# FISHERIES REPORT
# 18-01

## REGION IV
## TROUT FISHERIES REPORT
## 2017

**Prepared by:**


James W. Habera
Sally J. Petre
Bart D. Carter
Carl E. Williams

**Tennessee Wildlife Resources Agency**

Visit TWRA's website at ***[www.tnwildlife.org](http://www.tnwildlife.org)***., where you can learn more about Tennessee's trout fisheries across the state.

Cover (and left): Large Rainbow Trout from the Ft. Patrick Henry tailwater near Kingsport. Region 4's tailwater trout fisheries are monitored each year to obtain data for managing these resources. Photos by G. Loucks (TWRA).

# REGION 4
# TROUT FISHERIES REPORT
# 2017

**Prepared by:**

James W. Habera
Sally J. Petre
Bart D. Carter
and
Carl E. Williams

**TENNESSEE WILDLIFE RESOURCES AGENCY**

April 2018

*This report contains progress and accomplishments for the following TWRA Projects: "Stream Survey".*

*Development of this report was financed in part by funds from Federal Aid in Fish and Wildlife Restoration (Public Law 91-503) as documented in Federal Aid Project FW-6 (4350 and 4351)*

## ***Executive Summary***

***Long term monitoring streams:*** Seven trout streams were quantitatively sampled during 2017 field season (June-October) within Region IV. Overall, trout abundance remained below long term averages. This is likely due to the Tennessee River Watershed, particularly in eastern Tennessee, being in abnormally dry to extreme drought from May 2016 to mid-April 2017 according to United State Drought Monitor. Drought throughout the region decreases base stream flow and increase temperatures, which can limit reproductive success and affects overall health of trout. Since mid-April, this Region has been drought free and trout biomass should start to increase in the 2018 and 2019 sampling.

***Sympatric Brook/Rainbow Trout streams:*** Relative Brook Trout biomass decreased in both of the streams sampled this year (Briar Creek and Rocky Fork). Data from these stations continue to document long-term co-existence of Brook and Rainbow Trout and that drier periods (particularly 1998-2002; 2007-2008) favor Brook Trout while wetter periods (e.g., 2003-2005, and 2013) or floods (1994) favor Rainbow Trout.

***Brook Trout DNA sampling:*** All 42 Brook Trout streams remaining to be sampled as part of the effort to upgrade existing genetics information were visited in 2017. DNA samples were obtained from 1,081 fish representing 40 populations (two were found to no longer have Brook Trout), with sample sizes ranging from 6-39 and averaging 27 fish. Each fish collected for a DNA sample was also checked for gill lice, but none were observed. Results of microsatellite DNA analyses on these fish and those collected in 2016 are pending.

***Little Jacob Creek Brook Trout enhancement:*** In the early 2000s Little Jacob Creek was restored after translocating native Brook Trout in the stream and evaluating the population. In 2016 and 2017 the stream was surveyed again and enhanced by an extensive Rainbow Trout removal effort. After the 2016 removal effort, we found no age-0 Rainbow Trout in 2017. This suggests the Rainbow Trout removal, or Brook Trout enhancement project was successful, leaving this section of stream with only Brook Trout.

***Little Stony Creek Brook Trout Restoration:*** The Little Stony Creek restoration objective was to restore the historical native population of Brook Trout. In 2014 Rainbow Trout were evaluated and removed through intensive back pack electrofishing and native Brook Trout from Left Prong Hampton Creek were stocked. Rainbow Trout were removed and Brook Trout population assessed in 2015 and again in 2017. Currently, Brook Trout numbers and range have increased since 2014, with both age-0 and adult Brook Trout through the restoration area. Supplemental stocking of Brook Trout may be needed in the lower section of the creek to increase density, where fewer Brook Trout were found. Rainbow Trout range and population decreased, with no age-0 Rainbow Trout found in 2015 or 2017, indicating the removal effort is complete.

***Boone tailwater:*** Although the mean electrofishing catch rate for all trout ≥178 mm increased only slightly in 2017 (to 109 fish/h), catch biomass increased 23% as a result of more large (≥457 mm or 18 in.) Brown Trout (7 fish/h) than were present in any previous sample. More Brook Trout (19 fish/h) were also captured in 2017 than in any previous sample, although none were >303 mm. Repairs at Boone Dam continued in 2017 and require the drawdown of Boone Lake to an elevation of 412 m (1,352’)—3.1 m (10’) below winter pool (possibly until 2022). TVA water quality monitoring data from the tailwater near the dam indicated dissolved oxygen (DO) often fell below 6 mg/l (TDEC’s criterion for trout waters) during May-July 2016 (occasionally for over 12 h) and on most days in October, but always remained above 3.0 mg/l. The 2017 monitoring results do not indicate that the lower DO levels in 2016 (likely related to drought conditions and reduced

flows during summer and fall that year) had any notable effect on the Boone tailwater trout fishery. A management plan is currently in preparation for the Ft. Patrick Henry and Boone tailwater trout fisheries.

***Cherokee tailwater:*** Water temperatures in the Cherokee tailwater were exceptionally warm again during 2017. Minimum daily water temperature near the dam exceeded 21° C for 50 days beginning on 24 August—the longest period with no coldwater habitat observed there except for 2016 (55 days). Minimum daily water temperature at Blue Spring reached 21° C on 18 August and remained above 21° C (no coldwater habitat) for 52 days (exceeded only in 2003). Water temperatures in the Cherokee tailwater typically return to trout-tolerant levels (<21° C) by mid- to late October, and this occurred on 28 October in 2017. Fifteen Rainbow Trout and 7 Brown Trout were captured during monitoring efforts in October 2017, thus the overall mean catch rate (11 fish/h ≥178 mm) increased relative to 2016 (2.5 fish/h). Mean catch rates for larger trout (≥356 mm and ≥457 mm) also increased in 2017. The 2017 catch rate for trout ≥356 mm (9.5 fish/h) exceeded that for any previous monitoring sample.

***Ft. Patrick Henry tailwater:*** The mean catch rate for all trout ≥178 mm increased slightly (to 106 fish/h) in 2017, although the catch rate for larger trout (≥356 mm) decreased 34% to 44 fish/h. The mean catch rate for the largest trout (≥457 mm or 18 in.) also decreased (to 18 fish/h), but remained above the long-term average of 10 fish/h. The abundance of trout ≥457 mm was depressed during 2004-2010 (0 to 4 fish/h), but has improved since then, averaging nearly 18 fish/h. The Ft. Patrick Henry tailwater—like the Boone tailwater upstream—continues to produce large, extremely well-conditioned fish (particularly Rainbow Trout) with relative weights ($W_r$), often well in excess of 100. The management plan currently being prepared for this trout fishery (and Boone's) will seek to maintain this feature.

***Norris tailwater:*** The mean electrofishing catch rate for trout within the PLR (356-508 mm) was 73 fish/h in 2017 and has remained above 70 fish/h since 2014. The current Norris tailwater management plan (2014-2019) provides a mean PLR catch rate objective of 28 fish/h and is certainly being achieved. The relative stock density of trout 356 mm (14 in.) and larger (RSD-14) has increased from 12 (2009) to over 40 during 2016-17, indicating that trout population size structures have been shifted toward larger fish and maintained, as CPUE for trout ≥178 mm has been relatively stable (150-200 fish/h) and annual stocking rates have been relatively consistent. An RSD-14 value of 50 indicates that 50% of all stock-size trout—those at least 254 mm (10 in.) in length—are 356 mm (14 in.) or larger. Only 2,200 Brook Trout were stocked in 2016 and none were collected during the 2017 sampling efforts.

***South Holston tailwater:*** Brown Trout catch declined again in 2017 (219 fish/h), and mean catch rate for all trout ≥178 mm fell to 254 fish/h—the lowest level since 2006. However, numerous subadult (≤127 mm) Brown Trout were captured and may indicate a relatively large cohort is entering the population, which could add to existing density-dependent effects on growth and recruitment. There was better recruitment into the size classes approaching the PLR (356 and 381 mm) again in 2017, although the PLR (406-559 mm) catch rate fell slightly to 9.5 fish/h. Relative stock density for all trout ≥406 mm (RSD-16) was unchanged from 2016 (5) and remains well below the 2004-2007 average (15), indicating no current shift toward larger fish—one of the original intents of the PRL. If overall trout abundance remains relatively high (CPUE >200 fish/h) and angler harvest rates for Brown Trout remain low (3.5%), it is unlikely RSD-16 will improve. Therefore, other management actions that can decrease Brown Trout recruitment when necessary, such as altering dam operations (i.e., to produce high flows) could help maintain more stable trout populations with larger adults through relaxed intraspecific competition. A new angler survey was conducted on the South Holston tailwater in 2017 and results will be available for the

2018 report. A majority of anglers (87%) did rate their satisfaction with the trout fishery as good or excellent. Also, when informed that it could help improve Brown Trout population size structure, more anglers (44%) said they would increase harvest than those who said they would not (40%). Whirling disease was confirmed in Rainbow Trout and Brown Trout collected during the 2017 monitoring efforts.

***Wilbur tailwater:*** The overall 2017 mean catch rate for all trout (≥178 mm) increased 20% (to 296 fish/h) since 2016, primarily as a result of the increasing wild Brown Trout population in the upper half of the tailwater. The new management plan (2015-2020) prescribes developing a wild Brown Trout fishery throughout the tailwater, with a mean catch rate of 40 fish/h (≥178 mm) in the lower portion (Stations 8-12). The 2017 Brown Trout catch rate for that area (67 fish/h) achieved that objective. Results from TWRA's 2016 creel survey indicated that pressure (112,627 h), trips (22,965), and mean trip length (4.9 h), along with estimated trout catch (213,673) and harvest (21,477) increased substantially since the previous (2013) survey. Monitoring data continue to provide no clear indication that the QZ regulations are enhancing abundance of larger trout there, although they do suggest a general increase in the abundance of trout ≥356 mm throughout the tailwater since 2005. Because most anglers support the current QZ regulations—even if they do not catch more quality fish there—the QZ's effectiveness may be relatively unimportant. Whirling disease was confirmed in Rainbow Trout collected during the 2017 monitoring efforts.

TABLE OF CONTENTS

# 1. INTRODUCTION

The Tennessee Wildlife Resources Agency (TWRA) manages trout fisheries in a variety of waters in Tennessee including streams, tailwater rivers, and reservoirs. Together, these fisheries provide a popular and important set of angling opportunities. The U.S. Fish and Wildlife Service (USFWS) conducts nationwide surveys every five years to track trends in sport fishing and other outdoor recreation activities. The most recent survey providing demographic and economic data for trout angling (2011), estimated that 105,000 resident and non-resident anglers (age 16 or older) fished for trout in Tennessee (Maillett and Aiken 2015). They made an estimated 1.4 million trips and represented 15% of all Tennessee anglers (Maillett and Aiken 2015). The estimated total expenditure associated with these trips was approximately $53 million. Compared with the previous survey (2006; Harris 2010), the estimated number of trout anglers increased 10%, while trips increased 40%. A statewide survey by the University of Tennessee in 2012 also indicated that 15% of Tennessee's anglers fished for trout, making an average of 15 trips (averaging 4 hours) that year (Schexnayder et al. 2014). Most of those anglers targeted trout in hatchery-supported fisheries. Accordingly, while Agency management emphasizes habitat preservation and maintenance of wild stocks where they occur, artificially propagated trout are essential for managing substantial portions of the coldwater resource. In 2017, 624,455 pounds of trout (~1.95 million fish) produced or grown primarily at five state (TWRA), one municipal (Gatlinburg), and two federal (USFWS) facilities were stocked to manage Tennessee's hatchery-supported fisheries (Roddy 2018). Nearly half (276,855 pounds) was stocked in Region IV waters, with 38% of those trout used to support tailwater fisheries and another 27% used to provide reservoir fisheries.

The Blue Ridge physiographic province of eastern Tennessee contains about 1,000 km (621 mi) of coldwater streams inhabited by wild (self-sustaining) populations of Rainbow Trout *Oncorhynchus mykiss*, Brook Trout *Salvelinus fontinalis*, and Brown Trout *Salmo trutta*. Wild trout occur in 9 of Region IV's 21 counties (primarily those that border North Carolina; Figure 1-1). The Tennessee portion of Great Smoky Mountains National Park (GSMNP) in Cocke, Sevier, and Blount counties contains another 395 km (245 mi) of wild trout streams. Most of Region IV's wild trout resource outside GSMNP is located within the U.S. Forest Service's (USFS) 253,000-hectare (625,000-acre) Cherokee National Forest (CNF). However, a substantial portion (~30%) occurs on privately owned lands and includes some of the State's best wild trout streams.

Rainbow Trout, native to Pacific-drainage streams of the western U.S., and brown trout, native to Europe, were widely introduced into coldwater habitats during the past century and have become naturalized in many Tennessee streams. Brook Trout are Tennessee's only native salmonid and once occurred at elevations as low as 490 m (1,600 ft.) in some streams (King 1937). They currently occupy about 223 km (139 mi) in 109 streams, or about 24% of the stream length supporting wild trout outside GSMNP. Brook trout occur allopatrically (no other trout species are present) in 42 streams totaling 72 km (45 mi.), representing 32% of the Brook

Trout resource. Another 13 streams have waterfalls or man-made barriers that maintain Brook Trout allopatry in most of the 37 km (23 mi.) of habitat they provide.

Wild trout populations reflect the quality and stability of the aquatic systems they inhabit, as well as associated terrestrial systems. TWRA recognizes the ecological importance of Tennessee's wild trout resources (particularly native Brook Trout), their value to anglers, and the special management opportunities they offer. The Agency's current statewide trout management plan (Fiss and Habera 2006) features management goals and strategies designed to conserve wild trout and their habitat while providing a variety of angling experiences.

Many streams with unregulated flows can support trout fisheries, but are limited by marginal summer habitat or levels of natural production insufficient to meet existing fishing pressure. TWRA provides or supplements trout fisheries in 34 such streams in Region IV by annually stocking hatchery-produced (adult) Rainbow Trout. Some stocked steams (e.g., Beaverdam Creek, Doe Creek, Laurel Fork, and Doe River) do support excellent wild trout populations as well, but the moderate stocking rates employed are considered to pose no population-level problems for the resident fish (Meyer et al. 2012).

Cold, hypolimnetic releases from five Tennessee Valley Authority (TVA) dams in Region IV (Norris, Ft. Patrick Henry, South Holston, Wilbur, and Boone) also support year-round trout fisheries in the tailwaters downstream (Figure 1-1). The habitat and food resources that characterize these tailwaters provide for higher carrying capacities and allow trout to grow larger than they normally do in other streams. Tailwaters are typically stocked with fingerlings (~102 mm) in the early spring and adult fish (229-305 mm) throughout the summer. Stocked adult trout supplement the catch during peak angling season and by fall, fingerlings have begun to enter these fisheries. Recruitment of natural reproduction (mostly by Brown Trout) contributes substantially to the fisheries in the South Holston and Wilbur (Watauga River) tailwaters. The Holston River below Cherokee Reservoir (Figure 1-1) also supports a tailwater trout fishery, although high water temperatures (>21° C) during late summer and early fall limit survival. No fingerlings are stocked there, as few would survive the thermal bottleneck to recruit to the fishery.

Reservoirs that stratify during summer months but have habitat suitable for trout below depths normally occupied by warmwater species are termed 'two-story' fisheries. These reservoirs must have a zone with water below 21° C and a minimum dissolved oxygen concentration of 3.0 mg/L (Wilkins et al. 1967). Seven two-story reservoirs in Region IV (Calderwood, Chilhowee, Tellico, Ft. Patrick Henry, South Holston, Wilbur, and Watauga) have such zones and create an additional trout resource (Figure 1-1). These reservoirs are stocked with adult Rainbow Trout during the late fall and winter when reservoir temperatures are uniformly cold and piscivorous warmwater predators are less active. Watauga and South Holston reservoirs are also annually stocked with sub-adult Brown Trout and Lake Trout *Salvelinus namaycush,* and excellent Lake Trout fisheries have developed in these two reservoirs.

One of TWRA's core functions identified in its Strategic Plan (TWRA 2014) is outdoor recreation, and a primary objective is to maintain or improve programs that promote high user satisfaction for hunters, anglers, and boaters. Tennessee's trout anglers recently expressed a high level of satisfaction (89%) with the Agency's management of the State's trout fisheries (Schexnayder et al. 2014). Maintaining this level of satisfaction will require effective management of existing resources and opportunities—as well as development of new ones. TWRA's new statewide trout management plan for the next 10 years (TWRA 2017) addresses how these goals can be accomplished. This plan includes management guidelines for Tennessee's native Brook Trout, particularly in light of new genetics data being acquired for all Brook Trout populations. Acquisition of trout population status and dynamics data from streams and tailwaters through standardized stream survey techniques (e.g., abundance trends and size structures, etc.) will also continue to be an important strategy for managing these fisheries.

# Region IV Trout Streams, Tailwaters, and Reservoirs

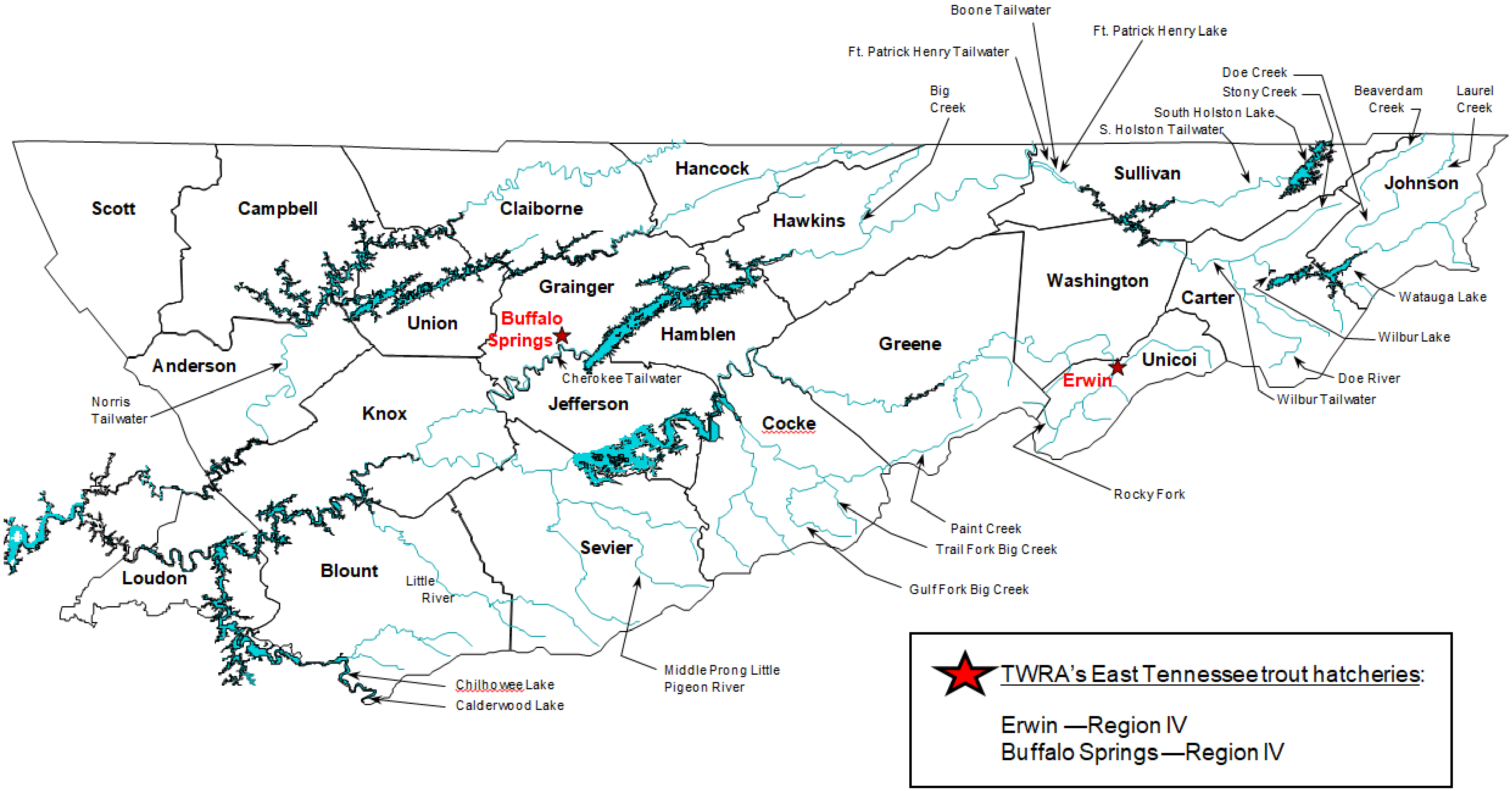



Figure 1-1. Locations of selected Region IV trout fisheries managed by TWRA.

# 2. WILD TROUT STREAM ACCOUNTS

Seven trout streams were quantitatively sampled during 2017 field season (June-October) within Region IV. Overall, trout abundance remained below long term averages. This is likely due to the Tennessee River watershed, particularly in eastern Tennessee, being in an abnormally dry to extreme drought condition from May 2016 to mid-April 2017 according to United State Drought Monitor. Drought throughout the region decreases base stream flow and increase temperatures, which can limit reproductive success and affects overall health of trout. Since mid-April, this Region has been drought free and trout biomass should start to in 2018 and 2019 given more normal flow conditions.

Individual accounts for all wild trout streams sampling during 2017 are provided below. A list of all streams sampling quantitatively during 1991-2017 is provided in Appendix A.

