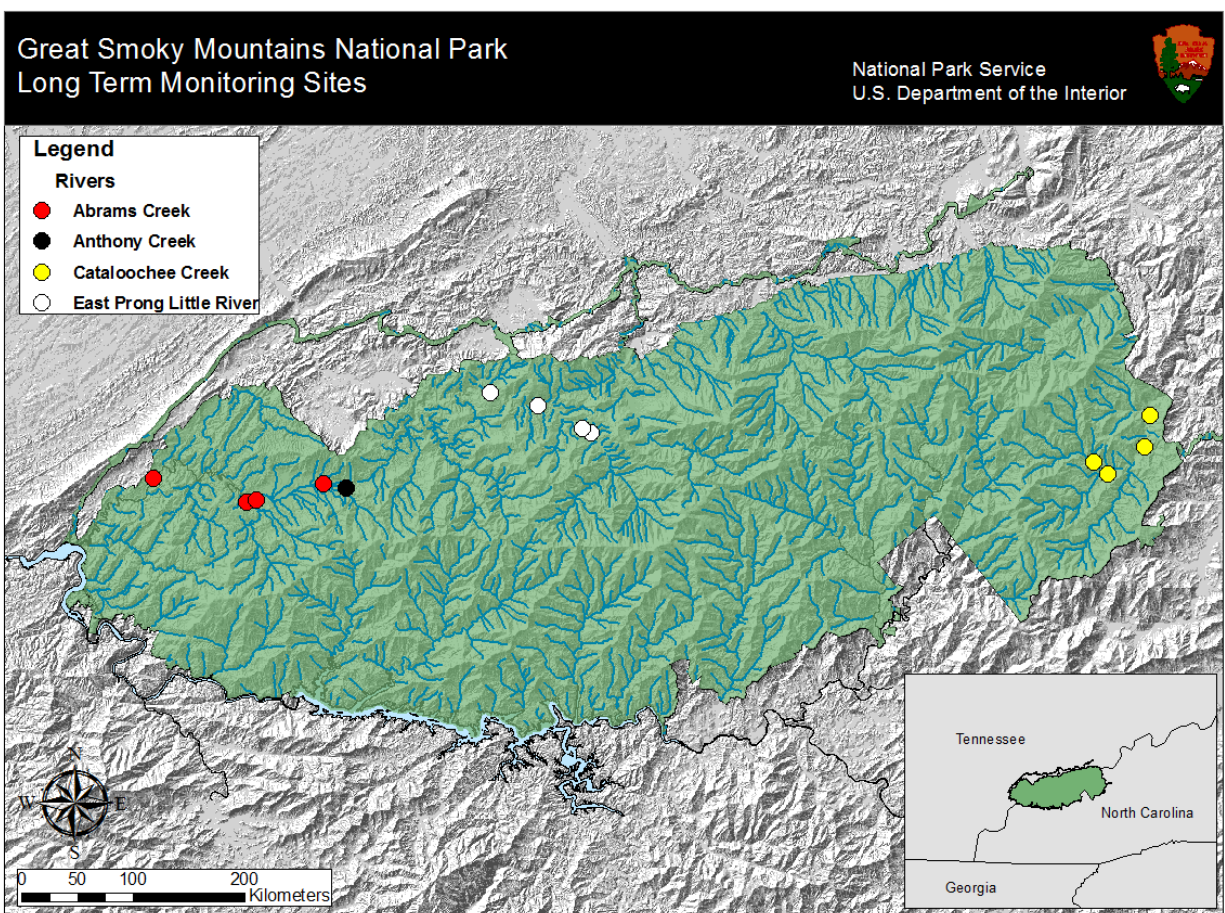


Figure 1. Map depicting locations of historical fish monitoring sites in the Great Smoky Mountains National Park.

Abrams and Anthony Creeks

The Abrams Creek drainage forms in the North District of GRSM (Blount County, TN) and drains from Cades Cove into Chilhowee Lake (an impoundment of the Little Tennessee River). Data were collected from four sampling sites along Abrams Creek (ABC-1, ABC-2, ABC-3, and ABC-4) and one site on Anthony Creek (ANC-1) (Figure 2). Abrams Creek sites 1-4 range in elevation from 341-549m, and ANC-1 is at 610m. Sites ABC-1 and ABC-2 are both 5th order streams with mean stream widths of $17.7\text{m} \pm \text{SE } 0.1$ and $17.8\text{m} \pm \text{SE } 0.4$ respectively. Site ABC-1 is dominated by pools and interspersed riffle habitat with cobble/bedrock substrate. Pools are also the dominant habitat unit within ABC-2 with complex habitat subdominant and substrate consisting of bedrock and cobble. Located just upstream of ABC-2, ABC-3 is a 4th order stream that consists completely of one long pool with large gravel/cobble-sand substrate and a mean width of $7.8\text{m} \pm \text{SE } 0.1$.