## 2.1 SAMPLING METHODS

Wild trout stream sampling was conducted with battery-powered backpack electrofishing units employing inverters to produce AC outputs. Output voltages were 125-600 VAC, depending upon water conductivity. All quantitative (three-pass depletion) sampling followed TWRA's standard protocols (TWRA 1998). Three-pass depletion sampling provides accurate trout abundance estimates in typical southern Appalachian streams (Habera et al. 2010), is endorsed by the Southern Division, American Fisheries Society's (SDAFS) Trout Committee, and is widely used by other state and federal agencies in the region. Stocked rainbow trout, distinguishable by dull coloration, eroded fins, atypical body proportions, and large size (usually >229 mm), were noted on data sheets but were not included in any analyses. A list of the common and scientific names of all fish collected during 2017 sampling efforts in wild trout streams is provided in Table 2-1.

Removal-depletion data were analyzed with *MicroFish 4.0* for Windows (http://microfish.org/) developed by Jack Van Deventer in cooperation with the SDAFS Trout Committee. Trout ≤90 mm in length were analyzed separately from those >90 mm. Trout in the smaller size group tend to have lower catchabilities (Lohr and West 1992; Thompson and Rahel 1996; Peterson et al. 2004; Habera et al. 2010), making separate analysis necessary to avoid bias. These two groups also roughly correspond to young-of-the-year (YOY or age-0) and adults.

Table 2-1. Common and scientific names of fishes collected during 2017 quantitative trout stream surveys[1].

| Common Name | Scientific Name |
|---|---|
| Minnows | Cyprinidae |
| Central Stoneroller | *Campostoma anomalum* |
| Warpaint Shiner | *Luxilus coccogenis* |
| River Chub | *Nocomis micropogon* |
| Saffron Shiner | *Notropis rubricroceus* |
| Tennessee Shiner | *N. leuciodus* |
| Blacknose Dace | *Rhinichthys atratulus* |
| Longnose Dace | *R. cataractae* |
| Creek Chub | *Semotilus atromaculatus* |
| Suckers | Catostomidae |
| White Sucker | *Catostomus commersonii* |
| Northern Hogsucker | *Hypentelium nigricans* |
| Trouts | Salmonidae |
| Rainbow Trout | *Oncorhynchus mykiss* |
| Brown Trout | *Salmo trutta* |
| Brook Trout | *Salvelinus fontinalis* |
| Sculpins | Cottidae |
| Mottled Sculpin | *Cottus bairdii* |
| Sunfishes | Centrarchidae |
| Rockbass | *Ambloplites rupestris* |
| Bluegill | *Lepomis macrochirus* |
| Perches | Percidae |
| Greenfin Darter | *Etheostoma chlorobranchium* |
| Fantail Darter | *E. flabellare* |
| Snubnose Darter | *E. simoterum* |
| Swannanoa Darter | *E. swannanoa* |

[1]Nomenclature follows Page et al. (2013).

## 2.2 BEAVERDAM CREEK

### Study Area

Beaverdam Creek is one of Tennessee's best-known wild trout streams. It originates in Johnson County's Iron Mountains and flows northeast into Virginia as part of the South Fork Holston drainage. The watershed is largely forested (much is CNF), although there is substantial agricultural and residential land use in the Shady Valley area. Shields (1950) described Beaverdam Creek as providing excellent Rainbow Trout water. However, because there was no reproduction (except in the tributaries), Shields recommended a stocking program that included fall fingerling stocking in the Shady Valley section and a permit system for managing this stream. Shields (1950) made no mention of a Brown Trout fishery at that time. Later, Bivens (1988) and Bivens and Williams (1990) conducted qualitative surveys of Beaverdam Creek for TWRA and documented excellent wild Rainbow Trout and Brown Trout populations. Brook Trout currently inhabit over 29 km in 12 Beaverdam Creek tributaries and most were determined to be of native heritage based on previous genetic analyses using allozymes (Strange and Habera 1997). DNA samples from all of these populations were collected in 2016 and 2017 to update current population genetics information (Section 2-4).

In 1988 a 10-km special regulation section of Beaverdam Creek between Tank Hollow Road and Birch Branch (located in the CNF) was managed under a 229-mm minimum length limit, three-trout creel limit, and single-hook, artificial-lures-only restriction to emphasize the wild trout fishery. Stocking was also discontinued within this area after 1988. In 2013, the 229-mm length limit was removed and creel limit increased to five trout as part of the revision of special wild trout regulations to make them more biologically sound. Outside the special regulations section, about 5,600 catchable Rainbow Trout are stocked each year during March-June. Brown Trout fingerlings have occasionally been stocked in upper Beaverdam Creek (vicinity of Hwy. 421 crossing and upstream) to supplement the wild Brown Trout population in that area, which has limited spawning habitat (Habera et al. 2006).

Two long-term monitoring stations were established in 1991 within the special regulations section and have been sampled annually since then. Sample site location and effort details, along with habitat and water quality information are summarized in Table 2-2.

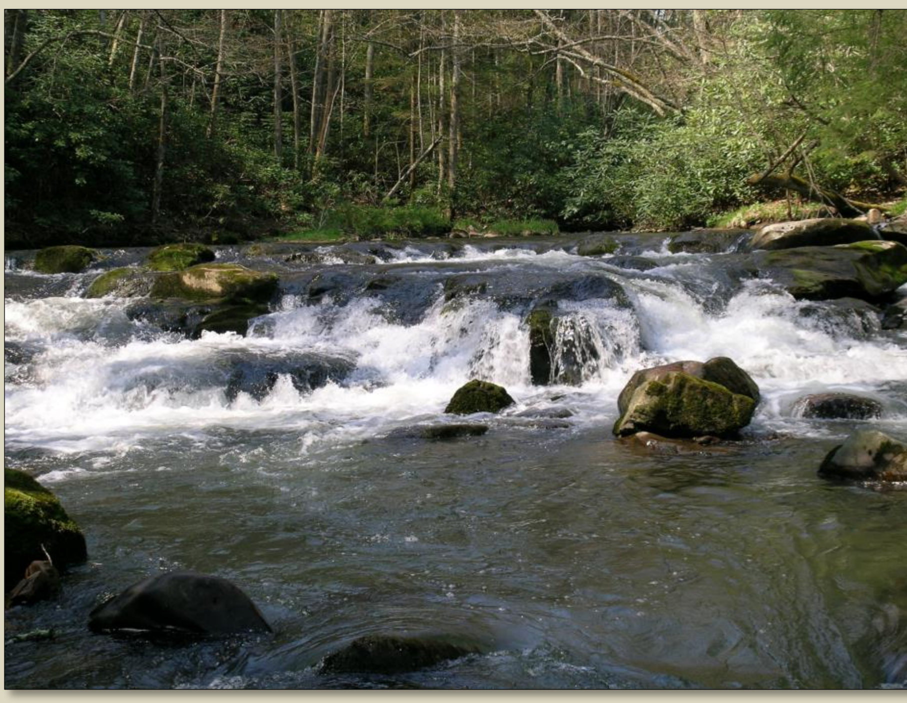
### Results and Discussion

Catch data and abundance estimates for trout and all other species collected at the Beaverdam Creek stations in 2017 are given in Table 2-3. Estimated total trout biomass remained relatively unchanged from 2016 at both stations, although density declined, primarily as the result of fewer age-0 Rainbow Trout (Figure 2-1). In fact the 2017 density estimates from Rainbow Trout ≤90 mm at both stations were among the lowest observed to date. Abundance estimates (except Station 2 biomass) were below long term averages.

Last year's (2016) density estimates for Brown Trout ≤90 mm (i.e. age 0) were among the lowest observed (Figure 2-1), which explains the limited number of age-1 (102-178 mm size classes) Brown Trout in the 2017 length frequency histogram Figure 2-2). Except for the reduced abundance of age-0 fish, Rainbow Trout size distributions were relatively well balanced with several fish >229 mm. Beaverdam Creek is well known for its large (>400 mm) Brown Trout, and these have been present in 20 of 26 annual surveys—including all but one since 2003 (2012).

## Management Recommendations

Beaverdam Creek supports one of Tennessee's best wild trout fisheries, which management should continue to maintain and emphasize. The current stocking program is compatible with wild trout management and native fish assemblages (Weaver and Kwak 2013), but there should be no expansion of the area or number of catchable trout currently stocked. Based on responses to the 2015 attitude/opinion survey questions, most anglers support the current regulations (which liberalized creel and size limits), but have not changed their harvest tendencies as a result of them. Annual monitoring should continue at both stations to increase our understanding of this important wild trout fishery.



Beaverdam Creek in Cherokee National Forest

Table 2-2. Site and sampling information for Beaverdam Creek in 2017.

| **Location** | **Station 1** | | **Station 2** | |
|---|---|---|---|---|
| **Site code** | 420172801 | | 420172802 | |
| **Sample date** | 29 August | | 30 August | |
| **Watershed** | S. Fork Holston River | | S. Fork Holston River | |
| **County** | Johnson | | Johnson | |
| **Quadrangle** | Laurel Bloomery 213 SE | | Laurel Bloomery 213 SE | |
| **Lat-Long** | 36.59176 N, -81.81847 W | | 36.56576 N, -81.87315 W | |
| **Reach number** | 06010102-23,0 | | 06010102-23,0 | |
| **Elevation (ft)** | 2,160 | | 2,440 | |
| **Stream order** | 4 | | 4 | |
| **Land ownership** | USFS | | USFS | |
| **Fishing access** | Excellent | | Excellent | |
| **Description** | Begins at Tank Hollow Rd. near Backbone Rock. | | Begins at Hwy. 133 mile marker 5 near Arnold Br. | |
| **Effort** | | | | |
| **Station length (m)** | 200 | | 177 | |
| **Sample area (m²)** | 2620 | | 2248 | |
| **Personnel** | 25 | | 19 | |
| **Electrofishing units** | 4 | | 4 | |
| **Voltage (AC)** | 250 | | 250 | |
| **Removal passes** | 3 | | 3 | |
| **Habitat** | | | | |
| **Mean width (m)** | 13.1 | | 12.7 | |
| **Maximum depth (cm)** | 100 | | 130 | |
| **Canopy cover (%)** | 70 | | 60 | |
| **Aquatic vegetation** | scarce | | scarce | |
| **Estimated % of site in pools** | 57 | | 47 | |
| **Estimated % of site in riffles** | 43 | | 53 | |
| **Habitat assessment score** | 165 (optimal) | | 162 (optimal) | |
| **Substrate Composition** | **Pool (%)** | **Riffle (%)** | **Pool (%)** | **Riffle (%)** |
| **Silt** | 10 | 0 | 10 | 0 |
| **Sand** | 5 | 5 | 10 | 5 |
| **Gravel** | 20 | 25 | 20 | 30 |
| **Rubble** | 30 | 35 | 20 | 30 |
| **Boulder** | 15 | 30 | 30 | 30 |
| **Bedrock** | 20 | 5 | 10 | 5 |
| **Water Quality** | | | | |
| **Flow (cfs; visual)** | 28.4; normal | | 26.9; normal | |
| **Temperature (C)** | 17.3 | | 16.6 | |
| **pH** | 7.3 | | 7.2 | |
| **Conductivity (µS/cm)** | 63 | | 78 | |
| **Dissolved oxygen (mg/L)** | N/M | | N/M | |
| **Alkalinity (mg/L $CaCO_3$)** | 35 | | 35 | |

Table 2-3. Fish population abundance estimates (with 95% confidence limits) for the monitoring stations on Beaverdam Creek sampled 29 and 30 August 2017.

| | | Population Size | | | Est. | Mean | Biomass (kg/ha) | | | Density (fish/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Total Catch | Est. | Lower C.L. | Upper C.L. | Weight (g) | Fish Wt. (g) | Est. | Lower C.L. | Upper C.L. | Est. | Lower C.L. | Upper C.L. |
| **Station 1** | | | | | | | | | | | | |
| RBT ≤90 mm | 20 | 22 | 22 | 30 | 116 | 5.2 | 0.44 | 0.44 | 0.60 | 84 | 84 | 115 |
| RBT >90 mm | 59 | 60 | 60 | 64 | 2,678 | 44.6 | 10.22 | 10.21 | 10.89 | 229 | 229 | 244 |
| BNT ≤90 mm | 34 | 34 | 24 | 37 | 163 | 4.3 | 0.62 | 0.39 | 0.61 | 130 | 92 | 141 |
| BNT >90 mm | 40 | 40 | 40 | 43 | 3,455 | 86.2 | 13.19 | 13.16 | 14.15 | 153 | 153 | 164 |
| BKT >90 mm | 1 | 1 | 1 | 1 | 8 | 8.0 | 0.03 | 0.03 | 0.03 | 4 | 4 | 4 |
| Fantail Darter | 82 | 92 | 92 | 106 | 118 | 1.3 | 0.45 | 0.46 | 0.53 | 351 | 351 | 405 |
| Tennessee Shiner | 7 | 7 | 7 | 13 | 8 | 1.1 | 0.03 | 0.03 | 0.05 | 27 | 27 | 50 |
| Greenfin Darter | 6 | 6 | 6 | 11 | 66 | 11.0 | 0.25 | 0.25 | 0.46 | 23 | 23 | 42 |
| N. Hogsucker | 19 | 19 | 19 | 21 | 2,556 | 134.5 | 9.76 | 9.75 | 10.78 | 73 | 73 | 80 |
| Snubonse Darter | 12 | 13 | 13 | 20 | 41 | 3.2 | 0.16 | 0.16 | 0.24 | 50 | 50 | 76 |
| Mottled Sculpin | 453 | 631 | 631 | 725 | 2,317 | 3.7 | 8.84 | 8.91 | 10.24 | 2,408 | 2,408 | 2,767 |
| Warpaint Shiner | 59 | 65 | 65 | 75 | 175 | 2.7 | 0.67 | 0.67 | 0.77 | 248 | 248 | 286 |
| Swannanoa Darter | 7 | 7 | 7 | 13 | 33 | 4.7 | 0.13 | 0.13 | 0.23 | 27 | 27 | 50 |
| Saffron Shiner | 159 | 198 | 198 | 232 | 204 | 1.0 | 0.78 | 0.76 | 0.89 | 756 | 756 | 885 |
| Blacknose Dace | 10 | 10 | 10 | 10 | 4 | 0.4 | 0.02 | 0.02 | 0.02 | 38 | 38 | 38 |
| Central Sonteroller | 103 | 104 | 104 | 108 | 2,760 | 26.5 | 10.53 | 10.52 | 10.92 | 397 | 397 | 412 |
| River Chub | 212 | 225 | 225 | 237 | 1,982 | 8.8 | 7.56 | 7.56 | 7.96 | 859 | 859 | 905 |
| Longnose Dace | 12 | 12 | 12 | 16 | 168 | 14.0 | 0.64 | 0.64 | 0.85 | 46 | 46 | 61 |
| **Totals** | **1295** | **1,546** | **1,525** | **1,751** | **16,852** | | **52.23** | **64.03** | **70.18** | **5,901** | **4,629** | **5,758** |
| **Station 2** | | | | | | | | | | | | |
| RBT ≤90 mm | 18 | 18 | 18 | 20 | 79 | 4.4 | 0.35 | 0.35 | 0.39 | 80 | 80 | 89 |
| RBT >90 mm | 60 | 60 | 60 | 62 | 3,341 | 55.7 | 14.86 | 14.87 | 15.36 | 267 | 267 | 276 |
| BNT ≤90 mm | 21 | 21 | 21 | 25 | 109 | 5.2 | 0.48 | 0.49 | 0.58 | 93 | 93 | 111 |
| BNT >90 mm | 36 | 36 | 36 | 39 | 5,036 | 139.9 | 22.40 | 22.40 | 24.27 | 160 | 160 | 173 |
| BKT ≤90 mm | 1 | 1 | 1 | 1 | 5 | 5.4 | 0.02 | 0.02 | 0.02 | 4 | 4 | 4 |
| Fantail Darter | 46 | 80 | 80 | 150 | 118 | 1.5 | 0.52 | 0.53 | 1.00 | 356 | 356 | 667 |
| Greenfin Darter | 3 | 3 | 3 | 15 | 22 | 7.3 | 0.10 | 0.10 | 0.49 | 13 | 13 | 67 |
| N. Hogsucker | 10 | 10 | 10 | 12 | 996 | 99.6 | 4.43 | 4.43 | 5.32 | 44 | 44 | 53 |
| Snubonse Darter | 24 | 33 | 33 | 58 | 61 | 1.8 | 0.27 | 0.26 | 0.46 | 147 | 147 | 258 |
| Mottled Sculpin | 487 | 871 | 871 | 1106 | 4,414 | 5.1 | 19.64 | 19.76 | 25.09 | 3,875 | 3,875 | 4,920 |
| Warpaint Shiner | 21 | 22 | 22 | 28 | 80 | 3.6 | 0.36 | 0.35 | 0.45 | 98 | 98 | 125 |
| Swannanoa Darter | 14 | 20 | 20 | 44 | 74 | 3.7 | 0.33 | 0.33 | 0.72 | 89 | 89 | 196 |
| Saffron Shiner | 79 | 94 | 94 | 118 | 153 | 1.6 | 0.68 | 0.67 | 0.84 | 418 | 418 | 525 |
| Blacknose Dace | 12 | 14 | 14 | 25 | 51 | 3.6 | 0.23 | 0.22 | 0.40 | 62 | 62 | 111 |
| Central Sonteroller | 37 | 39 | 39 | 45 | 546 | 14.0 | 2.43 | 2.43 | 2.80 | 173 | 173 | 200 |
| Longnose Dace | 6 | 6 | 6 | 13 | 119 | 19.8 | 0.53 | 0.53 | 1.15 | 27 | 27 | 58 |
| White Sucker | 2 | 2 | 2 | 53 | 166 | 83.0 | 0.74 | 0.74 | 19.57 | 9 | 9 | 236 |
| **Totals** | **877** | **1,330** | **1,329** | **1,813** | **15,370** | | **68.37** | **68.47** | **98.89** | **5,916** | **5,912** | **2,845** |

Note: RBT = Rainbow Trout, BNT = Brown Trout, and BKT = Brook Trout.

# Beaverdam Creek

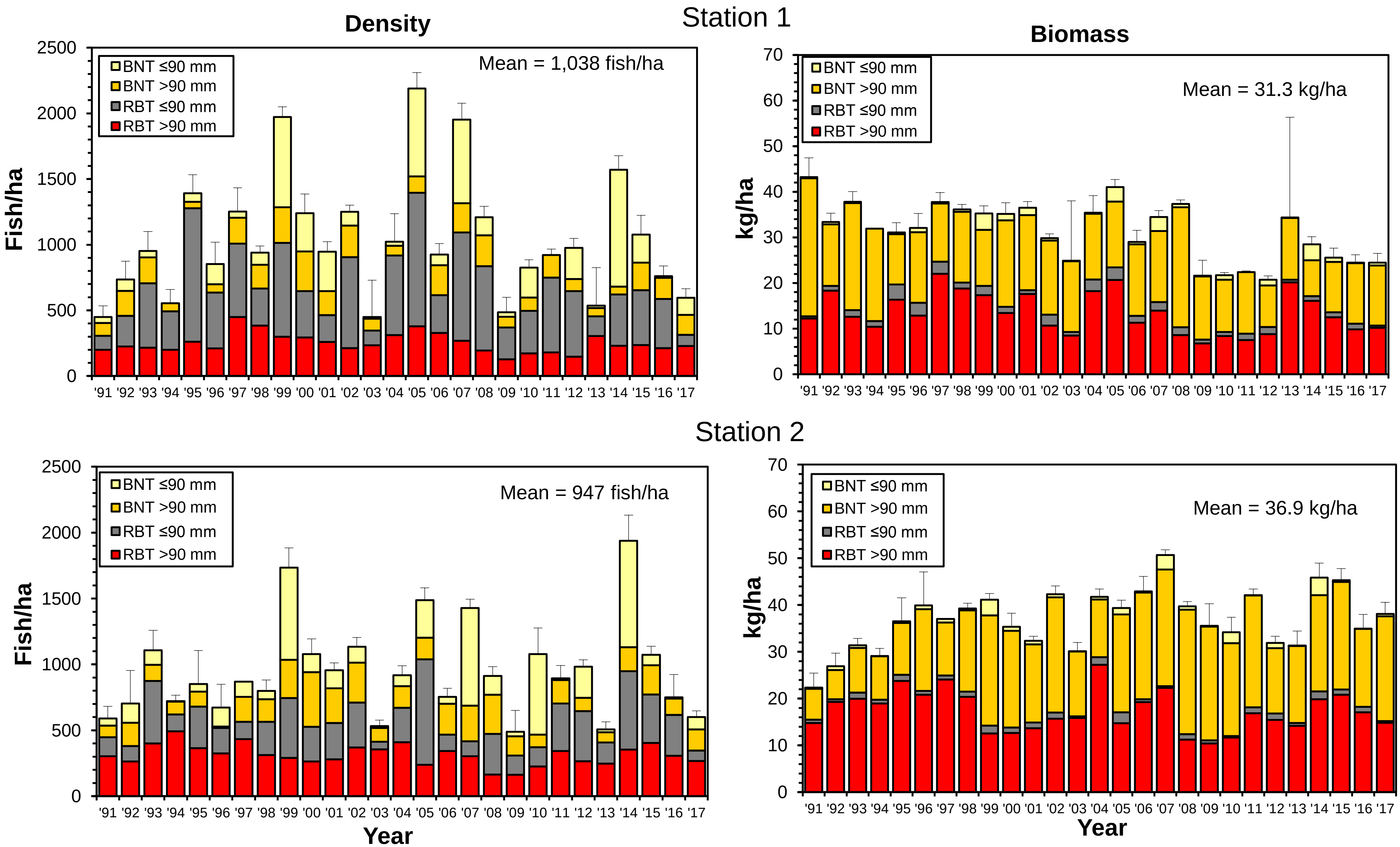
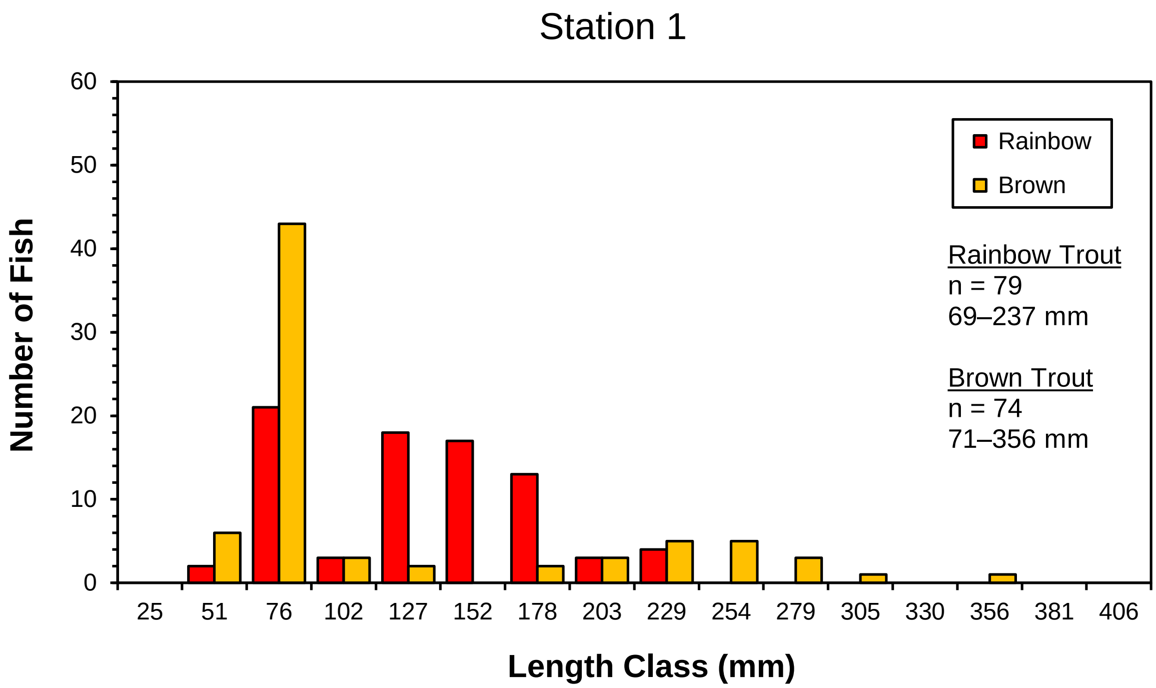