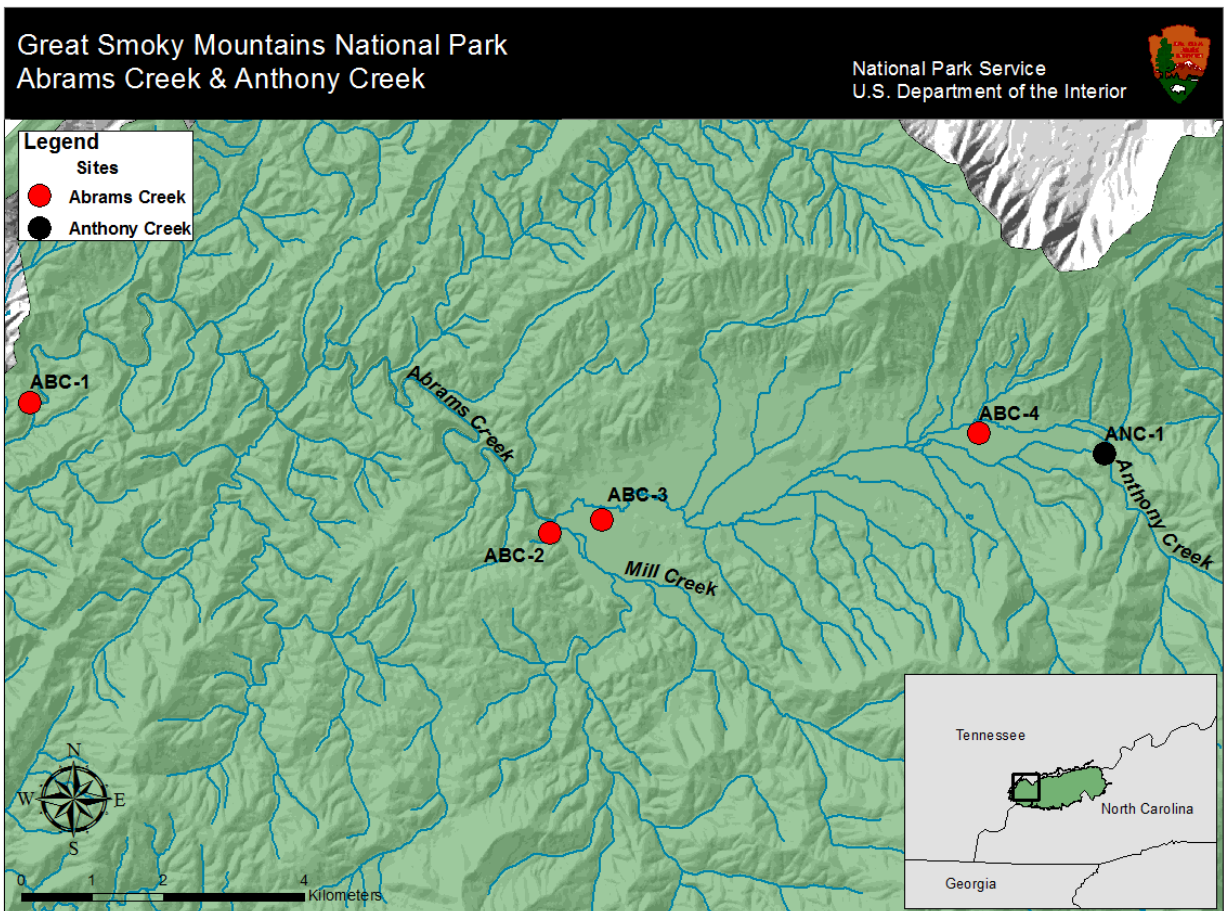


Figure 2. – Map depicting the location of historical fish monitoring sites on Abrams and Anthony Creeks, Great Smoky Mountains National Park, TN.

Cataloochee Creek

Cataloochee Creek drainage forms in the South District of GRSM (Haywood County, NC) and drains from the Cataloochee Valley into Waterville Lake (an impoundment of the Pigeon River). Data were collected from four sampling sites along Cataloochee Creek (CAT-1, CAT-2, CAT-3, and CAT-4, Figure 3). Cataloochee Creek is a 4th order stream with sites ranging in elevation from 744m at the lowest station (CAT-1) to 863m at CAT-4.

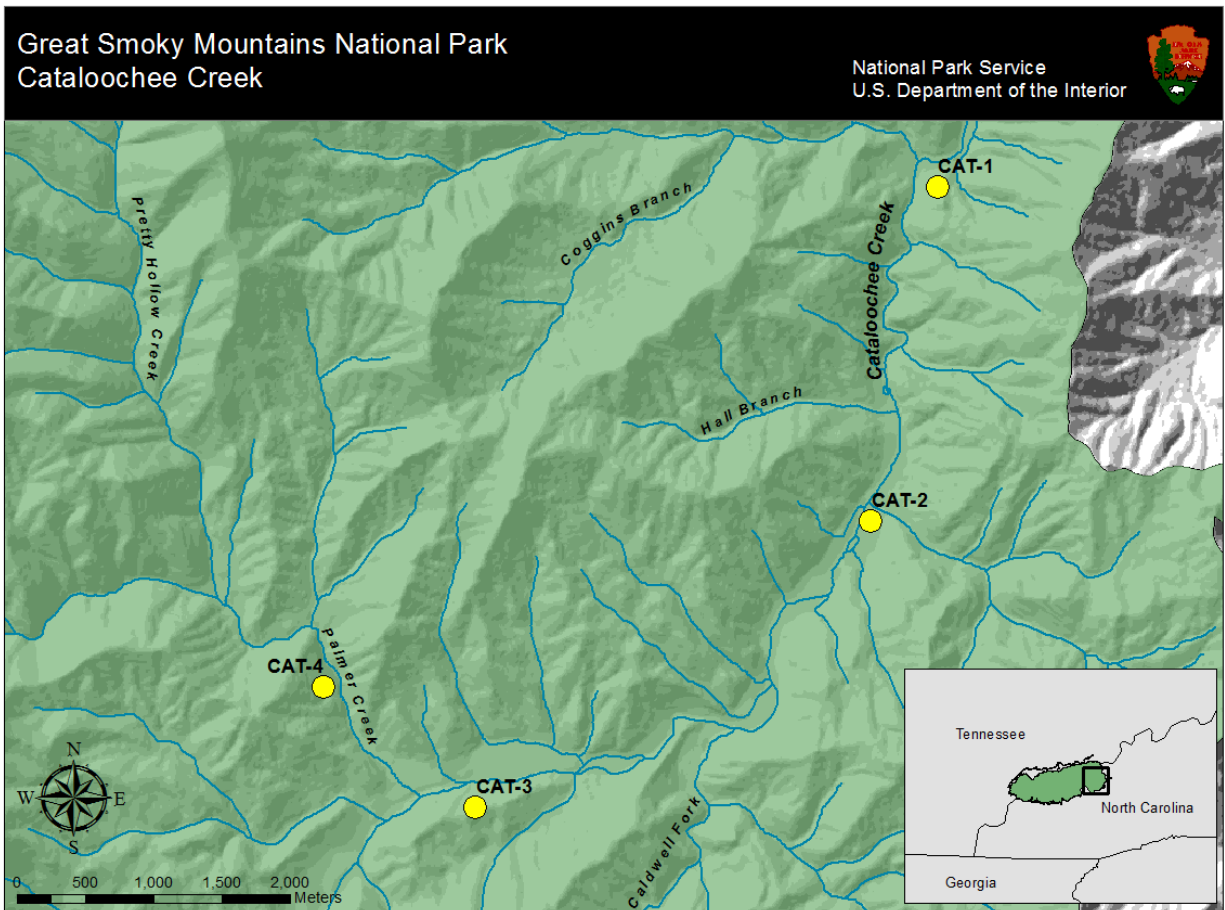


Figure 3. – Map depicting the location of historical fish monitoring sites on Cataloochee Creek, Great Smoky Mountains National Park, NC.

East Prong Little River

The East Prong of Little River is formed by an extensive set of tributaries draining from the North District (Sevier and Blount counties, TN) of GRSM. Four large-stream monitoring sites were sampled on the East Prong Little River: LRV-1, LRV-2, LRV-3, and LRV-3N (Figure 4). All monitoring sites are located at 4th order stream sections ranging in elevation 518 at LRV-1 to 1042m at LRV-3.

Great Smoky Mountains National Park
East Prong Little River

National Park Service
U.S. Department of the Interior

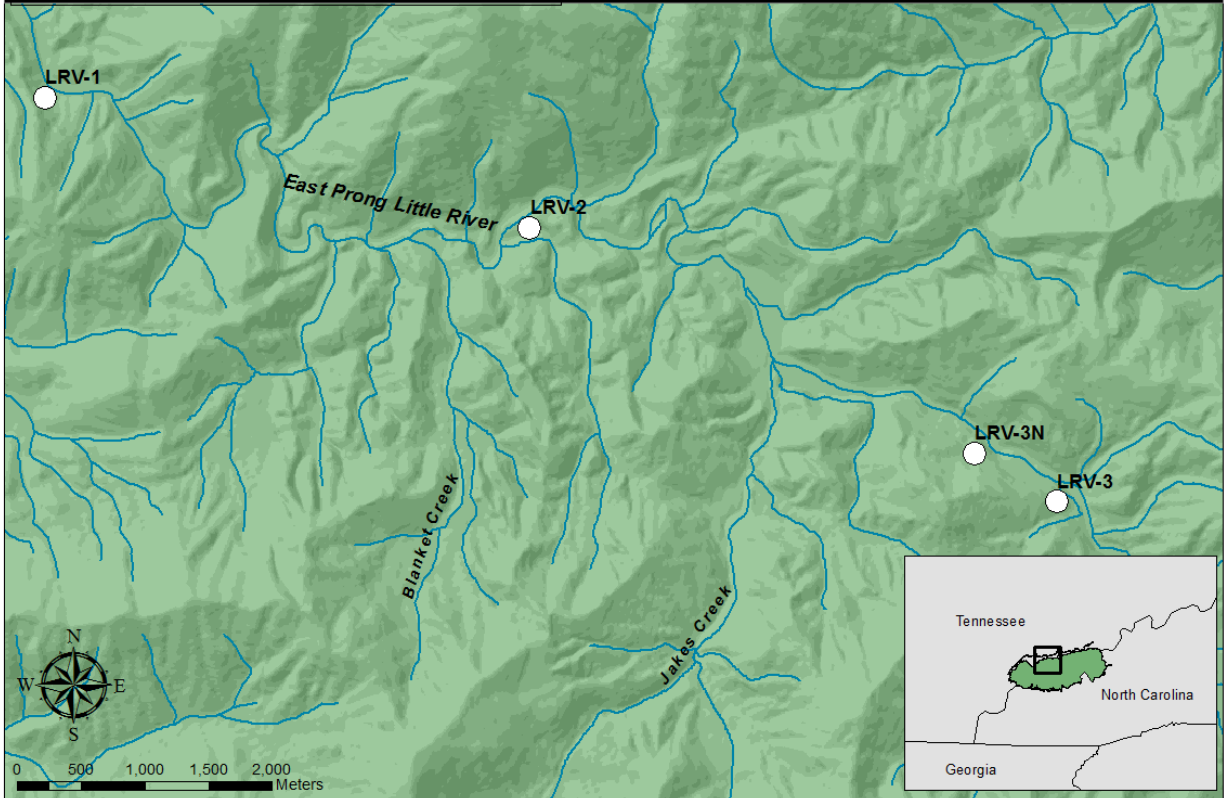


Figure 4. – Map depicting the location of historical fish monitoring sites on the East Prong of Little River, Great Smoky Mountains National Park, TN.

Table 2. – Physical and chemical results ($\pm$ S.E.) of large stream surveys at historic monitoring sites.

	Stream Order	Elevation (m)	Number of Shockers	Voltage	Area (sq/m)	Length (m)	Mean Width (m)	Habitat (Primary/Secondary)	Substrate (Primary/Secondary)	Mean Gradient (%)	Discharge (m³/s)	Water Temp (°C)	Mean pH	Conductivity (µS/cm)	
Abrams Creek															
	ABC-1	5	341	6	300	3780.9 ± 37.7	200	17.7 ± 0.1	Pool/Riffle	Cobble/Bedrock	1.5 ± 0.3	0.9 ± 0.2	16.0 ± 1.3	7.3 ± 0.2	54.0 ± 4.4
	ABC-2	5	521	6	250	3581.1 ± 81.4	200	17.8 ± 0.4	Pool/Complex	Bedrock/Cobble	1.3 ± 0.3	0.4 ± 0.1	14.0 ± 0.9	7.4 ± 0.3	91.1 ± 14.6
	ABC-3	4	523	3	125	1246.1 ± 40.6	150	7.8 ± 0.1	Pool	Large Gravel/Cobble-Sand	1.1 ± 0.2	0.2 ± 0.05	14.0 ± 0.3	7.6 ± 0.1	122.8 ± 11.3
	ABC-4	3	549	2	500	509.4 ± 16.8	100	5.3 ± 0.1	Riffle/Pool	Cobble/Small Boulder	1.7 ± 0.3	0.1 ± 0.02	14.1 ± 1.4	6.6 ± 0.2	21.2 ± 2.1
Anthony Creek															
	ANC-1	3	610	1	600	438.1 ± 10.9	100	4.6 ± 0.1	Pool/Riffle	Bedrock/Cobble-Boulder	2.8 ± 0.3	0.1 ± 0.06	13.2 ± 0.3	6.5 ± 0.1	12.1 ± 1.3
Cataloochee Creek															
	CAT-1	4	744	6	600	3065.4 ± 49.6	200	15.5 ± 0.2	Complex/Pool	Small Boulder/Large Boulder	1.4 ± 0.2	1.2 ± 0.2	12.9 ± 0.8	6.9 ± 0.1	15.1 ± 1.1
	CAT-2	4	808	5	600	2945.8 ± 45.4	200	14.3 ± 0.2	Complex/Pool	Boulder/Cobble	2.0 ± 0.2	1.0 ± 0.1	13.1 ± 0.9	6.7 ± 0.1	14.5 ± 1.1
	CAT-3	4	823	3	600	1973.7 ± 23.8	200	9.6 ± 0.1	Complex/Pool	Small Boulder/Cobble	2.2 ± 0.4	0.8 ± 0.1	13.4 ± 0.7	6.0 ± 0.6	15.3 ± 1.0
	CAT-4	4	863	3	650	1774.3 ± 69.8	200	8.9 ± 0.2	Complex/Pool	Large Boulder/Cobble	4.0 ± 0.3	0.4 ± 0.1	12.5 ± 0.8	6.4 ± 0.2	12.4 ± 0.7
E.P. Little River															
	LRV-1	4	518	6	600	3841.3 ± 257.1	200	18.9 ± 0.5	-	-	2.1 ± 0.2	1.2 ± 0.2	14.6 ± 0.8	6.8 ± 0.2	18.1 ± 2.2
	LRV-2	4	604	5	600	3069.6 ± 299.4	200	17.6 ± 0.4	Complex/Pool	Cobble/Large Boulder	2.1 ± 0.2	1.1 ± 0.2	12.7 ± 1.0	6.8 ± 0.2	18.1 ± 3.2
	LRV-3	4	1042	4	600	2232.2 ± 312.2	200	14.6 ± 0.4	Pool/Complex	Small Boulder/Large Boulder	2.8 ± 0.5	0.9 ± 0.1	11.7 ± 0.9	6.6 ± 0.1	12.2 ± 1.0
	LRV-3N	4	701	5	600	2990.4 ± 137.7	200	14.6 ± 0.3	-	-	3.2 ± 0.7	0.9 ± 0.3	14.8 ± 0.5	6.7 ± 0.1	13.7 ± 1.1

Table 3. – Habitat characteristics for large stream historic monitoring sites.