Figure 2-1. Trout abundance estimates for the Beaverdam Creek monitoring stations. BNT = Brown Trout and RBT = Rainbow Trout. Bars indicate upper 95% confidence limits (total).

# Beaverdam Creek



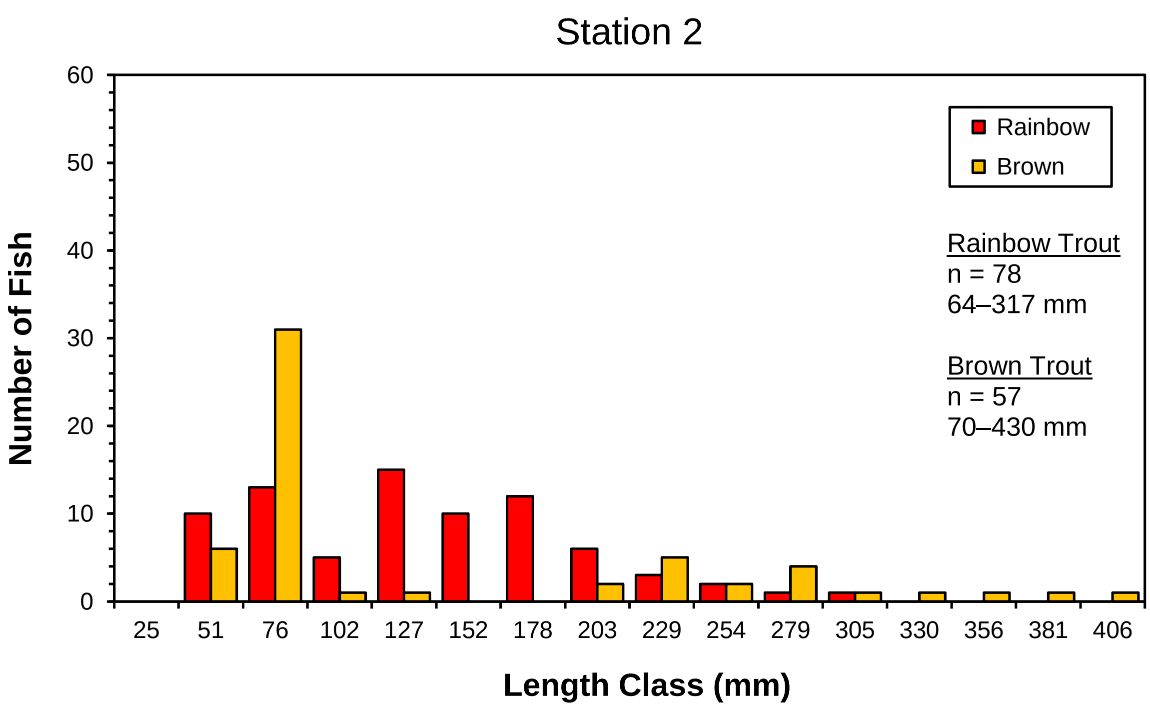




Figure 2-2. Length frequency distributions for Rainbow and Brown Trout from the 2017 Beaverdam Creek monitoring stations.

## 2.3 DOE CREEK

### Study Area

Doe Creek is a large spring-fed tributary to Watauga Reservoir in Johnson County. It flows through privately-owned land, much of which is being used for agricultural and residential purposes. Doe Creek is probably best known for the trophy Rainbow Trout fishery it supported during the 1950s and 1960s. That fishery consisted of an annual run of fall-spawning rainbows from Watauga Reservoir and probably originated from eggs planted at the mouth of the stream in 1954 (Bivens et al. 1998). Although the trophy fishery disappeared in the early 1970s, Doe Creek still supports one of Tennessee's finest populations of wild Rainbow Trout and some large (>500 mm) Rainbow Trout still enter Doe Creek each winter from the lake. Adult Rainbow Trout are also stocked during March-June (about 2,800/year) and general (statewide) trout fishing regulations apply.

Doe Creek was originally surveyed by Shields (1950) and later qualitatively sampled by Bivens (1989). Ironically, Shields (1950) recommended removal of Doe Creek from the trout stream list because of its limited trout carrying capacity and lack of potential for reproduction at that time. A 2003 creel survey indicated that Doe Creek had the highest estimated trout catch and harvest rates among the five streams surveyed and was second only to Doe River (much of which is in Roan Mountain State Park) in terms of estimated angler effort for trout (Habera et al. 2004).

The current long-term monitoring station on Doe Creek was established in 1993 and has been sampled annually since then. It is located along Highway 67 and ends at the old dam just below the confluence with the outflow from Lowe Spring, which is an important source of cold water for Doe Creek. Sample site location and effort details, along with habitat and water quality information are given in Table 2-4.

### Results and Discussion

Catch data and abundance estimates for all species sampled at the Doe Creek station in 2017 are given in Table 2-5. Estimated Rainbow Trout density and biomass has decreased each year since 2014, and both measures of abundance are below the corresponding long-term averages for this site (Figure 2-3). Doe Creek previously produced wild Rainbow Trout biomass estimates >100 kg/ha (1993, 1997, and 2004) and that averaged 75 kg/ha prior to 2007 (Figure 2-3). However, wild trout production in Doe Creek is not typically attaining this former potential. Biomass has averaged just below 60 kg/ha since 2007 and 2017 biomass and density estimates ranked among the lowest obtained since monitoring began in 1993. This decline may be a result of drought conditions over the past few years.

The Rainbow Trout cohort was relatively strong, as 60% (136) of the 224 rainbows captured were in the 70-110 mm size range (age 0). Now, these age-1 fish largely appear in the 127-178 mm size classes in the length frequency histogram (Figure 2-4). Recruitment into the larger (≥203 mm) adult size classes (4 fish; Figure 2-4) remained consistent with 2016 (5 fish), including two trout ≥229 mm. With improved habitat conditions in 2017 (higher flow and lower temperature), increased biomass and density could be expected next year.

## Management Recommendations

Doe Creek remains one of Tennessee's most productive wild trout streams and TWRA is committed to maintaining it. The seasonal hatchery-supported trout fishery in Doe Creek is popular (Habera et al. 2004), but management of this stream should feature the outstanding wild trout population. The current stocking program is not incompatible with wild trout management or native fish assemblages (Weaver and Kwak 2013), but it should not be expanded in scope or scale. Annual monitoring at the station near Lowe Spring should continue and may help identify any impacts related to Mountain City's water withdrawals (0.5 million gallons per day) from the spring, which began in 2002. Additionally, a new angler survey would help determine if current stocking levels are appropriate.

Table 2-4. Site and sampling information for Doe Creek in 2017.

| Location | Station 1 |
|---|---|
| **Site code** | 420173001 |
| **Sample date** | 13 September |
| **Watershed** | Watauga River |
| **County** | Johnson |
| **Quadrangle** | Doe 214 NW |
| **Lat-Long** | 36.42709 N, -81.93725 W |
| **Reach number** | 06010103-37,0 |
| **Elevation (ft)** | 2,210 |
| **Stream order** | 4 |
| **Land ownership** | Private |
| **Fishing access** | Good |
| **Description** | Site ends at small dam just below Lowe spring. |

| **Effort** | |
|---|---|
| **Station length (m)** | 134 |
| **Sample area (m²)** | 924 |
| **Personnel** | 11 |
| **Electrofishing units** | 3 |
| **Voltage (AC)** | 125 |
| **Removal passes** | 3 |

| **Habitat** | |
|---|---|
| **Mean width (m)** | 6.9 |
| **Maximum depth (cm)** | 60 |
| **Canopy cover (%)** | 45 |
| **Aquatic vegetation** | scarce |
| **Estimated % of site in pools** | 32 |
| **Estimated % of site in riffles** | 68 |
| **Habitat assessment score** | 155 (suboptimal) |

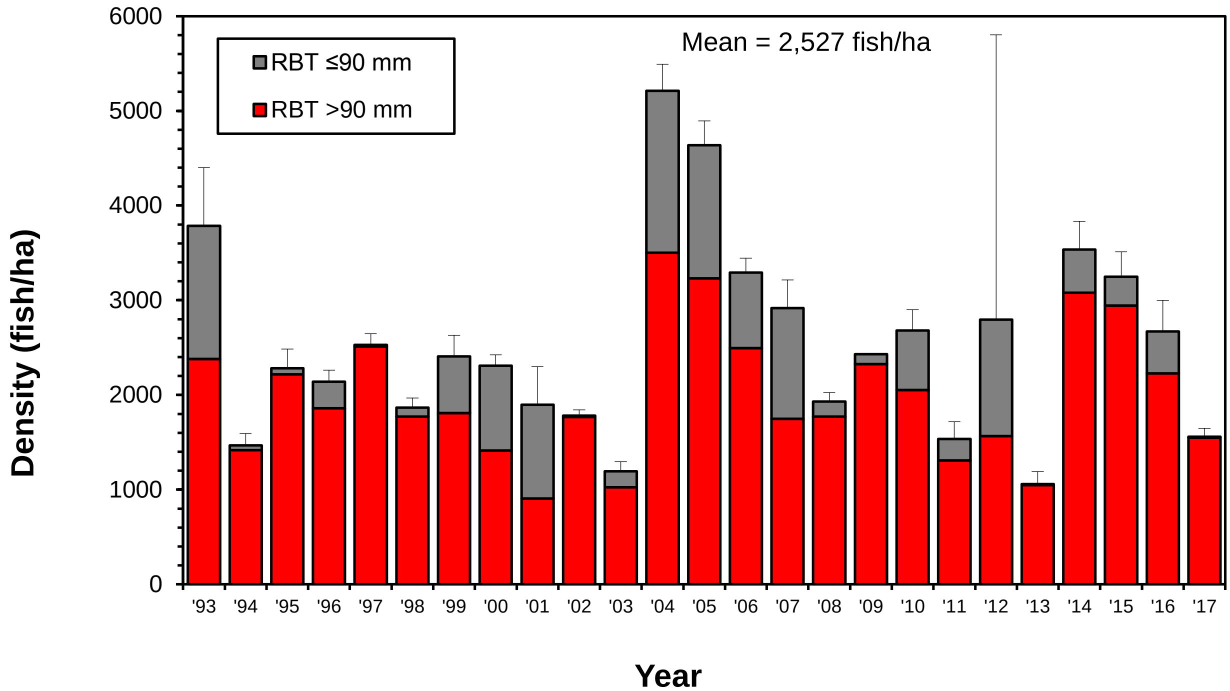
| **Substrate Composition** | **Pool (%)** | **Riffle (%)** |
|---|---|---|
| **Silt** | 5 | 0 |
| **Sand** | 5 | 5 |
| **Gravel** | 25 | 25 |
| **Rubble** | 20 | 35 |
| **Boulder** | 20 | 25 |
| **Bedrock** | 25 | 10 |

| **Water Quality** | |
|---|---|
| **Flow (cfs; visual)** | 18.3; normal |
| **Temperature (C)** | 14.0 |
| **pH** | 7.5 |
| **Conductivity (µS/cm)** | 151 |
| **Dissolved oxygen (mg/L)** | N/M |
| **Alkalinity (mg/L $CaCO_3$)** | 85 |

Table 2-5. Fish population abundance estimates (with 95% confidence limits) for the monitoring station on Doe Creek sampled 13 September 2017.

| | | Population Size | | | Est. | Mean | Biomass (kg/ha) | | | Density (fish/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Total Catch | Est. | Lower C.L. | Upper C.L. | Weight (g) | Fish Wt. (g) | Est. | Lower C.L. | Upper C.L. | Est. | Lower C.L. | Upper C.L. |
| RBT ≤90 mm | 1 | 1 | 1 | 1 | | | | | | | | |
| RBT >90 mm | 137 | 143 | 137 | 151 | 3,702 | 25.9 | 40.07 | 38.39 | 42.31 | 1,548 | 1,483 | 1,634 |
| Creek Chub | 1 | | | | | | | | | | | |
| Blacknose Dace | 136 | 147 | 136 | 159 | 650 | 4.4 | 7.03 | 6.50 | 7.60 | 1,591 | 1,472 | 1,721 |
| Fantail Darter | 16 | 19 | 16 | 29 | 39 | 2.1 | 0.42 | 0.36 | 0.65 | 206 | 173 | 314 |
| Mottled Sculpin | 233 | 476 | 234 | 718 | 1,698 | 3.6 | 18.37 | 9.03 | 27.71 | 5,152 | 2,532 | 7,771 |
| C. Stoneroller | 56 | 56 | 56 | 58 | 2,042 | 36.5 | 22.10 | 22.10 | 22.89 | 606 | 606 | 628 |
| N. Hogsucker | 4 | 6 | 6 | 6 | 371 | 61.8 | 4.01 | 4.01 | 4.01 | 65 | 65 | 65 |
| **Totals** | **584** | **848** | **586** | **1,122** | **8,501** | | **92.01** | **80.39** | **105.17** | **9,167** | **6,331** | **12,132** |

# Doe Creek



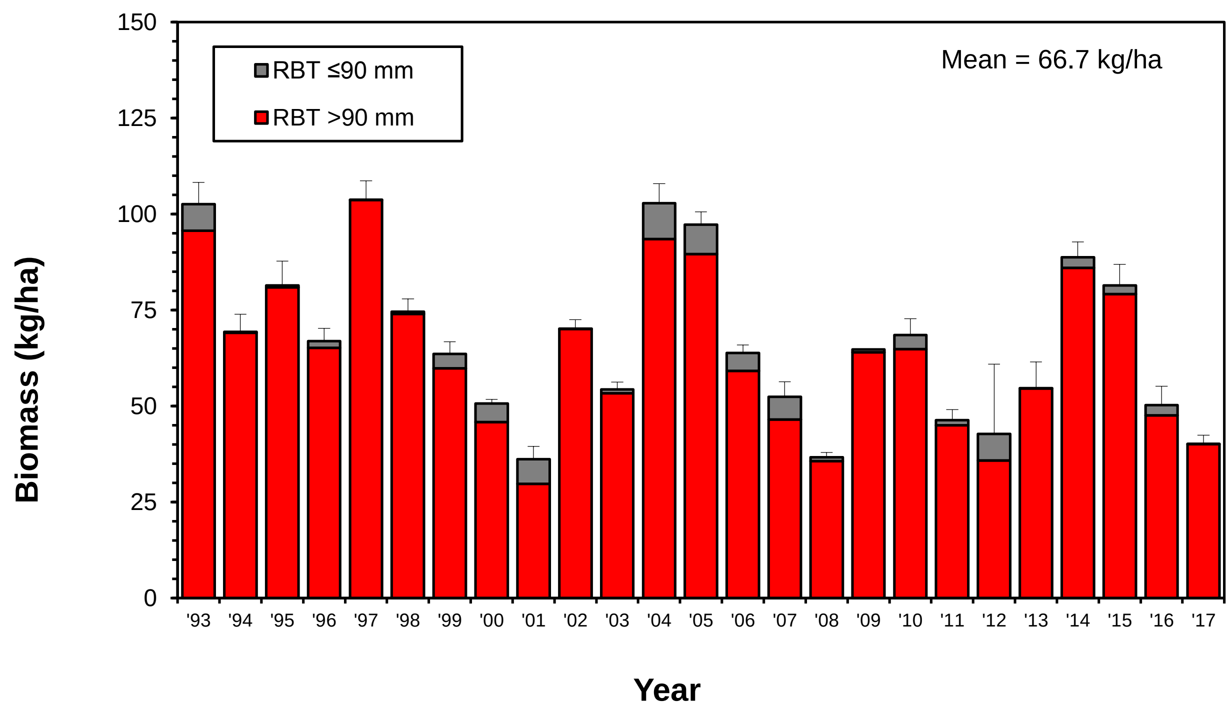




Figure 2-3. Trout abundance estimates for the Doe Creek monitoring station. RBT = Rainbow Trout. Bars indicate upper 95% confidence limits (total).

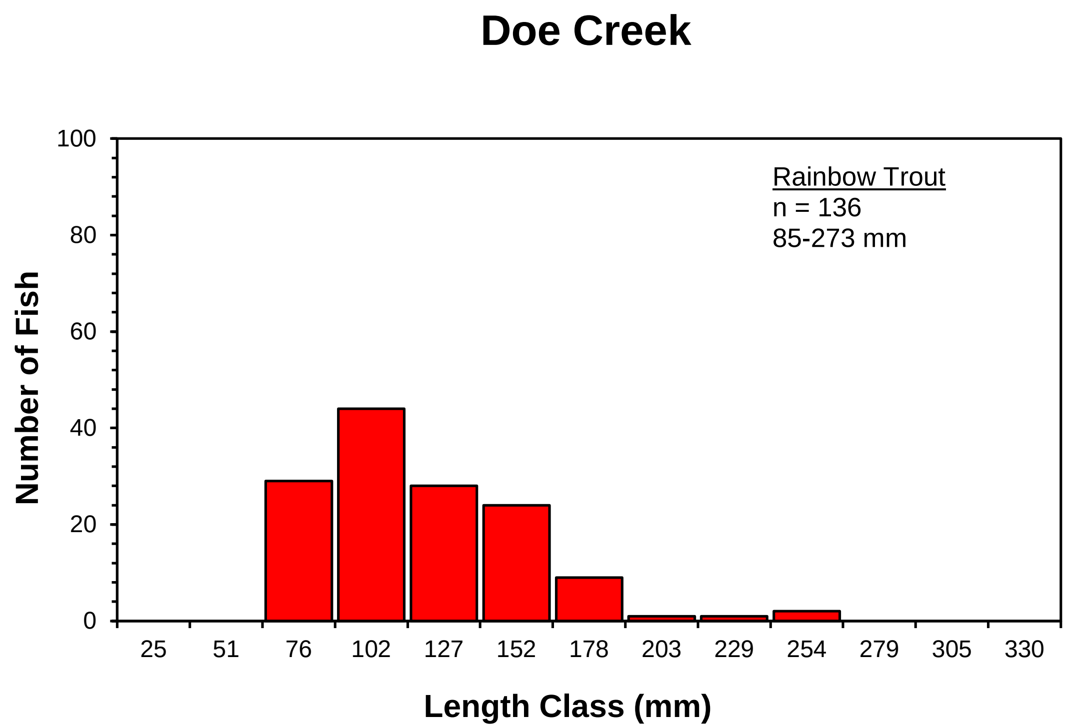



Figure 2-4. Length frequency distribution for Rainbow Trout from the 2017 Doe Creek sample.