		Year	Mean Depth	Instream Substrate								Instream Habitat			
				1	2	3	4	5	6	7	8	Pool	Riffle	Cascade	Complex
Abrams Creek															
	ABC-1	1995	0.42	0.0	2.8	0.0	2.8	63.9	8.3	8.3	13.9	62.2	35.6	0.0	2.2
	ABC-2	1995	0.40	0.0	3.0	6.1	0.0	18.2	12.1	3.0	57.6	80.5	4.5	0.0	15.0
	ABC-3	1995	0.50	3.6	17.9	10.7	42.9	17.9	0.0	0.0	7.1	100.0	0.0	0.0	0.0
	ABC-4	1995	0.22	0.0	0.0	3.0	6.1	69.7	21.2	0.0	0.0	40.0	56.8	0.0	3.2
Anthony Creek															
	ANC-1	1995	0.23	0.0	0.0	0.0	6.1	12.1	12.1	3.0	66.7	36.0	30.9	4.1	28.9
Cataloochee Creek															
	CAT-1	1995	0.42	0.0	0.0	0.0	6.1	24.2	42.4	27.3	0.0	29.6	0.0	0.0	70.4
	CAT-2	1995	0.32	0.0	0.0	0.0	3.0	21.2	54.5	21.2	0.0	10.0	6.5	0.0	83.5
	CAT-3	1995	0.31	0.0	0.0	0.0	3.0	27.3	54.5	15.2	0.0	12.5	4.0	1.5	82.0
	CAT-4	1995	0.36	0.0	0.0	0.0	11.8	29.4	20.6	32.4	5.9	37.1	8.8	2.9	51.2
E.P. Little River															
	LRV-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LRV-2	1995	0.37	0.0	0.0	3.0	3.0	39.4	18.2	27.3	9.1	28.0	26.9	0.0	45.1
	LRV-3	1995	0.46	0.0	0.0	0.0	13.9	16.7	36.1	33.3	0.0	77.3	0.0	0.5	22.3
	LRV-3N	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3 – Methods

Sites were sampled using three-pass depletion techniques as outlined in the Southern Division American Fisheries Society Trout Committee Standardized Sampling Guidelines (SD AFS Trout Committee 1994). The three pass depletion method was used because of its efficiency and that its assumptions are easily met; closed population, equal catchability, and equal effort. Block nets were first set at the upstream and downstream ends of each site to meet the three pass depletion assumption of a “closed population” (Ricker 1975; Zippin 1958). In large stream sites, block nets were clipped to a length of wire cable hung across the stream with large rocks placed across the bottom of the net to secure it to the stream bottom. A cable was not used in small stream sites (<10m wetted width). Sites with a mean wetted width $\leq 10\text{m}$ were then measured at 10m intervals for 100m and at 20m intervals for 200m for sites with mean wetted width $>10\text{m}$. At each transect, wetted width was measured to the nearest 0.1m. If an island was present in the section, its width was not included as part of the total stream width. Site area (m^2) was calculated by multiplying the mean stream width (m) by the total site length (m). Gradient (%) was measured using a clinometer between consecutive transects and then averaged between all measurements. Stream discharge (m^3/second), water temperature ($^{\circ}\text{C}$) and conductivity ($\mu\text{S}/\text{cm}$) were also measured at each site. Conductivity and stream water temperature were measured using a Yellow Springs Instruments (YSI) model 30, 33 or model 90 salinity-conductivity-temperature meter to the nearest 0.1 resolution. The meter was calibrated annually to ensure accuracy and precision. Stream discharge (m^3/second) was measured prior to leaving the area (Nielsen and Johnson 1983) using a Marsh-McBirney model 2000 or model 201D portable current meter along a transect in the stream perpendicular to the flow. Discharge was taken at a single transect that included a smooth stream bottom and uniformity across the channel. A measuring tape was stretched across the stream and measurements began at the streambank and proceeded in equal intervals depending on stream width. These intervals allowed the stream to be broken into cells where individual depths and velocity was measured. Velocity was measured at 0.6 depth from the water surface. A minimum of 10 cells were used to calculate discharge.

Discharge was calculated according to the following equation:

$$Q = \sum_{i=0}^n \left[\left(\frac{di1 + di2}{2} \right) \times (Vi) \times (CW) \right]$$

where Q is discharge, d is depth, V is velocity, CW is cell width, and n is the number of cells measured.

Sites were then sampled using the three pass depletion method with backpack electrofishing

units producing an alternating current (AC). For every 3-4m of stream width, one electrofishing unit was used (i.e., streams with 6m wetted width used 2 shockers). Each electrofishing unit was set to the same voltage output for each site, although voltage varied between sites. Voltage output was determined by fishery staff according to stream conductivity within the site. Electrofishing began at the downstream end of the site and proceeded upstream perpendicular to flow in a uniform line to the end of the site. One netter per electrofishing unit (in addition to the operator) per pass was used. Those personnel netting and bucketing followed closely behind the shocker assisting with fish collection and to carry fish. All personnel in operation of backpack electrofishing units and all using back-up nets were required to wear high voltage electrical linesman gloves and waterproof waders to prevent electrical shock during sampling. During sampling, water in buckets was changed regularly to reduce fish stress and mortality. If possible, fish were given to a workup crew for sorting during the electrofishing phase of each pass.

Fish were identified and sorted by species into individual buckets. Individual total length (mm) and weight (g) of all gamefish (i.e., trout and bass) were measured using either a 300mm or 600mm measuring board (Murphy and Willis 1996). Weights were measured using either 10g, 50g, 100g, 300g, or 500g Pesola hanging scales or 1kg electronic balance to the nearest 0.1g. Total batch number, batch weight (g), plus a minimum and maximum total length (mm) of all non-gamefish were recorded. Total weights for nongame species were measured using either a 5kg hanging scale or a 5kg electronic balance. All fish were placed in holding cages outside of the sampling area until three passes in the site were completed. Once completed, fish were re-distributed throughout the sampling area. Sampling efforts were conducted from mid-August to mid-October periodically throughout streams from 1986-2011.

All 3-pass depletion data were entered into Microfish 3.0 (van Deventer and Platts 1983; www.microfish.org) to calculate population estimates for each species. To calculate density, the population estimate for a given species was divided by the site area (m^2) and multiplied by site length to get species density per site length m^2 . Biomass (kg/ha) was calculated by multiplying the population estimate by the mean weight (g), dividing that number by the area (m^2), then multiplying the result by 10 to convert from g/m^2 to kg/ha.

Habitat variables were quantified within each of the study sites in 1995 using modified habitat quantification methods as outlined by Hankin and Reeves (1988) and Dolloff et al. (1993). All habitats within the stream section were sampled. Habitat units were classified visually and assigned 1 of 4 classifications (i.e., pool, riffle, cascade, complex) based upon morphological features. Total length was measured from the bottom to top of the each habitat unit. Lengths of each habitat type were then added together and divided by site length to obtain percent of

instream habitat type. Five transects were taken at 1/5 length intervals within the stream site to measure depth and classify substrate. Five observations were taken across each transect at intervals of 1/5 the width the measure of that transect. Dominant substrate type (Table 4) was then estimated for a 1m area around the base of the staff and was recorded.

Table 4. – Categories used to classify substrate within each stream reach.

Code	Type	Substrate Size (mm)
1	Silt	< 0.06 mm
2	Sand	> 0.06 mm to 2 mm
3	Small Gravel	2 mm to 2 cm
4	Large Gravel	2 cm to 10 cm
5	Cobble	10 cm to 30 cm
6	Small Boulder	30 cm to 60 cm
7	Large Boulder	> 60 cm
8	Bedrock	-

4 – Results

Species Composition

Of the 13 long term monitoring sites sampled from 1986-2011, a total of 34 species (Table _) were detected, including 2 federally endangered (i.e., Citico darter, Smoky madtom) and 1 federally threatened species (i.e., spotfin chub). However, detections of spotfin chub were recorded only in the area where ongoing efforts to re-establish their populations were taking place at the time. Spotfin chub never established a self-sustaining population and have now been extirpated from the park.