## 2.4 LEFT PRONG HAMPTON CREEK

### Study Area

Left Prong of Hampton Creek (Left Prong) flows through the 281-ha (693-acre) Hampton Creek Cove State Natural Area in Carter County and is a tributary to Doe and Watauga rivers. A substantial portion of this area remains as livestock pasture, although fencing prevents livestock access to the stream. Rhododendron (*Rhododendron* spp.), which often dominates the riparian vegetation of other wild trout streams, is absent along Left Prong. Historically, the stream would have been inhabited by Brook Trout, but TWRA found only an abundant wild Rainbow Trout population during a 1988 survey (Bivens 1989). Subsequently, Brook Trout were successfully restored to the upper 2 km of Left Prong during 1999-2000 through a cooperative, multi-agency effort involving TWRA, Overmountain Chapter TU, USFS, NPS, Tennessee Department of Environment and Conservation (TDEC), and the Southern Appalachian Highlands Conservancy. The ineffective modified-culvert fish barrier at the downstream end of the Brook Trout re-establishment zone was replaced in 2007 with a 2.7 m (9 ft) waterfall (Habera and Carter 2008; Habera et al. 2008). Maintenance on this structure was completed in 2015 by Overmountain TU and TWRA. Left Prong was placed under special regulations (three-fish creel limit for Brook Trout; single-hook, artificial lures only) during establishment period of the new Brook Trout population. It is now managed under TWRA's special wild trout regulations, which include a 5-fish creel limit and no minimum size limit.

A long-term monitoring station (Station 1) was established on lower Left Prong in 1994. Stations 2 and 3 were added in 1996 to better represent the upper portion of the stream, which has a higher gradient and more canopy cover, but have also served to monitor the Brook Trout population since 2000. All three stations have been sampled annually since 1996. Sample site location and effort details, along with habitat and water quality information are summarized in Table 2-6.

Cook and Johnson (2016) evaluated post-stocking performance in Left Prong for two cohorts (2013 and 2014) of native Brook Trout fingerlings produced at the Tellico Brook Trout hatchery and at the Tennessee Aquarium (re-circulating system). They found the overall annual survival rate for these fish was lower in Left Prong (16.7%) than in Region 3's Sycamore Creek (34.7%) and for seven pooled wild Brook Trout populations from GSMNP (29.3%; Kulp 1994). A possible explanation for the lower survival of stocked fingerlings in Left Prong is that this stream's higher Brook Trout density reduced growth—and ultimately survival—of the stocked fish (Cook and Johnson 2016).

Left Prong is also part of the ongoing multi-agency Tennessee's Ecologically At-Risk Streams—Appalachian Mountains (TEARS-AM) project to collect baseline chemical, physical and biological data on stream sections with naturally reproducing Brook Trout populations within the CNF and GSMNP. The project goal is to investigate global, regional and/or local influences on stream health such as climate change and atmospheric deposition of mercury. Food chain dynamics is being assessed by analyzing contaminant concentrations and stable isotopes of carbon and nitrogen in seven matrices: sediment, periphyton, emergent insects, crayfish, salamanders, eastern Brook Trout, and tetragnathid spiders.

## Results and Discussion

Catch data and abundance estimates for trout and all other species sampled at the three stations on Left Prong in 2017 are given in Table 2-7. The 2017 density and biomass estimates for Rainbow Trout at Station 1 continued their overall downward trend, with an all-time low density of 842 fish/ha and below-average biomass of 23.8 kg/ha (Figure 2-5). Total Rainbow Trout density at Station 1 declined not only because of the low density of adults, but also a very small 2017 cohort (fish ≤90 mm, Figure 2-5). The total Rainbow Trout biomass estimate at Station 1 remained consistent with last year (Figure 2-5), but remains about 40% below the long-term average (56.7 kg/ha; Figure 2-5). The substantially decreased adult density and increased adult biomass suggests the fish at Station 1 were larger fish than last year, which is also supported by the length frequency distribution (Figure 2-6).

Previously (1990s), biomass estimates at Station 1 averaged nearly 100 kg/ha and were among the highest obtained for wild Rainbow Trout anywhere in Tennessee. However, biomass has generally declined since 2000 (Figure 2-5) and the recent 10-year average biomass (32.77 kg/ha) and density (2929 fish/ha) are significantly different from the long term average biomass (56.7 kg/ha) and density (4498 fish/ha) (density: $F = 4.12$, $P = 0.05$, $df = 33$; biomass: $F = 6.31$, $P = 0.02$, $df = 33$). This was likely in response to the various droughts that prevailed since 2000, although the trend reversed briefly during 2003-2005 with more normal stream flows. Winter floods in this watershed (particularly in 1998) have also substantially reduced pool habitat at this site (e.g., by partial or complete filling) and although habitat data doesn’t show decreasing trends, it is suboptimal. A different method of data collection may be needed to pick up these changes in habitat. Roghair et al. (2002) and Carline and McCullough (2003) found that flooding in trout streams caused substantial substrate movement, which then decreased pool lengths, surface areas, and depths. Pool depth and quality are correlated with trout abundance (Lewis 1969; Bowlby and Roff 1986), and pools are important trout habitat features (Matthews et al. 1994; Anglin and Grossman 2013; Davis and Wagner 2016), particularly during low flows (Elliott 2000; Sotiropoulos et al. 2006) and for adult Brook Trout (Johnson and Dropkin 1996). Pool length or surface area is not one of our habitat assessment variables, although maximum depth is. However, maximum depth can vary with flow and provides only one data point per year. Habitat assessment scores decreased from optimal in 1999 through 2001 to suboptimal thereafter; however this does not correlate with abundance estimates, since biomass and density trend downward after 2002 and habitat quality remains relatively constant. Consequently, we hypothesize that unless pool quality improves, it is unlikely that this site will ever be capable of supporting the trout biomass it once did. However, other variables may be playing a part in the decrease of biomass that are not well represented in the habitat data collected such as temperature, stream nutrient availability, pH, alkalinity, complexity of habitat, etc.

Brook Trout abundance at Station 2 was relatively unchanged from 2016, although the density of fish ≤ 90 mm did decline somewhat, indicating a smaller 2017 cohort (Figure 2-5). Brook Trout abundance estimates at Station 3 (Figure 2-5) declined relative to 2016, with current density (2,537 fish/ha) and biomass (36.8 kg/ha) levels well below the long term averages 4,439 fish/ha and 76.0 kg/ha, respectively. Degraded pool habitat at Station 2 caused by the 1998 flood (as at Station 1) will likely prevent Brook Trout abundance from reaching the level previously attained by Rainbow Trout there (78 kg/ha). Sedimentation of the pools in Station 3 is also becoming increasingly evident and may be responsible for declining abundance there, even though it is not well-reflected in the habitat data obtained to date. No Rainbow Trout have been captured at these stations since construction of the new fish barrier in 2007, indicating that it is effectively preventing encroachment by Rainbow Trout from downstream.

The Rainbow Trout population size structure at Station 1 indicated a poor 2017 cohort, and limited recruitment to the adult size classes, even after large 2016 cohort (Figure 2-5 and 2-6). Poor recruitment to larger size classes has been typical of the Rainbow Trout population at Station 1 during recent years. It is unlikely that the lack of larger fish is a result of harvest, as fishing pressure on this stream (particularly the Rainbow Trout zone) would be considered relatively light. Some Brook Trout are typically captured at Station 1, but are likely transients from upstream of the barrier. Six were captured in 2016, but only two were adults (108-158 mm), indicating little recruitment from the 13 age-0 Brook Trout present in 2015. Only one Brook Trout was captured this year (109 mm). It will be interesting to determine if a small Brook Trout population can eventually become established below the barrier, especially given the reduced level of Rainbow Trout biomass there now. Size structures for the Brook Trout populations at Stations 2 and 3 also indicated the presence of an adequate 2017 cohort (Figure 2-6), which was typical of other streams sampled in 2017. There was recruitment into the larger Brook Trout size classes (≥178 mm; Figure 2-6) at both stations in 2017, which is significant because none were found at either station in 2016 (the first time this occurred since monitoring began.

**Management Recommendations**

Upper Left Prong's Brook Trout population has made it one of Tennessee's premier Brook Trout fisheries. Since fully established in 2003, mean Brook Trout biomass for the upper station (76 kg/ha) has substantially exceeded the statewide average for other streams (about 21 kg/ha), and is comparable to the mean biomass for the previous Rainbow Trout population (81 kg/ha). Native Brook Trout may be better adapted to and more tolerant of drought conditions (common during the past decade) than are nonnative Rainbow Trout. Monitoring data from other streams such as Rocky Fork (Section 2.3.2) and Gentry Creek also indicate Brook Trout have greater drought tolerance compared to Rainbows Trout. Management of Left Prong should feature its Brook Trout fishery and development of this important database should continue through annual monitoring at all three sites.

Because of the decreasing biomass and density trends at all three stations, suboptimal habitat scores, and decreasing quantity and quality pools, a more detailed habitat analysis may be useful.  Deployment of instream water temperature loggers would also help identify any potential effects on Brook Trout abundance related to temperature.

Table 2-6. Site and sampling information for Left Prong Hampton Creek in 2017.

| **Location** | **Station 1** | | **Station 2** | | **Station 3** | |
|---|---|---|---|---|---|---|
| **Site code** | 420172501 | | 420172502 | | 420172503 | |
| **Sample date** | 5 July | | 5 July | | 5 July | |
| **Watershed** | Watauga River | | Watauga River | | Watauga River | |
| **County** | Carter | | Carter | | Carter | |
| **Quadrangle** | White Rocks Mtn. 208 NE | | White Rocks Mtn. 208 NE | | White Rocks Mtn. 208 NE | |
| **Lat-Long** | 36.15132 N, -82.05324 W | | 36.14673 N, -82.04917 W | | 36.13811 N, -82.04473 W | |
| **Reach number** | 06010103 | | 06010103 | | 06010103 | |
| **Elevation (ft)** | 3,080 | | 3,240 | | 3,560 | |
| **Stream order** | 2 | | 2 | | 2 | |
| **Land ownership** | State (Hampton Cove) | | State (Hampton Cove) | | State (Hampton Cove) | |
| **Fishing access** | Good | | Good | | Good | |
| **Description** | Begins ~10 m upstream of the first foot bridge. | | Begins 50 m upstream of the fish barrier. | | Begins 880 m upstream of the upper end of Site 2. | |
| **Effort** | | | | | | |
| **Station length (m)** | 106 | | 94 | | 100 | |
| **Sample area (m²)** | 392 | | 432 | | 410 | |
| **Personnel** | 3 | | 4 | | 4 | |
| **Electrofishing units** | 1 | | 1 | | 1 | |
| **Voltage (AC)** | 300 | | 400 | | 500 | |
| **Removal passes** | 3 | | 3 | | 3 | |
| **Habitat** | | | | | | |
| **Mean width (m)** | 3.7 | | 4.6 | | 4.1 | |
| **Maximum depth (cm)** | 37 | | NM | | 60 | |
| **Canopy cover (%)** | NM | | 90 | | NM | |
| **Aquatic vegetation** | Scarce | | Scarce | | Scarce | |
| **Estimated % of site in pools** | 39 | | 45 | | NM | |
| **Estimated % of site in riffles** | 61 | | 55 | | NM | |
| **Habitat assessment score** | NM | | NM | | NM | |
| **Substrate Composition** | **Pool (%)** | **Riffle (%)** | **Pool (%)** | **Riffle (%)** | **Pool (%)** | **Riffle (%)** |
| **Silt** | 15 | 0 | 5 | 0 | 25 | 0 |
| **Sand** | 10 | 5 | 10 | 10 | 10 | 5 |
| **Gravel** | 35 | 40 | 40 | 25 | 20 | 30 |
| **Rubble** | 35 | 45 | 20 | 45 | 15 | 35 |
| **Boulder** | 5 | 10 | 25 | 20 | 25 | 25 |
| **Bedrock** | 0 | 0 | 0 | 0 | 5 | 5 |
| **Water Quality** | | | | | | |
| **Flow (cfs; visual)** | 3.86; high | | 3.86; high | | NM; low | |
| **Temperature (C)** | 17.6 | | 15.8 | | 14.6 | |
| **pH** | 7.0 | | 6.8 | | 6.9 | |
| **Conductivity (μS/cm)** | 27 | | 26 | | 15.3 | |
| **Dissolved oxygen (mg/L)** | NM | | NM | | NM | |
| **Alkalinity (mg/L $CaCO_3$)** | NM | | NM | | NM | |

Table 2-7. Fish population abundance estimates (with 95% confidence limits) for the monitoring stations on Left Prong Hampton Creek sampled 5 July2017.

| Species | Total Catch | Population Size | | | Est. | Mean | Biomass (kg/ha) | | | Density (fish/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Est. | Lower C.L. | Upper C.L. | Weight (g) | Fish Wt. (g) | Est. | Lower C.L. | Upper C.L. | Est. | Lower C.L. | Upper C.L. |
| **Station 1** | | | | | | | | | | | | |
| RBT ≤90 mm | 14 | 14 | 12 | 16 | 42 | 3 | 1.07 | 0.92 | 1.22 | 357 | 306 | 408 |
| RBT >90 mm | 19 | 19 | 17 | 21 | 890 | 46.9 | 22.70 | 16.33 | 25.13 | 485 | 434 | 536 |
| BKT >90 mm | 1 | 1 | 1 | 1 | 12 | 12.0 | 0.31 | 0.31 | 0.31 | 26 | 26 | 26 |
| Blacknose Dace | 65 | 67 | 62 | 72 | 231 | 3.4 | 5.89 | 5.38 | 6.24 | 1,709 | 1,582 | 1,837 |
| Fantail Darter | 5 | 7 | 1 | 13 | 32 | 4.6 | 0.82 | 0.12 | 1.53 | 179 | 26 | 332 |
| **Totals** | **104** | **108** | **93** | **123** | **1,207** | | **30.80** | **23.05** | **34.43** | **2,755** | **2,372** | **3,138** |
| **Station 2** | | | | | | | | | | | | |
| BKT ≤90 mm | 35 | 36 | 31 | 41 | 140 | 3.9 | 3.24 | 2.80 | 3.70 | 833 | 718 | 949 |
| BKT >90 mm | 37 | 37 | 36 | 38 | 1,006 | 27.2 | 23.29 | 22.67 | 23.93 | 856 | 833 | 880 |
| **Totals** | **72** | **73** | **67** | **79** | **1,146** | | **26.53** | **25.47** | **27.63** | **1,690** | **1,551** | **1,829** |
| **Station 3** | | | | | | | | | | | | |
| BKT ≤90 mm | 49 | 51 | 46 | 56 | 118 | 2.5 | 2.88 | 2.80 | 3.41 | 1,244 | 1,122 | 1,366 |
| BKT >90 mm | 53 | 53 | 51 | 55 | 1,394 | 26.3 | 34.00 | 32.71 | 35.28 | 1,293 | 1,244 | 1,341 |
| **Totals** | **102** | **104** | **97** | **111** | **1,512** | | **36.88** | **35.52** | **38.70** | **2,537** | **2,366** | **2,707** |

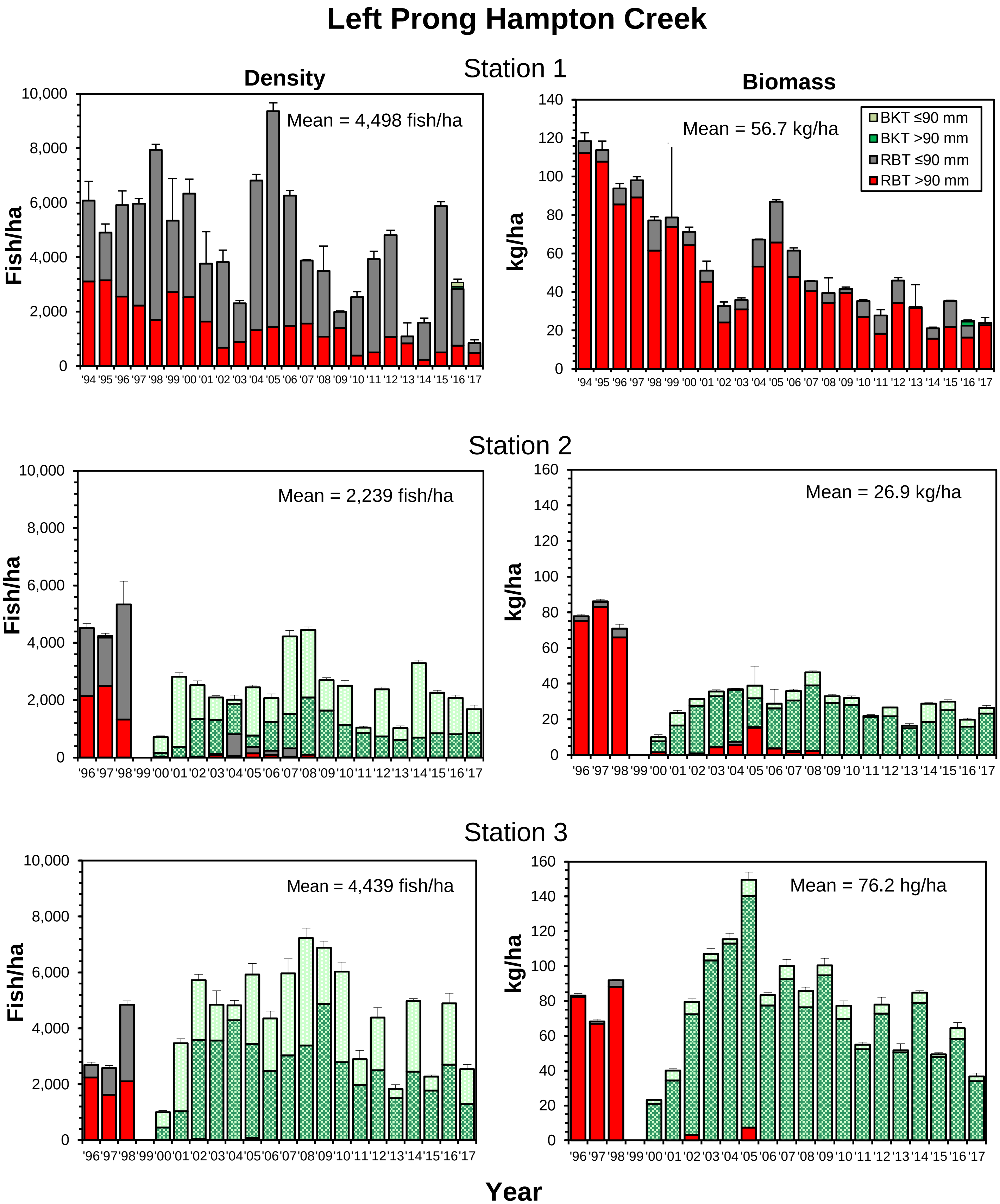



Figure 2-5. Trout abundance estimates for the Left Prong Hampton Creek monitoring stations. RBT = Rainbow Trout and BKT = Brook Trout. Bars indicate upper 95% confidence limits.

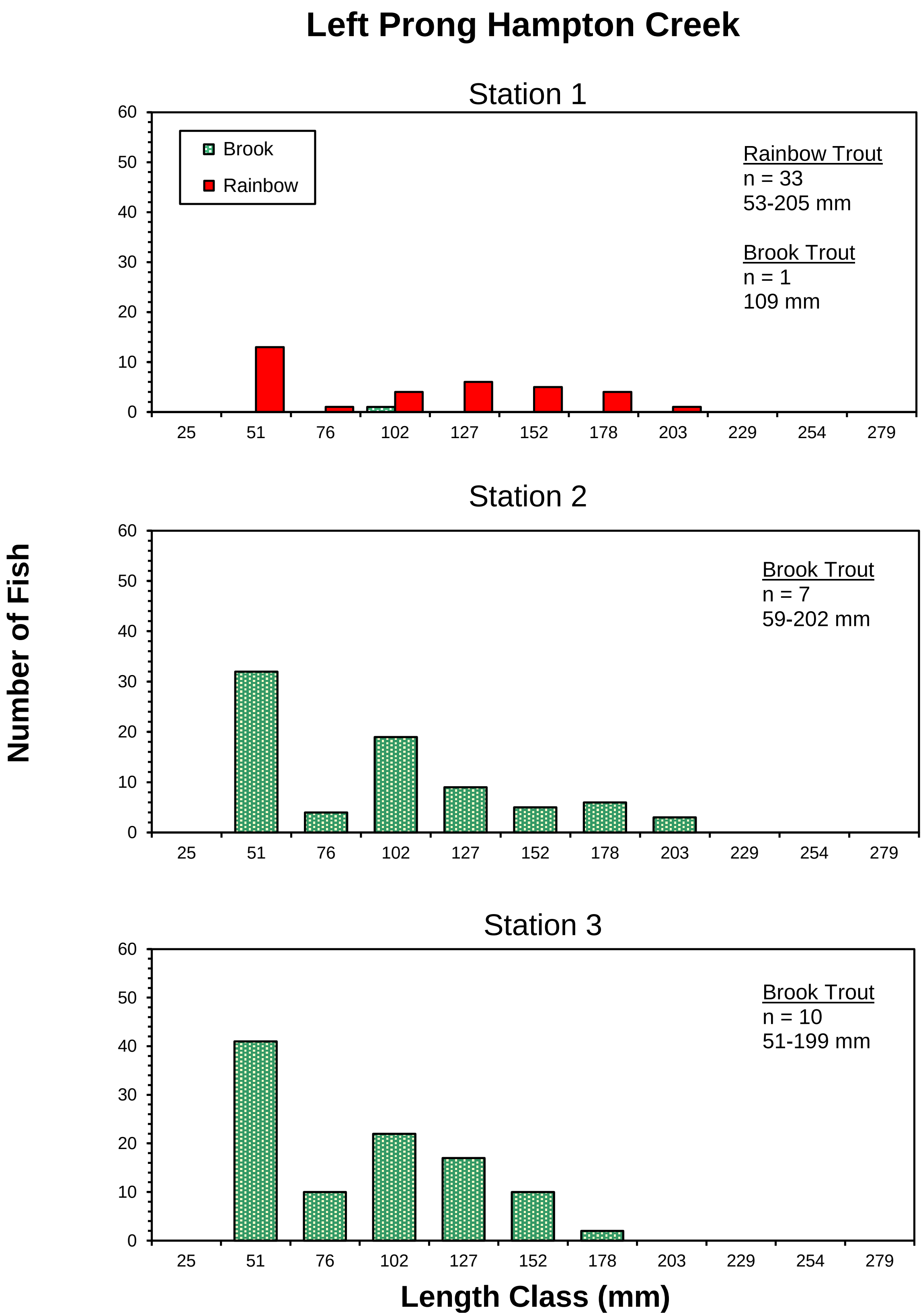



Figure 2-6. Length frequency distributions for trout from the 2017 Left Prong Hampton Creek samples.

## 2.5 PAINT CREEK

### Study Area

Paint Creek begins in the Bald Mountains of Greene County along the North Carolina border and flows 42 km southwest to its confluence with the French Broad River. Over three fourths of Paint Creek is located within the CNF, including all of the lower 19 km. The upper portion of the stream (upstream of Highway 70) is mostly privately owned with residential and small-scale agricultural land uses. Wild trout populations occupy almost the entire length of Paint Creek, with rainbows being present in the upper reaches and Brown Trout predominating downstream.

One tributary (Sawmill Branch) supports 1.8 km of Brook Trout water. These are native, southern Appalachian fish, but are originally from Stony Creek in the Watauga River watershed (USFS restoration). The 2.3-km hybrid brook trout population that had inhabited Little Paint Creek (Strange and Habera 1997) was not relocated during the 2013 distribution survey and may have been lost as a result of recent droughts. This was a relatively low-elevation Brook Trout population (beginning at 2,050’), where habitat could become marginal during periods of low flow and higher temperature. However, the population in nearby Sawmill Branch has a similar distribution and survived these conditions. Given that no trout are now present upstream of the man-made barrier on Little Paint Creek, it may be a candidate for restoration of a native Brook Trout population.

Paint Creek has a long history as a quality trout fishery. Shields (1950) described the portion of Paint Creek downstream of Highway 70 as “one of the finest [trout] streams of the upper East Tennessee area”. He noted that Little Paint Creek, Grassy Branch, and Sawmill Branch provided for excellent reproduction, thus making stocking in that area unnecessary. Lower Paint Creek’s initial trout fishery probably featured Rainbow Trout (put-and-take), but by 1950 the stream was well known for its large Brown Trout (Shields 1950). Paint Creek’s Brown Trout were also reproducing by 1950, making it the only self-sustaining Brown Trout population in the southern Appalachians known to Shields at that time.

Paint Creek continues to support a wild Brown Trout population, although abundance has declined in recent years—particularly downstream of the USFS campground. To meet angling demand, the portion from the USFS campground downstream is still managed as a put-and-take fishery. About 7,800 catchable rainbows are stocked each year, primarily during February-June. The section (including tributaries) between the campground and the upper USFS boundary (near Highway 70) was under a 229-mm minimum length limit, three-fish creel limit, and single-hook, artificial-lures-only restriction during 1994-2012 to emphasize the wild trout fishery. The 229-mm length limit was removed and the creel limit was increased to five fish in 2013 as part of the revision of special wild trout regulations to make them more biologically sound. A delayed harvest area is also in effect downstream of the campground during October-February. Additional stockings of catchable rainbows are made during this time and only artificial lures may be used in the designated area (all trout must be released).

Paint Creek was qualitatively sampled near the confluence with Little Paint Creek in 1986 (USFS) and 1987 (USFS/TWRA). These efforts were part of a study sponsored by the American Fisheries Society's Southern Division Trout Committee to evaluate stocking of half-wild Brown Trout in North Carolina, Virginia, and Tennessee streams. However, the Tennessee data were not included in the final report (Borawa 1990). Subsequently, Paint Creek was quantitatively sampled in 1992 and 1995 by TWRA. The current monitoring stations were established in 2002 and have been sampled on a three-year rotation since 2008. Site location and effort details, along with habitat and water quality information are summarized in Table 2-8.

## Results and Discussion

Only gamefish—salmonids (trout) and centrarchids (sunfish)—were collected and processed (weighed and measured) at the Paint Creek stations in 2017; all other species were noted, but were not collected. A similar procedure has been followed for all samples since 2002. Catch data and abundance estimates for trout and sunfish sampled at the Paint Creek stations in 2017 are given in Table 2-9. At Station 1, only one Rainbow Trout was captured in the first of two passes. A third pass was not attempted and no statistics were calculated based on this one fish. At Station 1, trout numbers and biomass were the lowest observed since monitoring efforts began. At Station 2, total trout biomass increased slightly from 2014, indicating some recruitment into larger size classes. However, total trout biomass at both stations remains substantially below the 1992/1995 and 2002- 2004 levels (Figure 2-7). The recent droughts are the most likely cause for the depressed abundance of the wild trout fishery in Paint Creek. Brown Trout had previously (1996-2014) dominated relative biomass at both stations, but Rainbow Trout biomass was essentially equal at Station 2 in 2017 and no Brown Trout were captured at Station 1 (Table 2-9, Figure 2-7). Species composition and relative abundance of the non-salmonid fish community was similar to what was present during previous surveys.

Size distributions for Paint Creek both rainbow and Brown Trout in 2017 indicated adult and age-0 size classes were present at Station 2 (Figure 2-8). However, only one Rainbow Trout and one Brown Trout < 100 mm were captured. This may indicate poor survival of fish spawned or spawning success over the past years, which again was likely influenced by low flow and high temperatures from the recent drought. Two Brown Trout ≥229 mm were captured for the first time since 2008; however no Brown Trout ≥300 mm have been captured since 2004. Prior to 2004, Paint Creek routinely produced Brown Trout >400 mm.

## Management Recommendations

Paint Creek continues to provide one of Tennessee's few wild trout fisheries that has predominantly been composed of Brown Trout, although current abundance is substantially below former levels. It is now likely more popular as a put-and-take and delayed-harvest (October-February) fishery for Rainbow Trout (particularly downstream of the campground). The management strategy now in place offers something for most trout anglers, thus no changes are recommended at this time. The Paint Creek monitoring stations should be sampled every three years to continue developing this stream's database. Temperature loggers might also be deployed to determine if summer/fall water temperatures are potentially limiting trout abundance

Table 2-8. Site and sampling information for Paint Creek in 2017.

| Location | Station 1 | | Station 2 | |
|---|---|---|---|---|
| Site code | 420172901 | | 420172902 | |
| Sample date | 06 September | | 06 September | |
| Watershed | French Broad River | | French Broad River | |
| County | Greene | | Greene | |
| Quadrangle | Hot Springs 182 NE | | Hot Springs 182 NE | |
| Lat-Long | 35.96560 N, -82.86275 W | | 35.97094 N, -82.82432 W | |
| Reach number | 06010105-71,0 | | 06010105-71,0 | |
| Elevation (ft) | 1,470 | | 1,890 | |
| Stream order | 4 | | 3 | |
| Land ownership | USFS | | USFS | |
| Fishing access | Excellent | | Fair | |
| Description | Begins ~300 m upstream of Waders Picnic Area (old campsite). | | Ends ~20 m upstream of first trail ford below confl. with Little Paint Creek. | |
| **Effort** | | | | |
| Station length (m) | 189 | | 206 | |
| Sample area (m²) | 1,550 | | 1,463 | |
| Personnel | 12 | | 11 | |
| Electrofishing units | 3 | | 3 | |
| Voltage (AC) | 300 | | 300 | |
| Removal passes | 2 (trout only) | | 3 (trout only) | |
| **Habitat** | | | | |
| Mean width (m) | N/M | | 8.3 | |
| Maximum depth (cm) | 100 | | 130 | |
| Canopy cover (%) | 70 | | 40 | |
| Aquatic vegetation | scarce | | scarce | |
| Estimated % of site in pools | N/M | | 51 | |
| Estimated % of site in riffles | N/M | | 49 | |
| Habitat assessment score | 140 (suboptimal) | | 145 (suboptimal) | |
| **Substrate Composition** | Pool (%) | Riffle (%) | Pool (%) | Riffle (%) |
| Silt | 15 | | 10 | |
| Sand | 10 | 10 | 15 | 15 |
| Gravel | 10 | 20 | 15 | 20 |
| Rubble | 15 | 35 | 15 | 25 |
| Boulder | 15 | 25 | 5 | 15 |
| Bedrock | 35 | 10 | 40 | 25 |
| **Water Quality** | | | | |
| Flow (cfs; visual) | 31.1; normal | | 9.8; normal | |
| Temperature (C) | 16.8 | | 17.0 | |
| pH | 7.0 | | 7.1 | |
| Conductivity (µS/cm) | 46 | | 53 | |
| Dissolved oxygen (mg/L) | N/M | | N/M | |
| Alkalinity (mg/L $CaCO_3$) | 25 | | 25 | |

Table 2-9. Estimated trout and sunfish population sizes, standing crops, and densities (with 95% confidence limits) for two stations on Paint Creek in 2017. No statistics were calculated for RBT >90 mm at Station 1 due to small sample size (n=1).

| | | Population Size | | | Est. | Mean | Standing Crop (kg/ha) | | | Density (Fish/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | Lower | Upper | Biomass | Fish Wt. | | Lower | Upper | | Lower | Upper |
| Species | Catch | Est. | C.L. | C.L. | (g) | (g) | Est. | C.L. | C.L. | Est. | C.L. | C.L. |
| **Station 1** | | | | | | | | | | | | |
| RBT >90 mm | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Rock bass | 4 | 4 | 4 | 6 | 173 | 43.3 | -- | -- | -- | -- | -- | -- |
| Longnose Dace | | Present | | | | | | | | | | |
| Blacknose Dace | | Present | | | | | | | | | | |
| Warpaint Shiner | | Abundant | | | | | | | | | | |
| Saffron Shiner | | Abundant | | | | | | | | | | |
| Tennessee Shiner | | Present | | | | | | | | | | |
| Creek Chub | | Abundant | | | | | | | | | | |
| River Chub | | Abundant | | | | | | | | | | |
| C. Stoneroller | | Abundant | | | | | | | | | | |
| Fantail Darter | | Common | | | | | | | | | | |
| Greenfin Darter | | Common | | | | | | | | | | |
| Swannanoa Darter | | Common | | | | | | | | | | |
| N. Hogsucker | | Abundant | | | | | | | | | | |
| **Totals (trout)** | **1** | **1** | **1** | **1** | **30** | | **0.00** | **0.00** | **0.00** | | | |
| **Station 2** | | | | | | | | | | | | |
| RBT >90 mm | 6 | 6 | 6 | 9 | 396 | 66.0 | 2.32 | 2.32 | 3.47 | 35 | 35 | 53 |
| BNT >90 mm | 6 | 6 | 6 | 9 | 492 | 82.0 | 2.88 | 2.88 | 4.32 | 35 | 35 | 53 |
| Bluegill | 3 | 3 | 3 | 8 | 48 | 16.0 | 0.28 | 0.28 | 0.75 | 18 | 18 | 47 |
| Blacknose Dace | | Present | | | | | | | | | | |
| Creek Chub | | Common | | | | | | | | | | |
| C. Stoneroller | | Abundant | | | | | | | | | | |
| Swannanoa Darter | | Common | | | | | | | | | | |
| N. Hogsucker | | Common | | | | | | | | | | |
| **Totals (trout)** | **12** | **12** | **12** | **18** | **888** | | **5.19** | **5.19** | **7.79** | **70** | **70** | **105** |

Note: RBT = Rainbow Trout and BNT = Brown Trout.

# Paint Creek

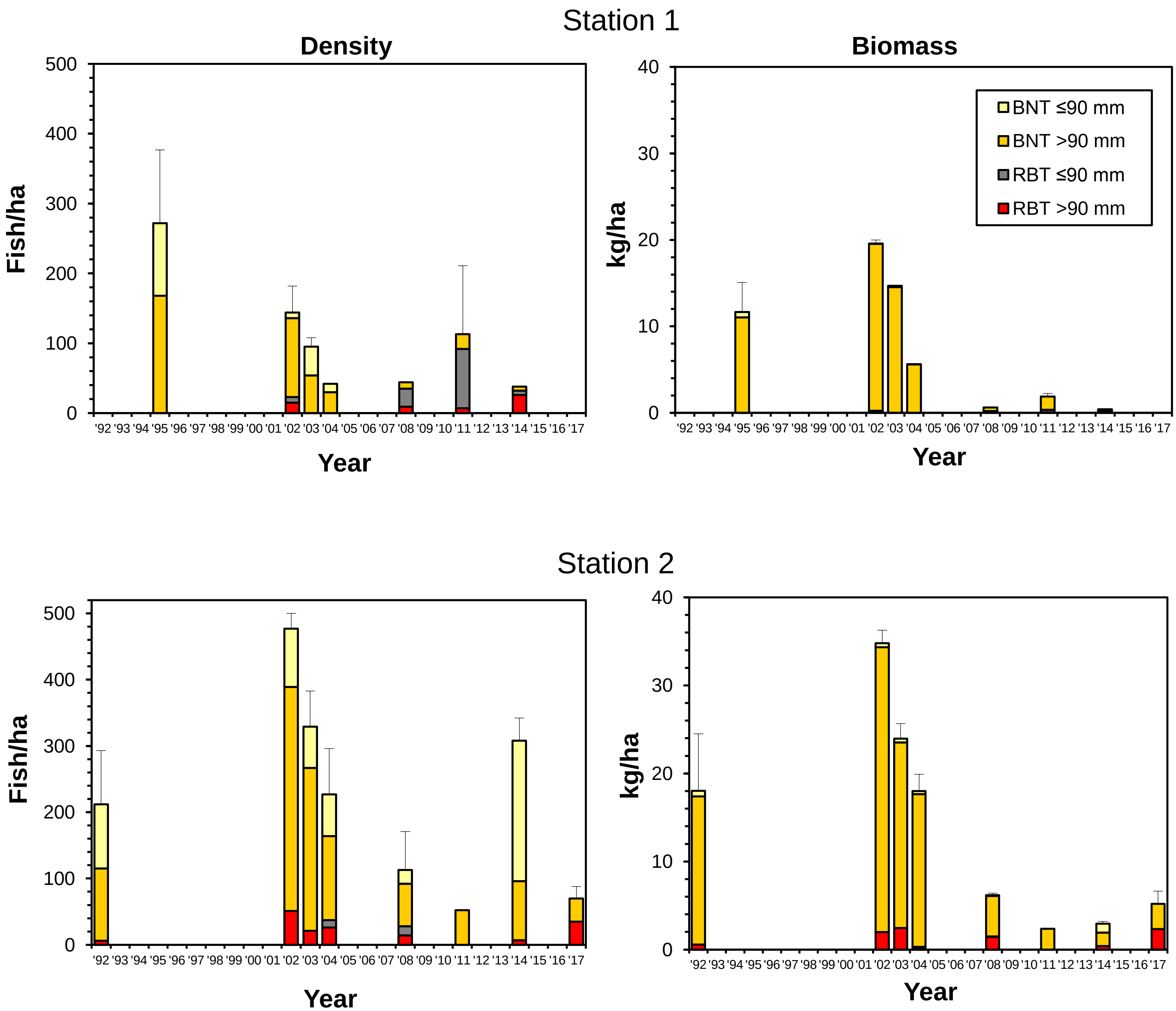
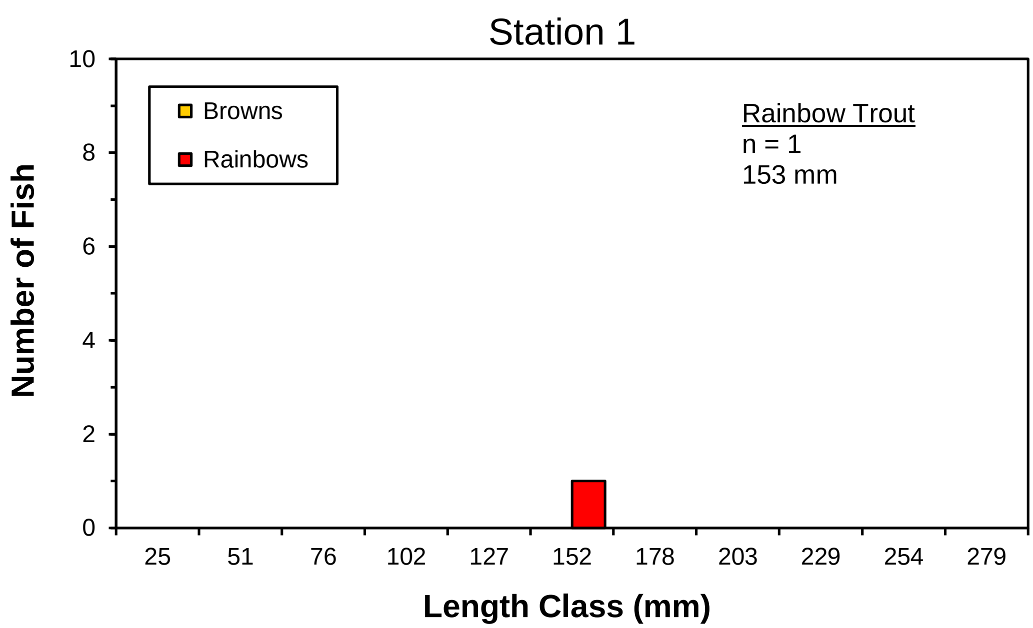



Figure 2-7. Annual trout abundance estimates for the Paint Creek 2017 monitoring stations. Note, starting in 2008, the stream was sampled every third year.

# Paint Creek



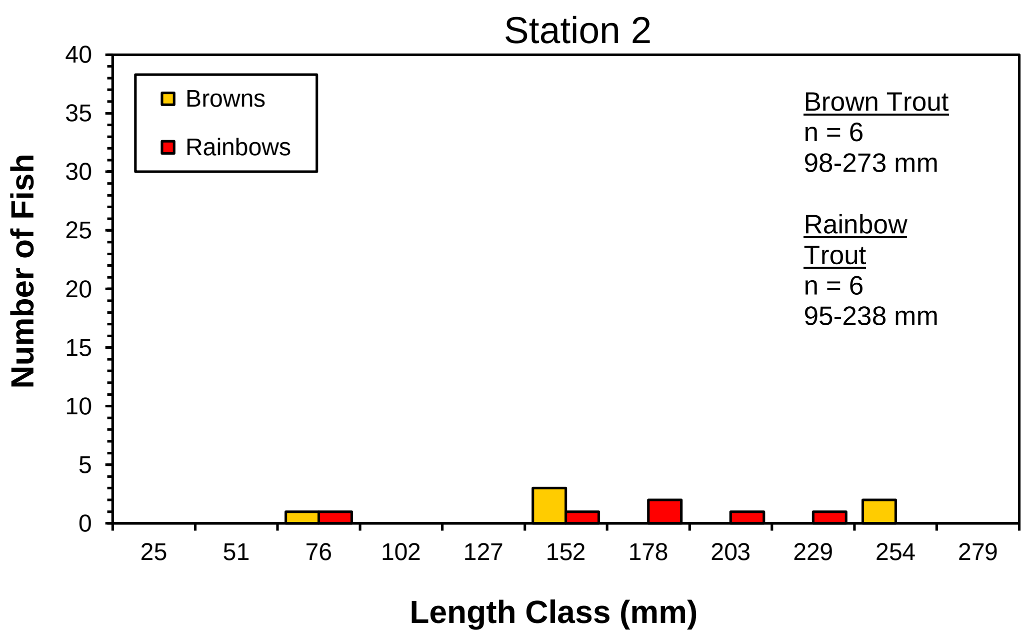




Figure 2-8. Length frequency distributions for Brown and Rainbow Trout from the 2017 Paint Creek samples.

## 2.6 RIGHT PRONG MIDDLE BRANCH

### Study Area

Right Prong Middle Branch is a headwater tributary to the Doe and Watauga rivers. Its Roan Mountain watershed is forested and located largely within the CNF in Carter County. It supports an allopatric population of native Brook Trout upstream of State Route 143 first documented by Bivens (1979). The current monitoring station was first sampled in 1994 (Strange and Habera 1995) and was added to the monitoring program in 1997 to represent a high-elevation (above 4,000' or 1,220 m) native Brook Trout population. Sample site location and effort details, along with habitat and water quality information are summarized in Table 2-10.