Length Distribution

Population Condition

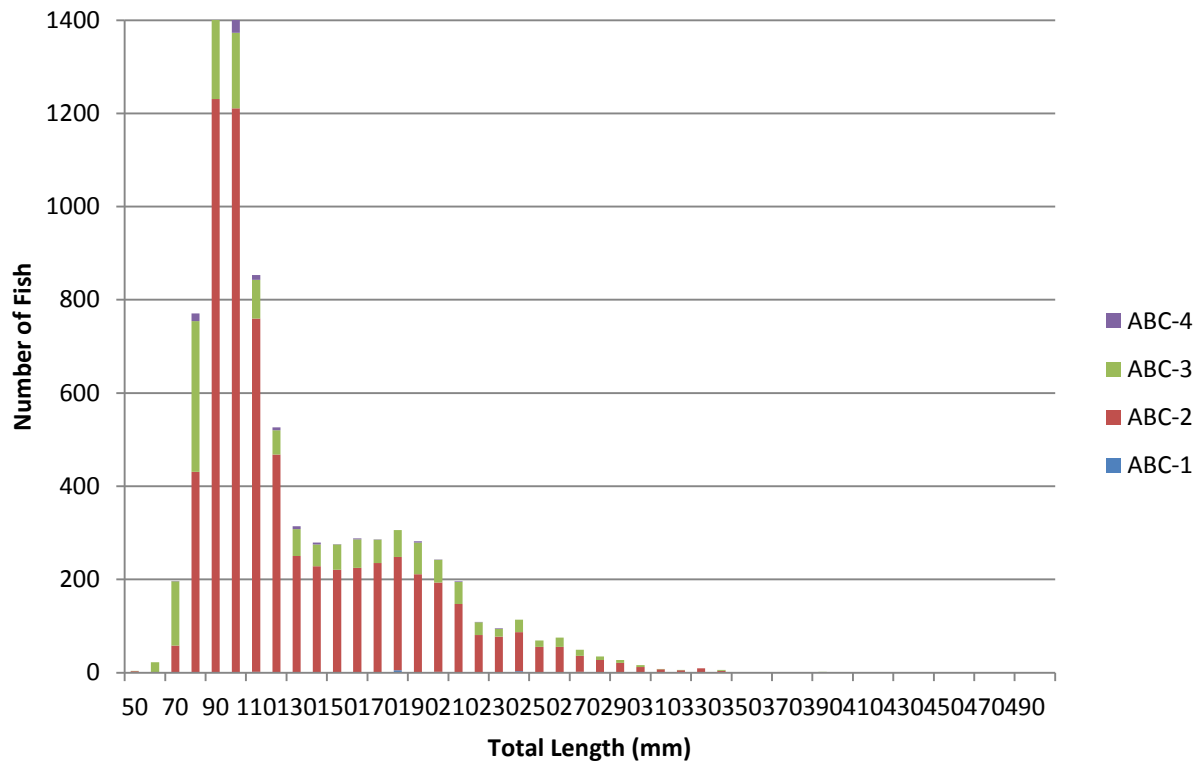
Population Trend

Population Drivers

Abrams Creek

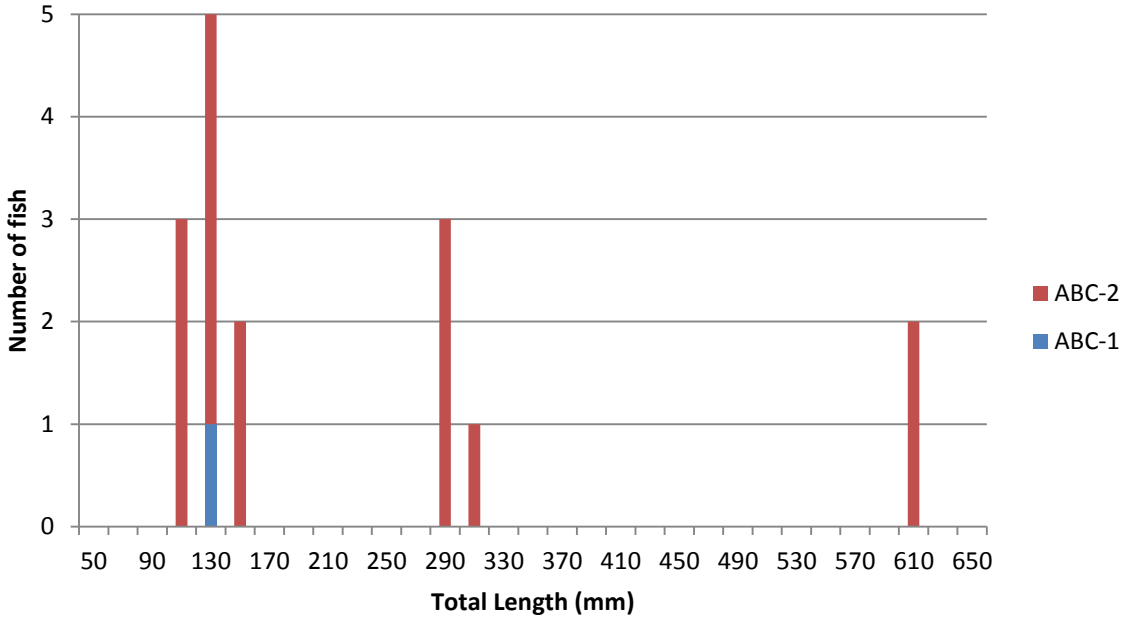
Rainbow Trout

Abrams Creek Rainbow Trout

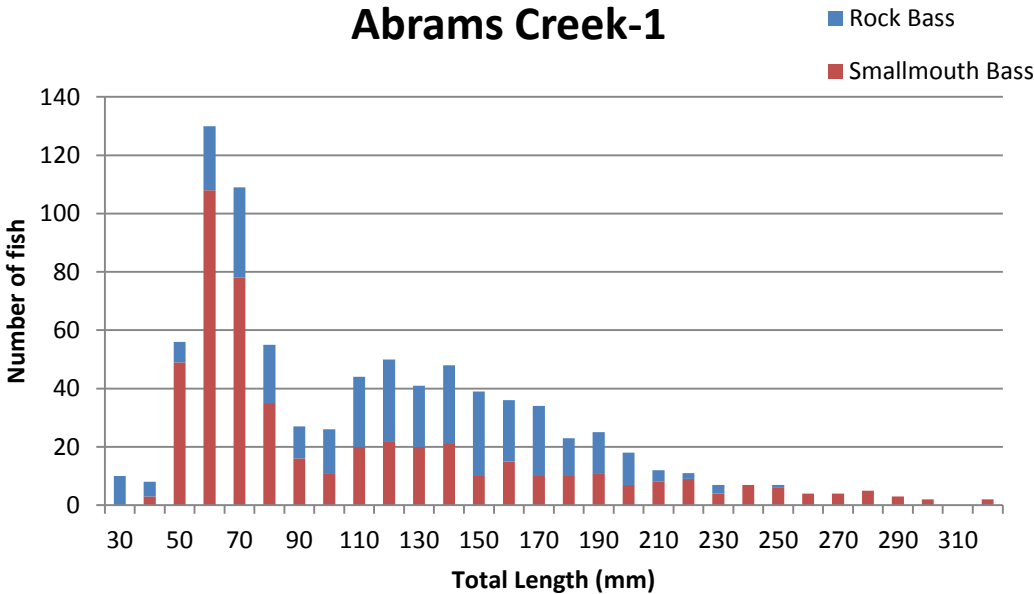


Brown Trout

Abrams Creek Brown Trout

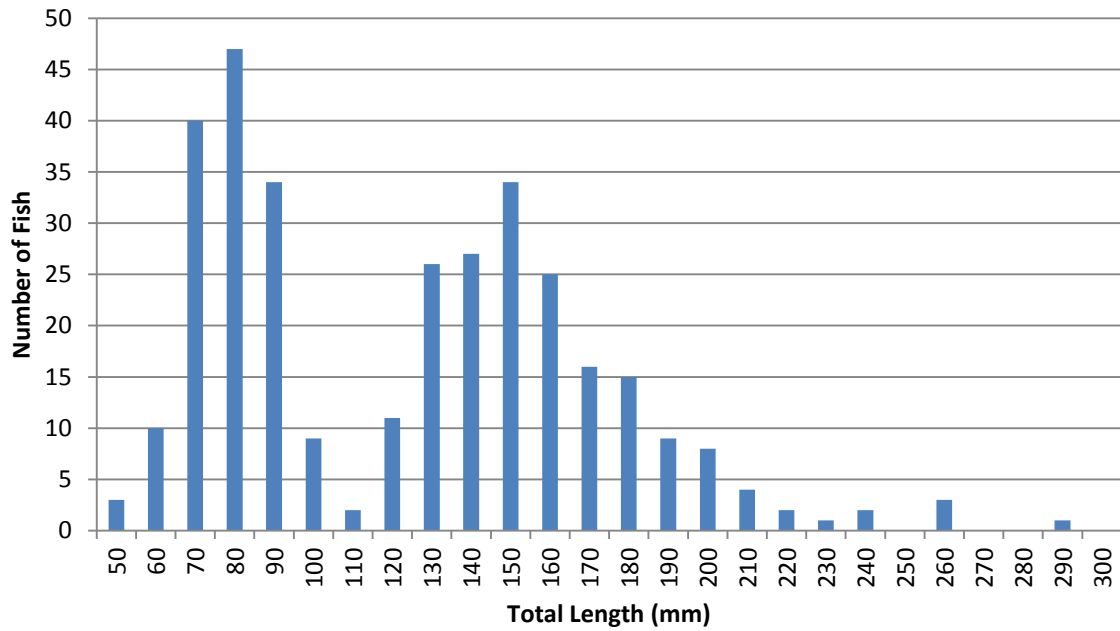


Smallmouth Bass & Rock Bass



Anthony Creek Rainbow Trout

Anthony Creek Rainbow Trout



Cataloochee Creek

Rainbow Trout

Brook Trout

Brown Trout

Little River

Population Condition

Table 3. — Species list of fish found within long term monitoring sites within Great Smoky Mountains National Park. An ‘x’ indicates species found within site. An asterisk denotes fish that are currently federally listed as a threatened or endangered (T&E) species.

Species	Abrams Creek				Anthony Creek	Cataloochee Creek				E.P. Little River			
	ABC-1	ABC-2	ABC-3	ABC-4	ANC-1	CAT-1	CAT-2	CAT-3	CAT-4	LRV-1	LRV-2	LRV-3	LRV-3N
Banded darter <i>Etheostoma zonale</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Banded sculpin <i>Cottus carolinae</i>	.	.	.	.	.	.	.	.	.	x	x	x	.
Bigeyed hub <i>Hybopsis amblops</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Black redhorse <i>Moxostoma duquesnei</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Blacknose dace <i>Rhinichthys obtusus</i>	x	x	x	x	x	x	x	x	.	x	x	x	.
Brook trout <i>Salvelinus fontinalis</i>	.	.	.	.	.	x	x	x	x	.	.	.	.
Brown trout <i>Salmo trutta</i>	.	x	.	.	.	x	x	x	x	x	x	x	x
Central stoneroller <i>Campostoma anomalum</i>	x	x	x	x	x	x	x	x	x	x	x	.	x
Citico darter <i>Etheostoma sitikunse</i> *	x	.	.	.	.	.	.	.	.	.	.	.	.
Creek chub <i>Semotilus atromaculatus</i>	x	x	x	x	x	.	.	.	.	.	.	.	.
Fantail darter <i>Etheostoma flabellare</i>	.	x	.	x	.	.	.	.	.	.	.	.	.
Fathead minnow <i>Pimephales promelas</i>	.	x	.	.	.	.	.	.	.	.	.	.	.
Gilt darter <i>Percina evides</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Greenfin darter <i>Etheostoma chlorobranchium</i>	x	x	.	.	.	.	.	.	.	.	.	.	.
Longnose dace <i>Rhinichthys cataractae</i>	.	x	.	x	x	x	x	x	x	x	x	x	x
Mottled sculpin <i>Cottus bairdi</i>	.	.	.	.	.	.	.	.	.	x	x	x	x
Northern hogsucker <i>Hypentelium nigricans</i>	x	x	x	x	x	x	x	x	.	x	x	.	x
Rainbow trout <i>Oncorhynchus mykiss</i>	x	x	x	x	x	x	x	x	x	x	x	x	x
Redline darter <i>Etheostoma rufileineatum</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
River chub <i>Nocomis micropogon</i>	x	x	x	.	.	.	.	.	.	x	x	.	x
Rock bass <i>Ambloplites rupestris</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Rosyside dace <i>Clinostomus funduloides</i>	.	x	x	x	x	.	.	.	.	.	.	.	.
Saffron shiner <i>Notropis rubricroceus</i>	.	x	x	.	x	.	.	.	.	x	x	.	.
Smallmouth bass <i>Micropterus dolomieu</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Smoky madtom <i>Noturus baileyi</i> *	x	.	.	.	.	.	.	.	.	.	.	.	.
Spotfin chub <i>Erimonax monachus</i> * <i>extirpated</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Telescope shiner <i>Notropis telescopus</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Tennessee dace <i>Notropis tennesseensis</i>	x	.	.	x	.	.	.	.	.	.	.	.	.
Tennessee shiner <i>Notropis leuciodus</i>	x	x	x	x	x	.	.	.	.	x	.	.	.
Tennessee snubnose darter <i>Etheostoma simoterum</i>	x	x	x	x	.	.	.	.	.	.	.	.	.
Warpaint shiner <i>Luxilus coccogenis</i>	x	x	x	x	.	.	.	.	.	x	x	.	.
White sucker <i>Catostomus commersonii</i>	x	x	x	.	.	x	.	.	.	x	x	.	.
Whitetail shiner <i>Cyprinella galactura</i>	x	.	.	.	.	.	.	.	.	.	.	.	.
Wounded darter <i>Etheostoma vulneratum</i>	x	.	.	.	.	.	.	.	.	.	.	.	.

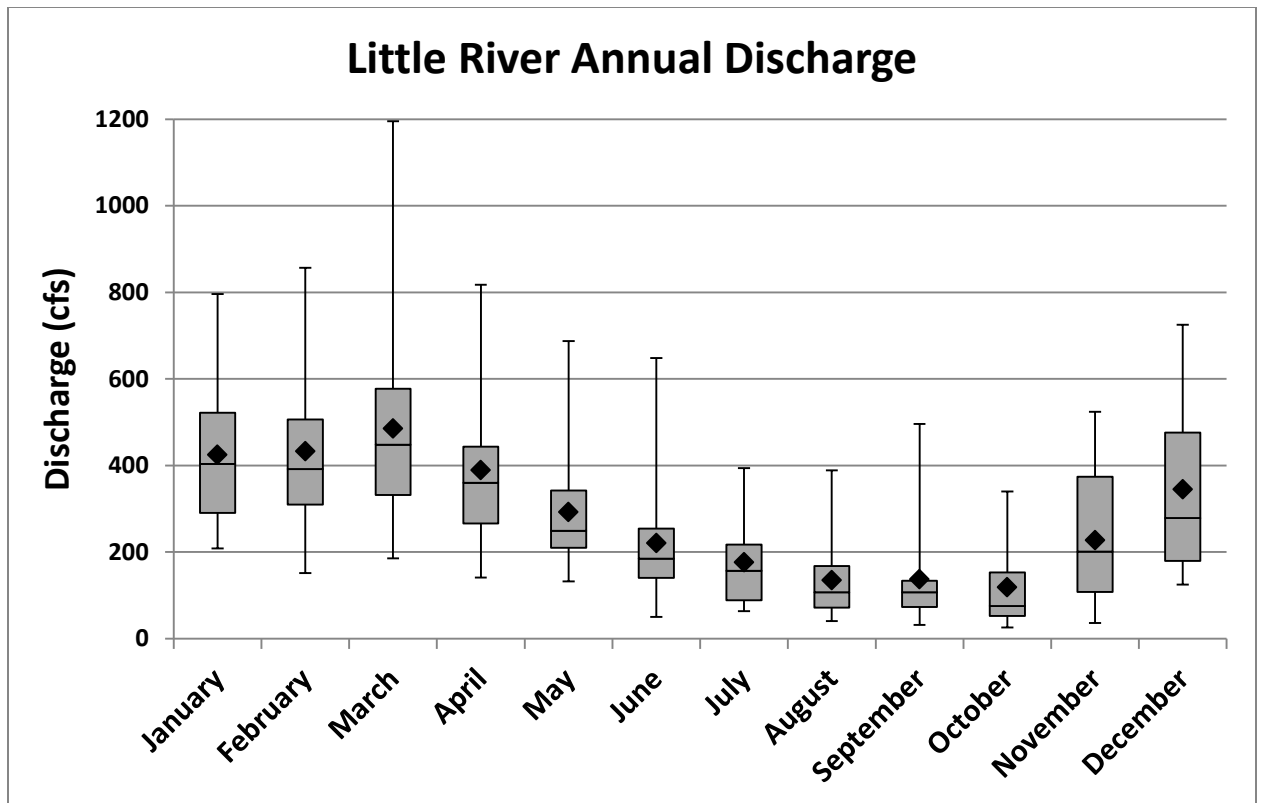


Figure___. Monthly mean discharge (cfs) on Little River from 1986-2011, Great Smoky Mountains National Park, TN.