### Results and Discussion

Catch data and abundance estimates for Brook Trout sampled at the monitoring station in 2017 are given in Table 2-11. Despite some relatively strong cohorts in recent years, biomass has decreased 59% since 2012 (from 76 kg/ha to 30 kg/ha in 2017; Figure 2-9). Consequently, biomass is below the long-term mean of about 47 kg/ha (Figure 2-9). Much of the biomass decline can be related to the presence of fewer large (≥152 mm) Brook Trout. The number of Brook Trout ≥152 mm captured during 2014-2017 (3-7 fish) has declined compared to the 2011-2013 samples (13 to 19 fish), suggesting reduced recruitment to these larger size classes. The number of large fish did increase from 3 to 7 during the past year, although total biomass remained relatively unchanged. No particular habitat changes at this site are apparent (e.g., pool quality degradation), so other factors may be involved, although excessive harvest seems unlikely due to Right Prong's relatively small size and obscurity.

DNA samples were collected from 27 Brook Trout during the 2016 monitoring efforts (Habera et al. 2017) to confirm the genetic identity of this population and examine relationships with other populations; results are pending.

### Management Recommendations

No special management of Right Prong Middle Branch is suggested at this time other than protection of the resource. Because of the small size of this stream and its relative obscurity, angling pressure is probably light. Sampling at the monitoring station should continue in order to increase our understanding of Brook Trout population dynamics, particular in higher-elevation streams. Temperature loggers should also be deployed for long-term water temperature monitoring, particularly summer months.

Table 2-10. Site and sampling information for Right Prong Middle Branch in 2017.

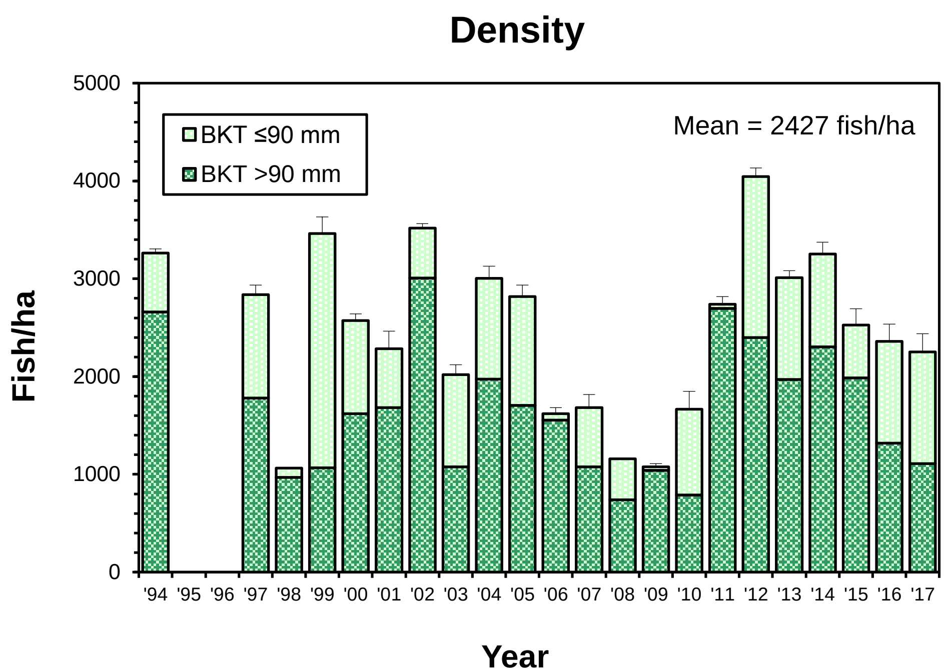
| **Location** | **Station 1** | |
|---|---|---|
| **Site code** | 420172701 | |
| **Sample date** | 18 August | |
| **Watershed** | Watauga River | |
| **County** | Carter | |
| **Quadrangle** | Carvers Gap 208 SE | |
| **Lat-Long** | 36.12007 N, -82.09574 W | |
| **Reach number** | 06010103 | |
| **Elevation (ft)** | 4,070 | |
| **Stream order** | 1 | |
| **Land ownership** | USFS | |
| **Fishing access** | Limited | |
| **Description** | Begins at head of small island ~270 m upstream of Rt. 143. | |
| **Effort** | | |
| **Station length (m)** | 90 | |
| **Sample area (m²)** | 324 | |
| **Personnel** | 2 | |
| **Electrofishing units** | 1 | |
| **Voltage (AC)** | 250 | |
| **Removal passes** | 3 | |
| **Habitat** | | |
| **Mean width (m)** | 3.6 | |
| **Maximum depth (cm)** | 70 | |
| **Canopy cover (%)** | 95 | |
| **Aquatic vegetation** | scarce | |
| **Estimated % of site in pools** | 43 | |
| **Estimated % of site in riffles** | 57 | |
| **Habitat assessment score** | 160 (optimal) | |
| **Substrate Composition** | **Pool (%)** | **Riffle (%)** |
| **Silt** | 25 | 0 |
| **Sand** | 5 | 5 |
| **Gravel** | 30 | 30 |
| **Rubble** | 15 | 30 |
| **Boulder** | 20 | 35 |
| **Bedrock** | 5 | 0 |
| **Water Quality** | | |
| **Flow (cfs; visual)** | 3.1; normal | |
| **Temperature (C)** | 13.9 | |
| **pH** | 6.9 | |
| **Conductivity (µS/cm)** | 42 | |
| **Dissolved oxygen (mg/L)** | NM | |
| **Alkalinity (mg/L $CaCO_3$)** | NM | |

Table 2-11. Fish population abundance estimates (with 95% confidence limits) for the monitoring station on Right Prong Middle Branch sampled 18 August 2017.

| Species | Total Catch | Population Size Est. | Population Size Lower C.L. | Population Size Upper C.L. | Est. Weight (g) | Mean Fish Wt. (g) | Biomass (kg/ha) Est. | Biomass (kg/ha) Lower C.L. | Biomass (kg/ha) Upper C.L. | Density (fish/ha) Est. | Density (fish/ha) Lower C.L. | Density (fish/ha) Upper C.L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BKT ≤90 mm | 37 | 37 | 34 | 40 | 133 | 3.6 | 4.10 | 3.78 | 4.44 | 1,142 | 1,049 | 1,235 |
| BKT >90 mm | 36 | 36 | 33 | 39 | 986 | 27.4 | 30.43 | 28.78 | 32.98 | 1,111 | 1,019 | 1,204 |
| **Totals** | **73** | **73** | **67** | **79** | **1,119** | | **34.54** | **32.56** | **37.43** | **2,253** | **2,068** | **2,438** |

Note: BKT = Brook Trout.

# Right Prong Middle Branch



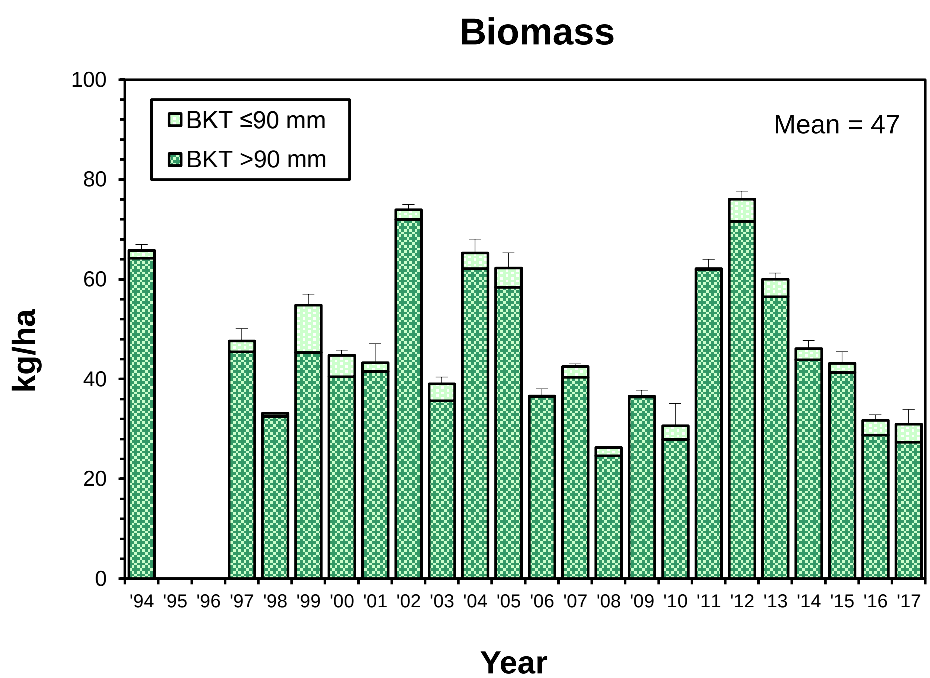




Figure 2-9. Trout abundance estimates for the Right Prong Middle Branch monitoring station for 2017. BKT = Brook Trout. Bars indicated upper 95% confidence limits (total).

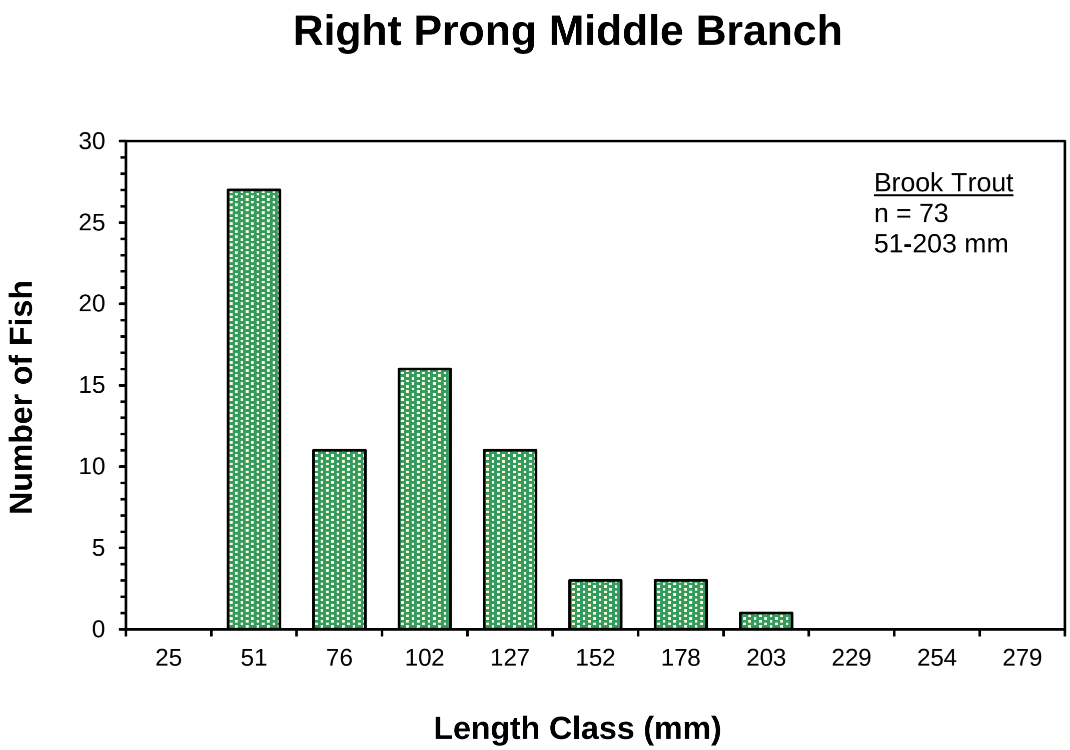



Figure 2-10. Length frequency distribution for Brook Trout from the 2017 Right Prong Middle Branch sample.

## 2.7 ROCKY FORK

### Study Area

Rocky Fork is a tributary of South Indian Creek in the Nolichucky River basin and is located within Greene and Unicoi counties. The watershed is mountainous and forested, with some recent (although limited) logging activity. The lower portion of the stream is contained within the 825-ha (2,036-acre) Rocky Fork State Park. Planning continues for development of the Park's access roads, trail system, welcome center, picnic shelters, and campground. The remaining 3,000 ha (7,600 acres) of the formerly privately-owned Rocky Fork tract were added to the CNF. The middle and lower reaches of Rocky Fork support an excellent wild Rainbow Trout population. The upper portion (above 2,890') has both Brook and Rainbow Trout. Three tributaries (Blockstand Creek, Broad Branch, and Fort Davie Creek) also contain Brook Trout populations. Genetically, all four populations (including Rocky Fork) have substantial hatchery influence from numerous stockings that occurred into the 1980s (Strange and Habera 1997). New DNA samples were collected from each population in 2016 to evaluate current genetic characteristics, but results are still pending.

Shields (1950) noted that Rainbow Trout growth and production in Rocky Fork was quite good and described the portion from Fort Davie Creek downstream (12.9 km) as carrying a large crop of fish. Despite the Rocky Fork's capacity for wild trout production, it was intensively managed as a put-and-take fishery with hatchery-produced rainbow and Brook Trout for many years (Bivens et al. 1998). That strategy was changed in 1988 to feature wild trout by discontinuing stocking except in the 1.7-km segment upstream of the confluence with South Indian Creek. The stocking rate for that portion of Rocky Fork averages ~4,800 adult Rainbow Trout per year. A three-trout creel limit was also added to the 229-mm minimum length limit and single-hook, artificial-lures only regulations already in place. Regulations were changed again in 1991 to focus harvest on Rainbow Trout by removing their size limit and raising the creel limit to seven trout (to include only three Brook Trout). Subsequently, as more data from Rocky Fork and other wild trout streams have become available, regulations were changed again in 2013 to make them more biologically relevant. Accordingly, the creel limit was increased to five fish and minimum size limits were removed (including the 152-mm statewide size limit for Brook Trout).

TWRA qualitatively sampled Rocky Fork in the 1980s (Bivens 1989; Bivens and Williams 1990), which then led to the current quantitative sampling program in 1991 with the establishment of two long-term monitoring stations. These stations have been sampled annually since 1991. Site location and effort details, along with habitat and water quality information are summarized in Table 2-12.

### Results and Discussion

Catch data and abundance (biomass) estimates for trout and all other species sampled at the Rocky Fork stations in 2017 are given in Table 2-13. In general, both stations had decreased trout density compared to 2016. The total trout biomass estimate at Station 1 decreased (29.21 kg/ha) relative to the past two years and is the third lowest since annual monitoring began (Figure 2-11). Also, trout biomass dropped below the long-term average of

41.23 kg/ha trout. Trout density at Station 1 (1,504 fish/ha) also decreased relative to the past two years and is below the long-term average (2,331 fish/ha).

The total trout density estimate at Station 2 decreased relative to 2016, primarily as the result of decreased abundance of age-0 and adult Brook Trout (Figure 2-11). However, total trout biomass at Station 2 (40.5 kg/ha) increased to the highest level observed since 2011, although it still remains below the long-term average (44.7 kg/ha; Figure 2-11). A more detailed discussion of the relative abundance of Brook and Rainbow Trout at Station 2 is provided in Section 2.8.2.

Abundance of the 2017 Rainbow Trout cohort at Station 1 (age-0 fish) was below average, although 2017 Rainbow Trout cohorts in most streams were also below average. Size distributions for Rainbow and Brook Trout at Station 2 are provided and discussed in Section 2.8.2.

**Management Recommendations**

Rocky Fork provides a good fishery for wild Rainbow and Brook Trout that management continues to emphasize. Because the stream is relatively long (>13 km) and access is limited to foot travel, it provides an ideal setting for anglers seeking a more solitary experience. Monitoring of the Rocky Fork stations should be conducted annually to maintain the continuity of this important wild trout database and document any effects related to development of the road/trail system in the State Park and upstream areas in the CNF.

Table 2-12. Site and sampling information for Rocky Fork in 2017.

| Location | Station 1 | | Station 2 | |
|---|---|---|---|---|
| Site code | 420173101 | | 420171302 | |
| Sample date | 21 September | | 21 September | |
| Watershed | Nolichucky River | | Nolichucky River | |
| County | Unicoi | | Greene | |
| Quadrangle | Flag Pond 190 SE | | Flag Pond 190 SE | |
| Lat-Long | 36.04801 N, -82.55889 W | | 36.06758 N, -82.59608 W | |
| Reach number | 06010108 | | 06010108 | |
| Elevation (ft) | 2,360 | | 3,230 | |
| Stream order | 4 | | 3 | |
| Land ownership | State of TN (TDEC) | | USFS | |
| Fishing access | Good | | Limited | |
| Description | Begins ~100 m upstream of the blue gate. | | Ends ~10 m upstream of confl. with Ft. Davie Ck. | |
| **Effort** | | | | |
| Station length (m) | 130 | | 100 | |
| Sample area (m²) | 871 | | 360 | |
| Personnel | 12 | | 4 | |
| Electrofishing units | 2 | | 1 | |
| Voltage (AC) | 450 | | 600 | |
| Removal passes | 3 | | 3 | |
| **Habitat** | | | | |
| Mean width (m) | 6.7 | | 3.6 | |
| Maximum depth (cm) | 100 | | 70 | |
| Canopy cover (%) | N/M | | N/M | |
| Aquatic vegetation | scarce | | scarce | |
| Estimated % of site in pools | 64 | | 48 | |
| Estimated % of site in riffles | 36 | | 52 | |
| Habitat assessment score | 160 (optimal) | | 164 (optimal) | |
| **Substrate Composition** | **Pool (%)** | **Riffle (%)** | **Pool (%)** | **Riffle (%)** |
| Silt | 5 | 0 | 5 | 0 |
| Sand | 10 | 5 | 10 | 5 |
| Gravel | 20 | 15 | 25 | 35 |
| Rubble | 30 | 35 | 30 | 40 |
| Boulder | 20 | 40 | 25 | 20 |
| Bedrock | 15 | 5 | 5 | 0 |
| **Water Quality** | | | | |
| Flow (cfs; visual) | 4.9; Normal | | 2.0; Normal | |
| Temperature (C) | 15.8 | | 15.9 | |
| pH | 6.9 | | 7.0 | |
| Conductivity (µS/cm) | 20 | | 11.2 | |
| Dissolved oxygen (mg/L) | N/M | | N/M | |
| Alkalinity (mg/L $CaCO_3$) | 15 | | N/M | |

Table 2-13. Fish population abundance estimates (with 95% confidence limits) for the monitoring stations on Rocky Fork sampled 21 September 2017.

| Species | Total Catch | Population Size Est. | Population Size Lower C.L. | Population Size Upper C.L. | Est. Weight (g) | Mean Fish Wt. (g) | Biomass (kg/ha) Est. | Biomass (kg/ha) Lower C.L. | Biomass (kg/ha) Upper C.L. | Density (fish/ha) Est. | Density (fish/ha) Lower C.L. | Density (fish/ha) Upper C.L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | | | | | | | | | | | | |
| RBT ≤90 mm | 19 | 25 | 5 | 44 | 110 | 4.6 | 1.26 | 0.26 | 2.32 | 287 | 57 | 505 |
| RBT >90 mm | 105 | 106 | 102 | 110 | 2,429 | 22.9 | 27.89 | 26.82 | 28.92 | 1,217 | 1,171 | 1,263 |
| BKT >90 mm | 1 | 1 | 1 | 1 | 6 | 5.6 | 0.06 | 0.06 | 0.06 | 11 | 11 | 11 |
| Longnose Dace | 2 | 2 | 2 | 2 | 51 | 13.5 | 0.59 | 0.59 | 0.59 | 23 | 23 | 23 |
| Blacknose Dace | 128 | 200 | 121 | 279 | 667 | 3.3 | 7.66 | 4.58 | 10.57 | 2,296 | 1,389 | 3,203 |
| Mottled Sculpin | 93 | 161 | 66 | 256 | 1,135 | 7.1 | 13.03 | 5.38 | 20.87 | 1,848 | 758 | 2,939 |
| **Totals** | **348** | **495** | **294** | **689** | **4,398** | | **52.23** | **37.05** | **62.68** | **5,683** | **4,629** | **5,758** |
| **Station 2** | | | | | | | | | | | | |
| RBT ≤90 mm | 6 | 6 | 6 | 6 | 34 | 5.7 | 0.94 | 0.95 | 0.95 | 167 | 167 | 167 |
| RBT >90 mm | 24 | 24 | 22 | 26 | 734 | 30.6 | 20.39 | 18.70 | 22.10 | 667 | 611 | 722 |
| BKT ≤90 mm | 7 | 7 | 4 | 10 | 30 | 4.3 | 0.83 | 0.48 | 1.19 | 194 | 111 | 278 |
| BKT >90 mm | 27 | 27 | 26 | 28 | 661 | 24.5 | 18.36 | 17.69 | 19.06 | 750 | 722 | 778 |
| **Totals** | **64** | **64** | **58** | **70** | **1,459** | | **40.53** | **37.82** | **43.30** | **1,778** | **1,611** | **2,845** |

Note: RBT = Rainbow Trout and BKT = Brook Trout.

# Rocky Fork

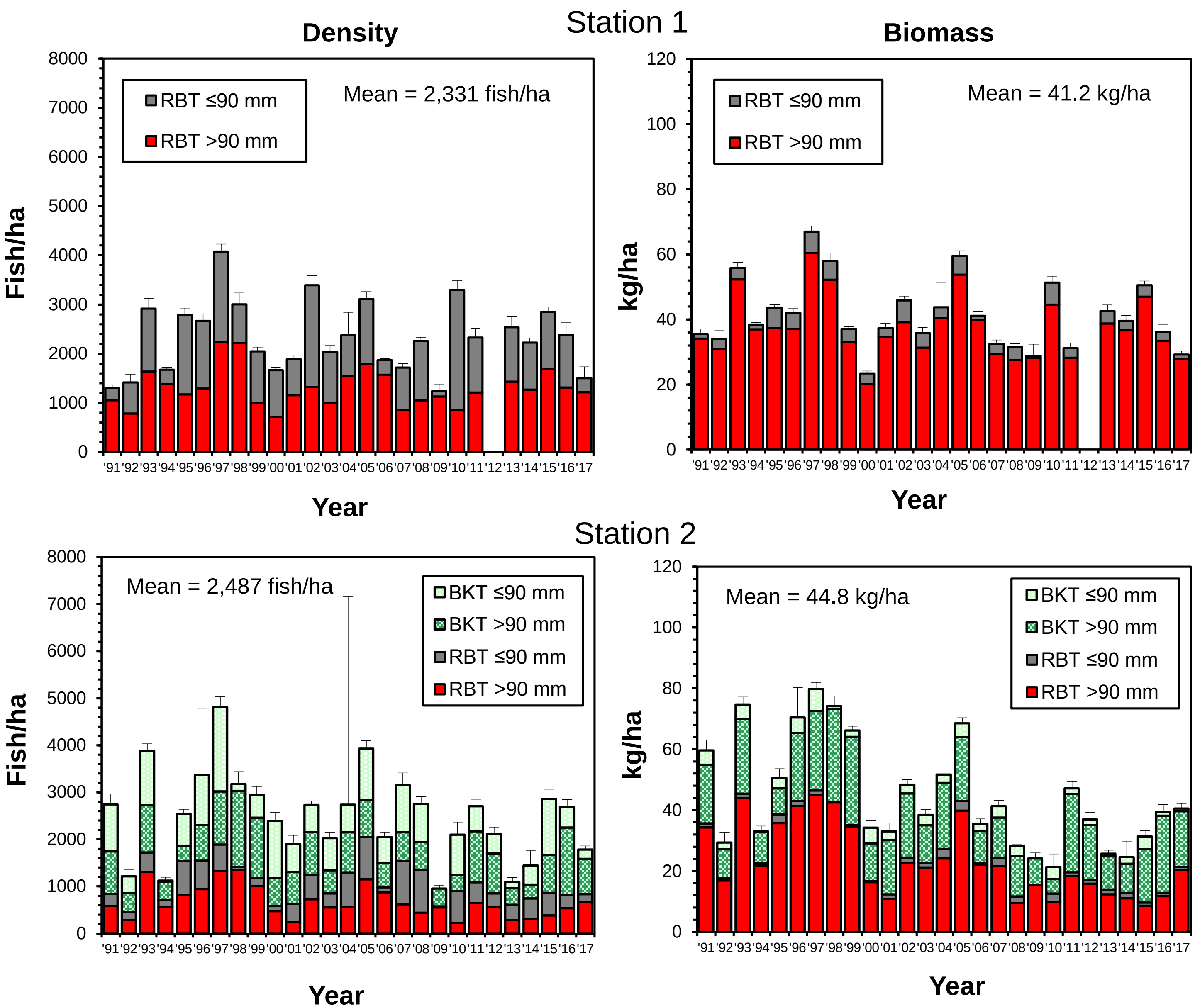



Figure 2-11. Trout abundance estimates for Rocky Fork monitoring stations RBT = Rainbow Trout and BKT = Brook Trout. Bars indicated upper 95% confidence limits (total).

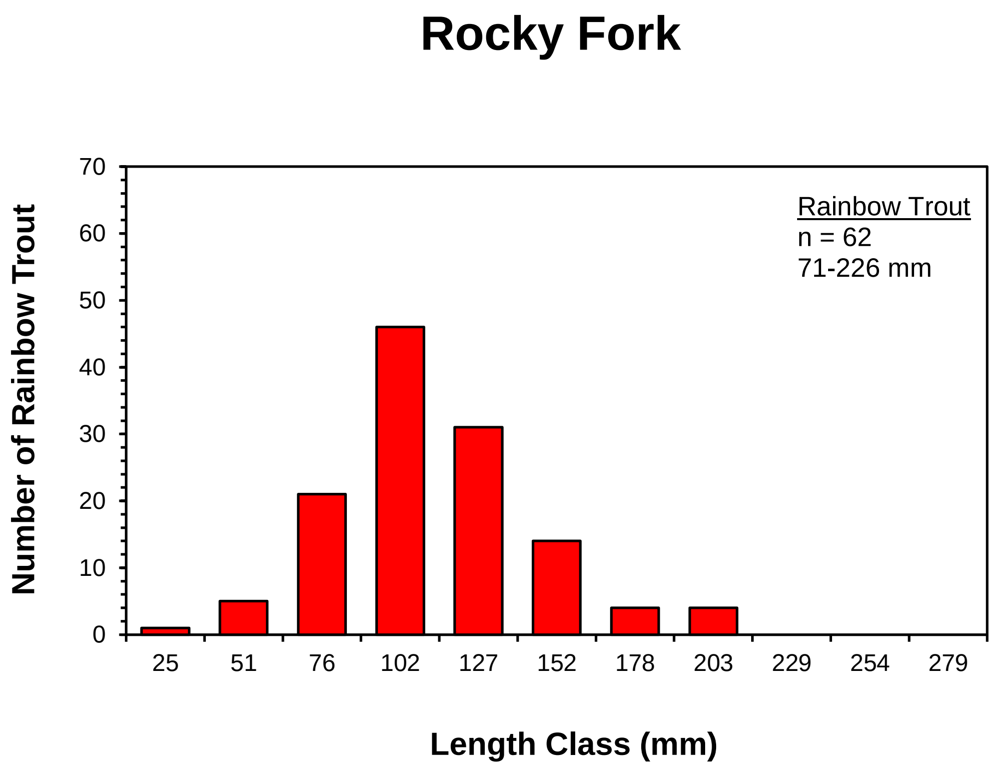



Figure 2-12. Length frequency distribution for Rainbow Trout from the 2017 Rocky Fork sample at Station 1 (Station 2 data are provided in Section 2.8.2)

## 2.8 SYMPATRIC BROOK/TRAINBOW TROUT MONIORING STREAMS

Four streams (upper Rocky Fork, Briar Creek, Birch Branch, and Gentry Creek) are currently being monitored annually with the objective of documenting how (or if) Rainbow Trout eventually replace Brook Trout in areas where the two species occur sympatrically. Briar and Rocky Fork were sampled again in 2017 to continue tracking changes and trends in the relative abundance of each species over time. Gentry Creek and Birch Branch (typically sampled during June and July) were not sampled in 2017 because of extensive Brook Trout DNA sampling efforts during that time frame.

### 2.8.1 Briar Creek

**Study Area**

Briar Creek is a Nolichucky River tributary in Washington County that flows from Buffalo Mountain through a forested watershed located within the CNF. It contains 4.7 km of native Brook Trout water beginning at an elevation of about 657 m (2,140'). Rainbow Trout are present throughout the stream to its confluence with Dry Creek. Brook Trout were re-introduced to Briar Creek in 1983 and the existing Rainbow Trout population was thinned in the 1.37-km introduction zone during 1983-1986 (Nagel 1986). A total of 114 native Brook Trout (mixed ages) were translocated from East Fork Beaverdam Creek, George Creek, and Tiger Creek during 1983-1984 (Nagel 1986). A reproducing Brook Trout population became established in the introduction zone by 1986, and then expanded into areas from which no Rainbow Trout were removed (Nagel 1991). Currently, Brook Trout inhabit 4.7 km of Briar Creek, all of which remains sympatric with Rainbow Trout. DNA samples were obtained from 30 fish in 2016 to confirm their genetic identity and obtain other population genetics information (Section 2.4); results are pending. Briar Creek is currently subject to general, statewide trout angling regulations.

A station at 662 m (2,170') elevation was quantitatively sampled in 1992 to check the Brook Trout population status in the original introduction zone (Strange and Habera 1993). This site contained 27% Brook Trout, but several were removed for genetic analyses (Kriegler et al. 1995). Therefore, a new site was established at 671 m (2,200') and annual monitoring began in 1995 (Strange and Habera 1996). Site location and effort details, along with habitat and water quality information are summarized in Table 2-14.

**Results and Discussion**

Catch data and abundance estimates for trout and all other species sampled at the Briar Creek station in 2017 are given in Table 2-15. Briar Creek has been impacted by droughts since 1998, resulting in August flows typically well below 1 cfs. Only six fish (two Brook Trout) were captured in 2010 (Habera et al. 2011), but better flow conditions by 2014 and 2015 led to a substantial increase in trout abundance (>100 fish) with numerous age-0 fish of both species (Habera et al. 2015a and 2016). However, trout numbers were reduced by extremely dry conditions and low stream flows again in 2016 and declined further in 2017 (Figure 2-13). Only eight Brook Trout (all age-0) were captured this year.

Total trout biomass at the Briar Creek monitoring station generally declined from the late 1990s through 2013 in conjunction with the previously-mentioned droughts during that time (Figure 2-14). Following the improvement to 32 kg/ha in 2014, biomass has consistently declined again to 10 kg/ha in 2017 (Figure 2-14).

Brook Trout relative biomass (compared to Rainbow Trout) generally increased at the Briar Creek monitoring station during 1997-2002, exceeding 50% during the drought years of 1998-2002 (Figure 2-14). However, it has generally declined since then, falling to 12% in 2010 and 10% in 2017 (Figure 2-14). Given its persistence over the past three decades, this Brook Trout population is obviously resilient and has been capable of withstanding a combination of environmental and competitive challenges.

**Management Recommendations**

Upper Briar Creek typically supports a good wild trout fishery featuring Brook Trout except when reduced by droughts. Fortunately, wild trout populations (particularly Brook Trout in Briar Creek) tend to be resilient and this fishery will likely recover from recent drought-related impacts. Annual sampling at the monitoring station should continue in order to learn more about Brook Trout and Rainbow Trout populations under sympatric conditions, particularly their responses to abiotic events (droughts and floods). No efforts to remove Rainbow Trout or enhance Brook Trout should occur in upper Briar Creek while this monitoring is underway so that only natural processes can be studied.

The culvert at the upper road crossing (FR 188; above the monitoring station), which had a perched downstream lip, was recently replaced by the USFS and TU with a new structure that will improve connectivity with the upstream Brook Trout population upstream, which is more abundant than downstream. A temperature logger may also be deployed for long term water temperature monitoring, particularly summer months.

Table 2-14. Site and sampling information for Briar Creek in 2017.

| **Location** | **Station 1** |
|---|---|
| **Site code** | 420172601 |
| **Sample date** | 3 August |
| **Watershed** | Nolichucky River |
| **County** | Washington |
| **Quadrangle** | Erwin 199 NW |
| **Lat-Long** | 36.22825 N, -82.38883 W |
| **Reach number** | 06010108 |
| **Elevation (ft)** | 2,200 |
| **Stream order** | 3 |
| **Land ownership** | USFS |
| **Fishing access** | Good |
| **Description** | This site is located along the adjacent road (USFS 188). The lower end is marked |

| **Effort** | |
|---|---|
| **Station length (m)** | 145 |
| **Sample area (m²)** | 450 |
| **Personnel** | 2 |
| **Electrofishing units** | 1 |
| **Voltage (AC)** | 400 |
| **Removal passes** | 3 |

| **Habitat** | |
|---|---|
| **Mean width (m)** | 3.1 |
| **Maximum depth (cm)** | 84 |
| **Canopy cover (%)** | 85 |
| **Aquatic vegetation** | scarce |
| **Estimated % of site in pools** | 45 |
| **Estimated % of site in riffles** | 55 |
| **Habitat assessment score** | 151 (suboptimal) |

| **Substrate Composition** | **Pool (%)** | **Riffle (%)** |
|---|---|---|
| **Silt** | 0 | 0 |
| **Sand** | 15 | 5 |
| **Gravel** | 40 | 35 |
| **Rubble** | 30 | 45 |
| **Boulder** | 10 | 15 |
| **Bedrock** | 5 | 0 |

| **Water Quality** | |
|---|---|
| **Flow (cfs; visual)** | NM; low |
| **Temperature (C)** | 17.7 |
| **pH** | 6.9 |
| **Conductivity (µS/cm)** | 27 |
| **Dissolved oxygen (mg/L)** | NM |
| **Alkalinity (mg/L $CaCO_3$)** | NM |

Table 2-15. Fish population abundance estimates (with 95% confidence limits) for the monitoring station on Briar Creek sampled 3 August 2017.

| Species | Total Catch | Population Size Est. | Population Size Lower C.L. | Population Size Upper C.L. | Est. Weight (g) | Mean Fish Wt. (g) | Biomass (kg/ha) Est. | Biomass (kg/ha) Lower C.L. | Biomass (kg/ha) Upper C.L. | Density (fish/ha) Est. | Density (fish/ha) Lower C.L. | Density (fish/ha) Upper C.L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RBT ≤90 mm | 8 | 8 | 5 | 11 | 26 | 3.2 | 0.58 | 0.36 | 0.78 | 178 | 111 | 244 |
| RBT >90 mm | 11 | 11 | 9 | 13 | 366 | 33.3 | 8.13 | 6.66 | 9.62 | 244 | 200 | 289 |
| BKT ≤90 mm | 7 | 7 | 5 | 9 | 36 | 5.1 | 0.80 | 0.57 | 1.02 | 156 | 111 | 200 |
| BKT >90 mm | 1 | 1 | 1 | 1 | 7 | 7.3 | 0.16 | 0.16 | 0.16 | 22 | 22 | 22 |
| Blacknose Dace | 228 | 235 | 227 | 243 | 538 | 2.3 | 11.96 | 11.60 | 12.42 | 5,222 | 5,044 | 5,400 |
| **Totals** | **255** | **262** | **247** | **277** | **973** | | **21.62** | **19.35** | **24.00** | **5,822** | **5,489** | **6,156** |

Note: RBT = Rainbow Trout and BKT = Brook Trout.

# Briar Creek

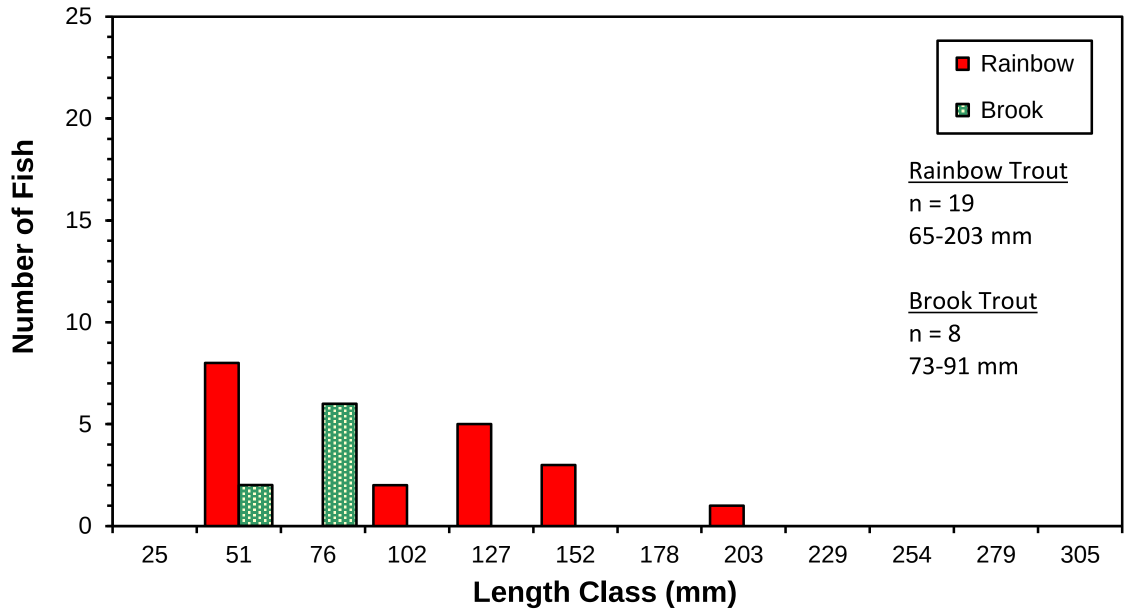



Figure 2-13. Length frequency distribution for Rainbow Trout and Brook Trout from the 2017 Briar Creek sample.

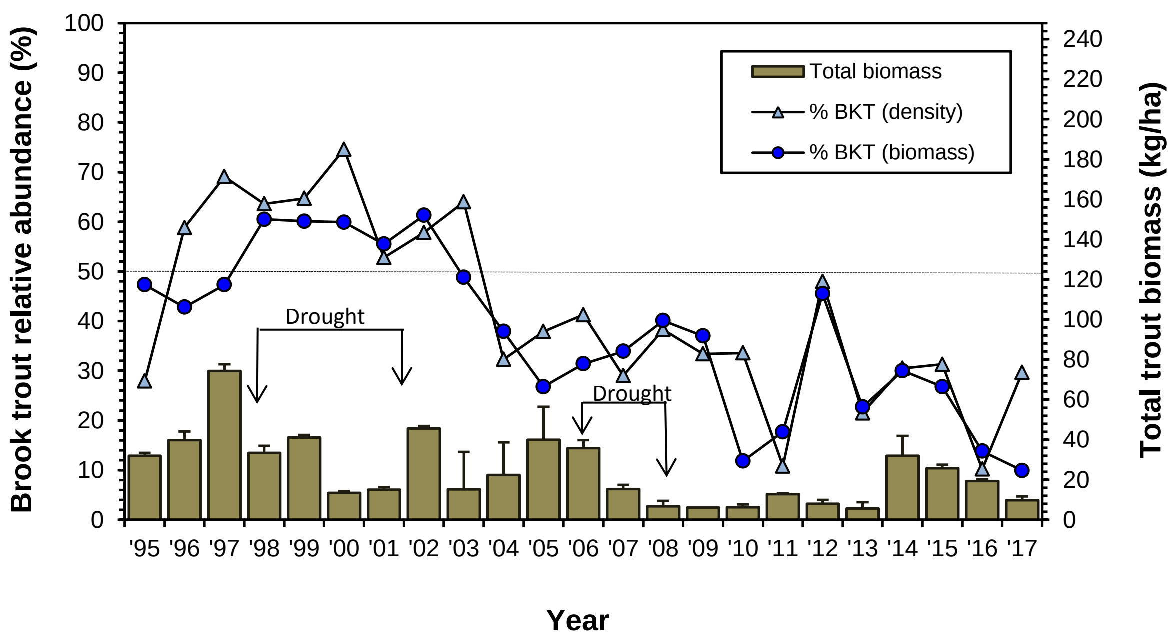



Figure 2-14. Total biomass and relative Brook Trout abundance at the Briar Creek monitoring station. Bars indicate upper 95% confidence limits.

### 2.8.2 Rocky Fork

**Study Area**

Rocky Fork is part of the general long-term wild trout monitoring program and was described in Section 2.7. The upper portion of Rocky is primarily in Greene County and contains 3.2 km of Brook Trout water beginning at approximately 914m (3,000 ft) elevation (Strange and Habera 1997). Sample site location and effort details along with habitat and water quality information were previously provided in Section 2.7.

**Results and Discussion**

Catch and abundance estimates for trout sampled at Station 2 on Rocky Fork in 2017 are given in Table 2-13 (Section 2.7). Total trout biomass remained relatively unchanged from 2016 (Figure 2-11; Section 2.7), there was a shift in favor of Rainbow Trout, causing Brook Trout relative biomass to fall below 50% (Figure 2-16). Brook Trout relative density, however remained above 50% in 2017 (Figure 2-16).

Population size structures indicated relatively weak 2017 cohorts (Figure 2-15). Rainbow Trout are typically more abundant than Brook Trout in the larger size classes (≥178 mm), but this was not the case at Station 2 in 2016 or 2017 (Figure 2-16). Nagel and Deaton (1989) questioned the size advantage Rainbow Trout were thought to hold over Brook Trout in Rocky Fork's headwaters (Whitworth and Strange 1983) and elsewhere. However, monitoring data from Rocky Fork and other streams have generally verified the tendency of Rainbow Trout to grow larger than Brook Trout in a variety of sympatric situations. This advantage may be lost at times during droughts such as in 2008, (Habera et al. 2009a), 2015, and 2016, when survival and recruitment appear to be impacted more for Rainbow Trout than for Brook Trout.

Brook Trout relative abundance (biomass) was quite stable at about 40% from 1991 through 1993, but declined rapidly after the flood in early 1994 (Figure 2-26) and associated Brook Trout year-class failure (Strange and Habera 1995). Brook Trout relative abundance recovered to the pre-flood level in 1996, then surpassed 50% in 2000 and 60% in 2001 (Figure 2-16) during the dry years of 1998-2002 (Habera et al. 2003). Brook Trout relative abundance (biomass) generally increased again with the next drought, surpassing 60% in 2015 and 2016 (Figure 2-16). In fact, Brook Trout relative abundance (biomass) in 2015 and 2016 was the highest observed during the 26 years this station has been monitored. Consequently, it is clearly evident in Rocky Fork (and elsewhere) that Brook Trout can exist—and even thrive—in sympatry with Rainbow Trout for long periods of time. Brook Trout appear to be favored during droughts in the sense that competitive pressure is reduced as Rainbow Trout are more markedly impacted. However, cumulative drought effects on recruitment may reach a level where the abundance of both species is reduced to the point that relative abundance percentages have little meaning. This occurred in Briar Creek in 2009-2011 (Section 2.8.1), Rocky Fork in 2010, and Birch Branch in 2008-2010.