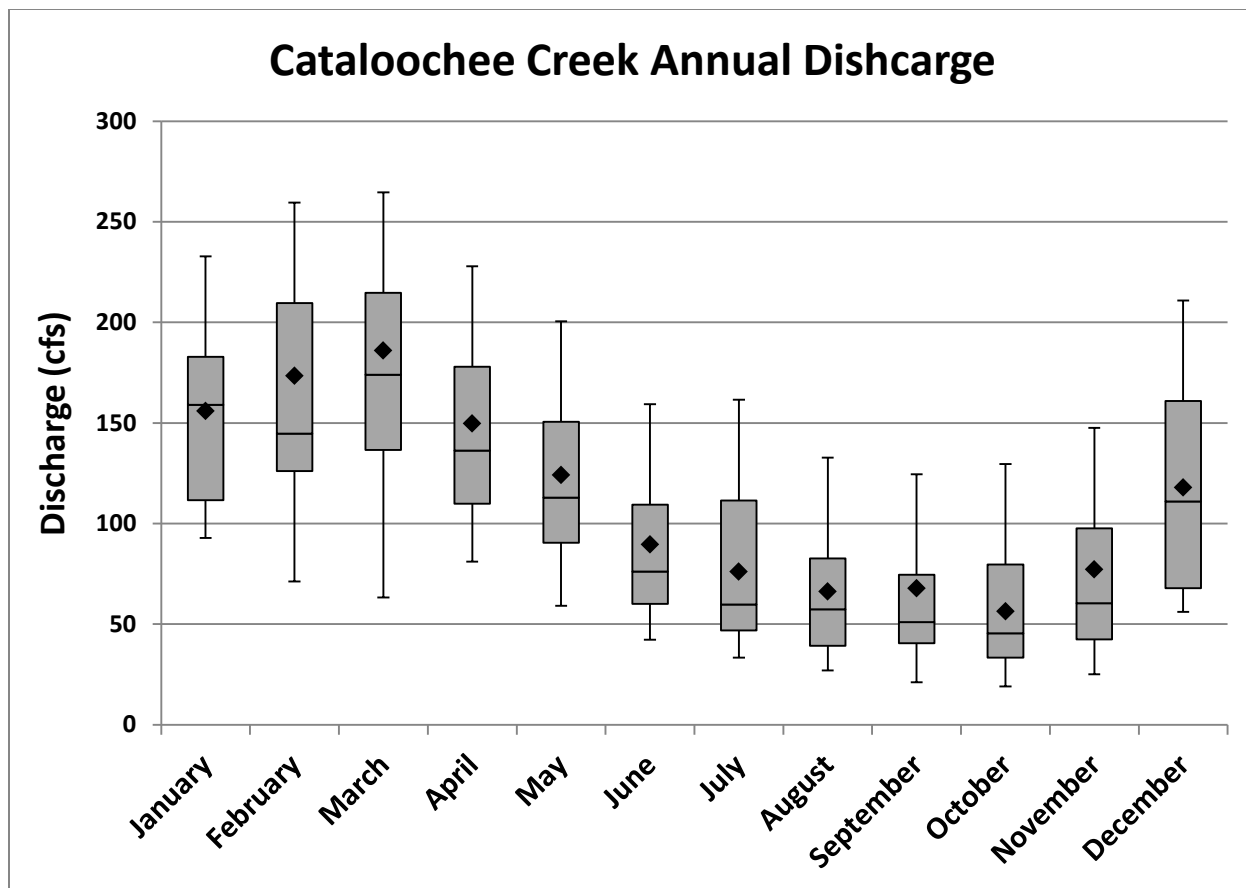


Figure__. Monthly mean discharge (cfs) on Cataloochee from 1986-2011, Great Smoky Mountains National Park, NC.

5 – Discussion

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Appendix I.

Abrams Creek Site Descriptions

ABC-1

Abrams Creek site 1 located just downstream of the Ranger Station at Abrams Creek Campground. Before the Ranger Station (approximately 50 m), take the dirt drive to the right. Proceed down the drive to the stream. Take the trail to the Rabbit Creek Trail crossing. The site begins approximately 20m below the footbridge and proceeds 200m upstream.

ABC-2

Drive to the Abrams Falls parking area. Site begins approximately 240m below the confluence of Abrams Creek and Mill Creek. The upper ends approximately 40m below the confluence. Both the upstream and downstream site tags are located on the right side of the stream on large hemlocks.

ABC-3

Drive around the Cades Cove loop road to the Abrams Falls parking area. As you turn onto the falls parking lot road, pull into the first pull-off area on the right. Proceed directly towards Abrams Creek from the pull-off. The site ends approximately 100m below the bridge on Loop Road.

ABC-4

Drive the Cades Cove loop road to Sparks Lane. Take Sparks Lane across Abrams Creek and take a left onto the gated road. Proceed to the second field on the left and travel through the gate, then take an immediate left. Travel to the back right corner of the field and cross the fence to get to the stream. The site starts just above an old metal pole gate fixed across the stream.

Anthony Creek Site Descriptions

ANC-1

Drive to the Cades Cove picnic area. Proceed into the back of the picnic area and take the gated road past Horse Camp, approximately 300m. Site begins above a small log jam and proceeds approximately 100m upstream.

Cataloochee Creek Site Descriptions

CAT-1

Site begins approximately 300m downstream of the United States Geological Survey gauge station at the iron bridge on the lower Cataloochee Creek, just above its confluence with Little Cataloochee Creek.

CAT-2

Site begins approximately 10m above the iron bridge below the cataloochee bunkhouse.

CAT-3

Site begins approximately 400m downstream stream of Palmer Church. Site starts at small riffle near rock wall.

CAT-4

Drive up Palmer Creek to the Horse Camp gate. Walk up the road to Davidsons Branch Trailhead. The site begins approximately 200m below the trailhead and ends just above the trailhead at a small island.

E. Prong Little River Site Descriptions

LRV-1

The site begins approximately 100m below the first pulloff east of Metcalf Bottom picnic area. Site starts at the base of a long pool and proceeds 200m and ends at the head of a long run, just below the second pulloff east of Metcalf Bottoms picnic area.

LRV-2

Site begins at the Milsap pulloff just below the Elkmont Junction. The site starts at the bottom end of a riffle in the middle of the pullout and proceeds 200m to the beginning of a rockwall.

LRV-3

Access the site by traveling up Little River truck road, through the gate at Jakes Creek and the old metal gate and travel up the road to the site, approximately ¼ of a mile before Huskey Branch.

LRV-3N

Take the Little River truck road, through the gate at Jakes Creek to the old metal gate. Site begins approximately 200m below the old metal gate and turnaround and ends at the turnaround.