## Management Recommendations

Upper Rocky Fork continues to provide an example of the resiliency of wild trout populations (particularly Brook Trout) in southern Appalachian streams. Despite large reductions in abundance related to droughts and floods, the Brook Trout population has demonstrated the ability to recover, even in the presence of Rainbow Trout. Future management should protect and emphasize this important fishery. Annual monitoring should continue at Station 2 to further develop our understanding of sympatric Brook and Rainbow Trout interactions and assess the ability of Rainbow Trout to replace Brook Trout over time. It is recommended that no efforts to removed Rainbow Trout or enhance Brook trout be initiated in upper Rocky Fork while this monitoring is underway so that only natural processes can be studied. Temperature loggers may be placed in the stream to monitor water temperatures during the summer months.

Upper Rocky Fork (Station 2).

# Rocky Fork

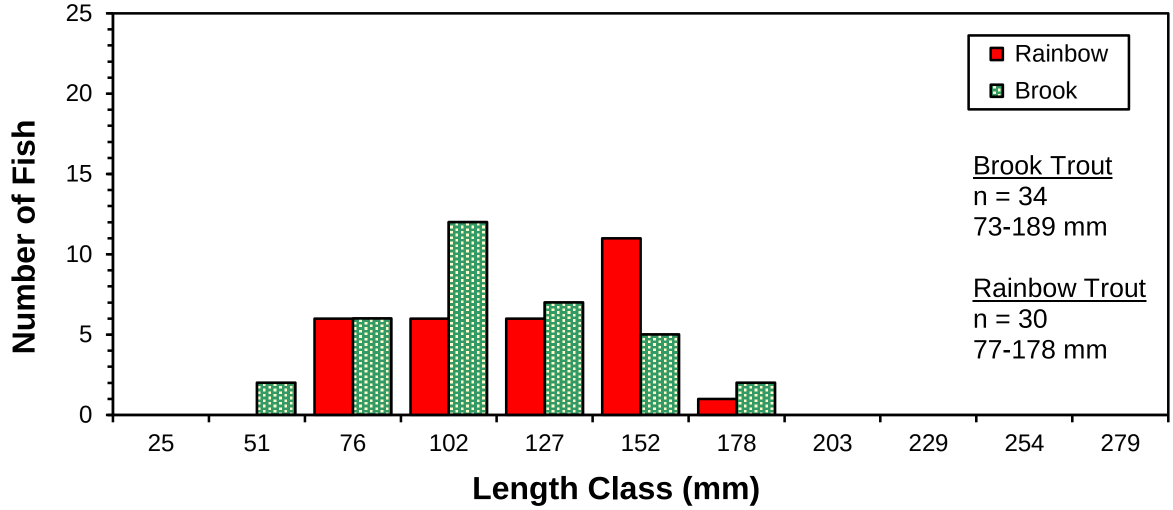



Figure 2-15. Length frequency distributions for Brook and Rainbow Trout from the 2017 sample at the upper monitoring station (2) on Rocky Fork.

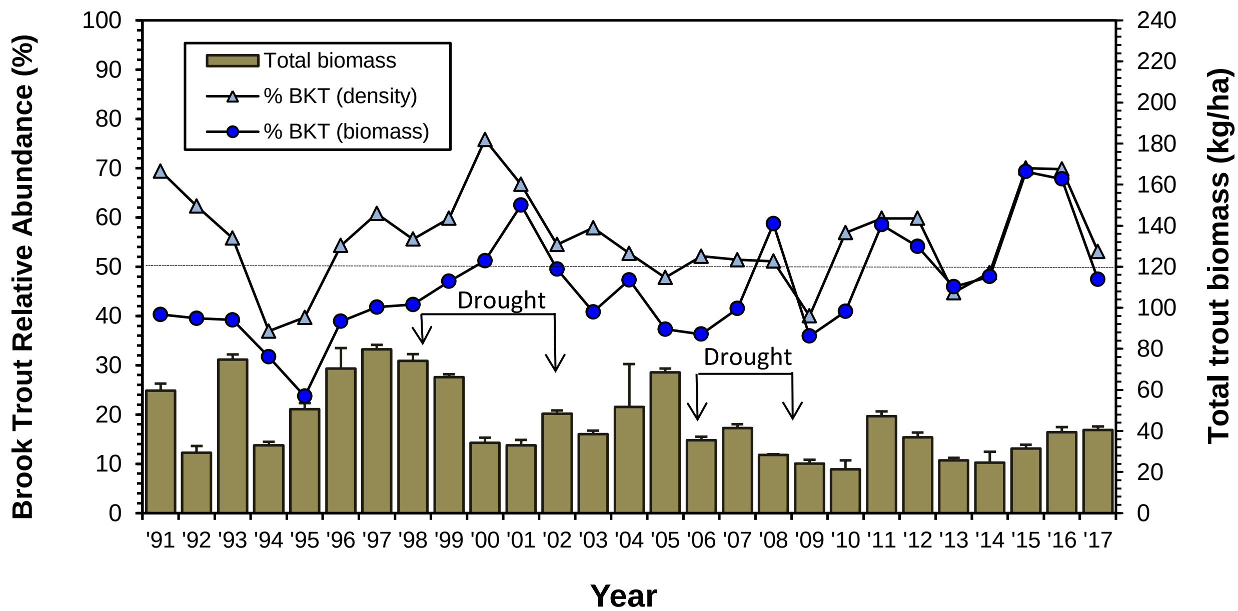



Figure 2-16. Total biomass and relative Brook Trout abundance at the upper monitoring station (2) on Rocky Fork. Bars indicate upper 95% confidence limits.

2.3.3 Summary

Appalachian streams historically had Brook Trout, however in the 1900s Rainbow Trout were stocked throughout many of the streams and Brook Trout have become extirpated from many streams for various reasons. Currently, four streams with both wild Brook Trout and wild Rainbow Trout are being monitored long term with the objective of documenting how (or if) Rainbow Trout replace Brook Trout.

Clark and Rose (1997) recognized conventional theory—a niche shift induced by the presence of a superior competitor—did not explain replacement of Brook Trout by Rainbow Trout. Their modeling emphasized the importance of year-class failures (e.g., those caused by floods), but predicted that Rainbow Trout would not replace Brook Trout if such failures occurred infrequently (intervals of 10-20 years). Even with much more frequent year-class failures (3-year intervals), it still required 80 years for a simulated Brook Trout population to be eliminated. Simulated year-class failures included both species, even though typical late-winter/early-spring floods could impact year-class strength of Brook Trout (fall spawners) much more severely than Rainbow Trout (Strange and Habera 1995, 1996; Warren et al. 2009). Additionally, these and subsequent (Clark et al. 2001) model simulations did not include droughts, which can be frequent and are clearly more detrimental to Rainbow Trout survival and recruitment in sympatric Tennessee populations. However, both floods and droughts would be expected to occur over several decades and their effects on relative abundance can be offsetting.

Many studies observed long-term density fluctuations of native and introduced trout, but not total elimination of the native trout (Larson et al. 1995; Adams et al. 2002). However, larger and longer-lived Brown Trout have been shown to limit Brook Trout growth, recruitment, and abundance (Hoxmeier and Dieterman 2013; 2016) or essentially replace them (Waters 1999) in Minnesota streams. Complete replacement of Brook Trout by Rainbow Trout in Tennessee streams might be possible only through unusual circumstances, such as a succession of late winter/early spring floods or drought that severely weaken or eliminate multiple Brook Trout year classes. Conversely, data from all four monitoring streams indicate that droughts (particularly 1998-2002 and 2006-2008, where the drought periods were less severe during fall and early spring) can offset Brook Trout declines related to previous floods by reducing Rainbow Trout relative abundance. Extended drought, however, may eliminate Brook Trout populations in marginal habitats regardless of the presence of any sympatric salmonids (Habera et al. 2014a). Moreover, timing of the drought may affect species differently; similar to how late-winter/early-spring floods could impact year-class strength of Brook Trout more so than Rainbow Trout. For example if the drought occurs during the fall into the spring compared to in the summer, this may impact the trout differently.

Although Brook Trout relative abundance has fluctuated over the years at the monitoring stations, it appears that Rainbow Trout have no particular competitive advantage, thus these species can coexist for many years at some general equilibrium. Strange and Habera (1998) and Habera et al. (2001a; 2014a) found no broad-scale loss of distribution or inexorable replacement by Rainbow Trout in sympatric populations. Furthermore, Brook Trout have gained distribution (2 km or more in some cases) in the presence of Rainbow Trout in several streams since the 1990s (Habera et al. 2014a; Section 2.10). Additional monitoring data will be useful for identifying any conditions that may eventually enable Rainbow Trout to eliminate brook trout. These could include landscape alterations (Hudy et al. 2008; Stranko et al. 2008) and climate change (Trumbo et al. 2010; Myers et al. 2014; DeWeber and Wagner 2015). Interestingly, Trumbo et al. (2010) found that their direct measurement of paired air and water temperatures in Virginia identified more Brook Trout watersheds that would be resistant to predicted air temperature increases—and with potential refugia existing at lower elevations—than predicted by previous modelling. Additionally, Stitt et al. (2014) found that among Brook Trout strains, thermal tolerance was highest for the one with the most southern ancestry. Verhille et al. (2016) observed the same characteristic for wild Rainbow Trout at the southern limit of distribution within their native range. This would potentially provide Brook Trout additional flexibility for adjusting to changing climatic conditions and some resistance to replacement by Rainbow Trout in thermally stressed environments. In mainstem habitats, competition for thermal refugia, rather than food, is likely more important for Brook Trout and would be heightened under current climate change scenarios, especially in the presence of exotic salmonids (Huntsman and Petty 2014). To monitor these changes and help explain fluctuations in Brook and Rainbow Trout abundances, temperature monitoring loggers will be placed in these streams.

## 2.9 COMPLETION OF BROOK TROUT DNA SAMPLING

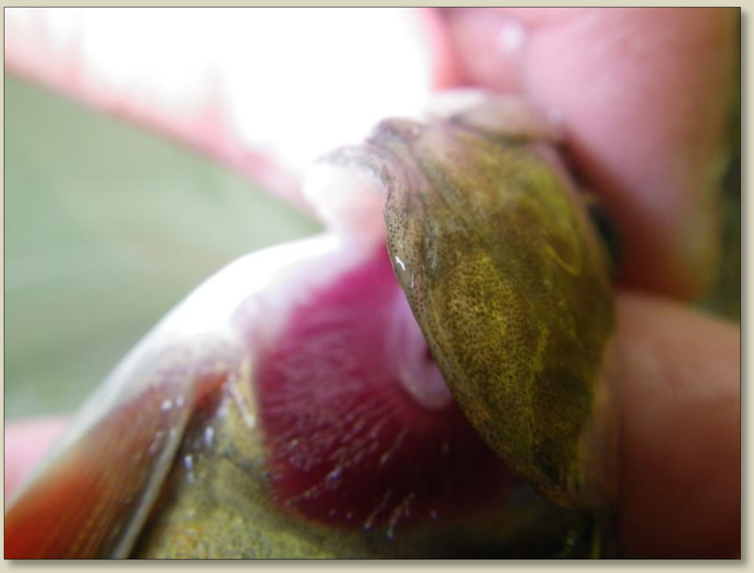
The 42 Brook Trout populations remaining to be sampled as part of the effort to upgrade existing genetics information (Habera et al. 2017) were visited during May-July 2017. The Little Stony Creek population, which is the focus of an ongoing restoration project, was included. Brook Trout were not relocated in two streams during 2017 (Bitter End Branch and Vaught Creek; Table 2-16), although both had populations during the most recent distribution survey. Target sample size for each population was 30 fish representing as much of the existing distribution as possible. A single pelvic fin clip was taken from each fish and stored in 95% ethanol. Age-0 fish were avoided if possible, as was the collection of more than one fish per pool (to avoid siblings). Overall, DNA samples were obtained from 1,081 fish representing 40 populations, with sample sizes ranging from 6-39 and averaging 27 (24 samples included ≥30 fish; Table 2-16). Mean length of the collection zone in each stream was 790 m and samples were collected upstream of major waterfalls where present. Streams with relatively short distributions and low abundances produced the smaller samples sizes (≤15), although in these cases a high percentage of the existing population was sampled. Sampling in 2017 focused on streams in the Watauga and South Fork Holston basins and with completion of those efforts, DNA samples from all 109 known Brook Trout populations in Tennessee (outside GSMNP) have now been obtained. These samples are being analyzed using microsatellite DNA at the U.S.

Collecting a Brook Trout DNA sample (fin clip) during 2017 (C. Chapman, UT TWRA intern assisting).

A set of Brook Trout DNA samples from Hoot Owl Hollow (Johnson Co.) obtained during 2017

Geological Survey (USGS) Leetown Science Center lab in Kearneysville, WV; results for fish collected in 2016 or 2017 are not yet available. All 1,081 Brook Trout collected for DNA samples in 2017 were also examined for gill lice (*Salmincola edwardsii*), which have been detected in some Brook Trout populations in the Watauga River basin in North Carolina by the North Carolina Wildlife Resources Commission. None of these fish were infected.

Detailed rationale for upgrading Tennessee's Brook Trout genetic information is provided in Habera et al. (2017), but important results will include verification of the genetic identity of existing native brook trout populations (currently based on allozymes), along with more detailed information (including effective population size) for selecting appropriate source populations as part of restoration and enhancement projects. Effective population size ($N_e$) is the number of individuals from a population required to represent the genetic diversity present—usually much smaller than census size. Managers should consider $N_e$ when selecting brook trout populations as sources for restoration projects. Populations with larger $N_e$ have more genetic diversity and a higher probability of long-term survival. Range-wide, $N_e$ averages about 50, although 8 of 11 Tennessee populations (outside GSMNP) for which results are available had $N_e$ <20 (range, 1-58). Genotype verification of all extant brook trout populations, along with acquiring other population genetics characteristics (e.g., $N_e$ and relatedness to other populations), is also an important goal of Tennessee's new Native Brook Trout Management Plan (and ultimately addresses objectives and strategies relative to brook trout in TWRA's 2014-2020 Strategic Plan (TWRA 2014). Efforts to upgrade Tennessee's Brook Trout genetics information began during distribution surveys that got underway in 2011 (Habera et al. 2012) and have culminated in Region 4 with DNA collections from 45 streams in 2016 and 40 in 2017 (Table 2-16).



All Brook Trout collected for DNA samples during 2017 were examined for gill lice (*Salmincola edwardsii*). No infected fish were observed.

A manuscript summarizing the most current Brook Trout population genetics data across the southern Appalachian and mid-Atlantic range (including Tennessee's) is now being prepared under the leadership of the USGS Leetown Science Center lab staff. Basic goals and objectives of this paper will be to:

1. Describe baseline genetic attributes of Brook Trout populations across the southern portion of their distribution and compare/contrast differences:

    i. in genetic diversity within and genetic differentiation among drainages,
    ii. relative to population size, spatial distance, drainage,
    iii. related to stocked and unstocked populations,
    iv. in population segments with/without movement barriers,
    v. between genetic attributes of populations found north and south of New River watershed, VA/NC.

2. Describe the evolutionary relationships among brook trout populations at the population and phylogeographic scale across their range.
3. Identify patterns in most recent common ancestry within/among streams, drainages, and regions.
4. Determine if there is evidence of effective genetic migration of populations within/among watershed(s) (i.e., panmictic populations vs. isolated gene flow vs. isolated fragmented populations).
5. Assess genetic signature and degree of introgression within/among hybrid populations exposed to single vs. repeated stocking of hatchery Brook Trout.
6. Determine if repeated removals of Brook Trout from source streams for translocation to restored stream segments has caused significant declines in genetic metrics.
7. Define management units based upon genetic metrics and hydrological patterns.

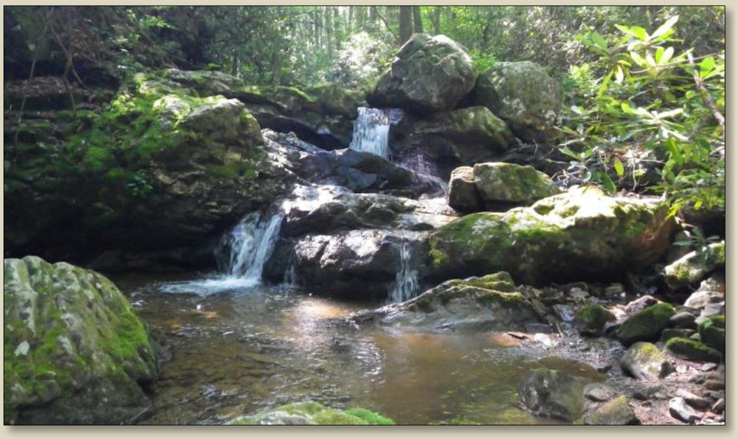
The SDAFS Trout Committee will then use this information to update their position statement on managing southern Appalachian Brook Trout (Habera and Moore 2005). Consequently, Brook Trout conservation and management strategies throughout the region can be refined, particularly with respect to Brook Trout restoration and enhancement projects.

Table 2-16. Brook Trout streams from which DNA samples were collected during 2017 (May-July).

| | | | | | Sample collection zone | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Stream | County | Basin | Date | Samples | Lower Lat. | Lower Long. | Upper Lat. | Upper Long. | Distance (km) |
| Leonard Branch | Carter | Watauga | 6/6/2017 | 30 | 36.24119 | -82.08323 | 36.23901 | -82.08949 | 0.68 |
| Wagner Branch | Carter | Watauga | 6/13/2017 | 30 | 36.23970 | -82.07484 | 36.24849 | -82.06406 | 1.79 |
| Moreland Branch | Carter | Watauga | 6/13/2017 | 30 | 36.23644 | -82.07496 | 36.23342 | -82.08083 | 0.76 |
| White Rocks Br. | Carter | Watauga | 6/6/2017 | 6 | 36.23098 | -82.06922 | 36.23042 | -82.06796 | 0.15 |
| Camp 15 Br. | Carter | Watauga | 6/5/2017 | 30 | 36.22549 | -82.05173 | 36.22268 | -82.05424 | 0.52 |
| Bitter End Branch | Carter | Watauga | 6/5/23017 | No BKT | -- | -- | -- | -- | 0.30 |
| Hays Branch | Carter | Watauga | 6/8/2017 | 10 | 36.23038 | -82.03356 | 36.23271 | -82.03128 | 0.31 |
| Tiger Creek | Carter | Watauga | 5/25/2017 | 27 | 36.16359 | -82.17514 | 36.15891 | -82.16537 | 1.07 |
| Roberts Hollow | Carter | Watauga | 6/1/2017 | 30 | 36.17002 | -82.18287 | 36.16822 | -82.18900 | 0.64 |
| Bill Creek | Carter | Watauga | 5/30/2017 | 30 | 36.16372 | -82.17506 | 36.16264 | -82.18120 | 0.71 |
| Fall Branch | Carter | Watauga | 5/25/2017 | 30 | 36.16176 | -82.17293 | 36.15491 | -82.17432 | 0.83 |
| Ruins Branch | Carter | Watauga | 5/30/2017 | 23 | 36.16172 | -82.17129 | 36.15887 | -82.16875 | 0.45 |
| Roaring Ck. (upper) | Carter | Watauga | 6/1/2017 | 15 | 36.16695 | -82.14892 | 36.16688 | -82.15508 | 0.90 |
| No-Name (Andy) Ck. | Carter | Watauga | 6/1/2017 | 21 | 36.17496 | -82.14414 | 36.18403 | -82.14591 | 1.19 |
| Heaton Creek | Carter | Watauga | 5/23/2017 | 27 | 36.12862 | -82.06953 | 36.12301 | -82.07053 | 0.67 |
| Middle Branch | Carter | Watauga | 5/22/2017 | 30 | 36.12972 | -82.09474 | 36.11996 | -82.09113 | 1.16 |
| Panther Branch | Carter | Watauga | 5/18/2017 | 25 | 36.14285 | -82.11887 | 36.14667 | -82.12042 | 0.47 |
| Cove Creek | Carter | Watauga | 5/18/2017 | 36 | 36.13248 | -82.11659 | 36.12646 | -82.12317 | 0.92 |
| Little Cove Creek | Carter | Watauga | 5/22/2017 | 30 | 36.13520 | -82.11473 | 36.12851 | -82.11168 | 0.85 |
| Little Laurel Branch | Carter | Watauga | 6/14/2017 | 39 | 36.25685 | -81.99355 | 36.24612 | -82.00161 | 1.58 |
| Morgan Branch | Carter | Watauga | 6/15/2017 | 27 | 36.24522 | -82.00146 | 36.24220 | -82.00628 | 0.66 |
| Little Stony Ck. (lake trib.) | Carter | Watauga | 7/6 & 8/16/17 | 32 | 36.29180 | -82.06680 | 36.28348 | -82.06850 | 1.11 |
| Roan Creek | Johnson | Watauga | 6/21/2017 | 30 | 36.34523 | -81.72935 | 36.34473 | -81.72278 | 0.63 |
| Mill Creek | Johnson | Watauga | 6/21/2017 | 12 | 36.35771 | -81.86082 | 36.35503 | -81.85915 | 0.39 |
| Vaught Creek | Johnson | Watauga | 6/19/2017 | No BKT | -- | -- | -- | -- | 0.33 |
| Furnace Creek | Johnson | Watauga | 6/19/2017 | 30 | 36.37790 | -81.81341 | 36.37014 | -81.80441 | 1.21 |
| Corn Creek | Johnson | Watauga | 6/26/2017 | 28 | 36.49638 | -81.85843 | 36.50089 | -81.85929 | 0.53 |
| Cress Branch | Johnson | Watauga | 6/26/2017 | 22 | 36.49622 | -81.85836 | 36.49702 | -81.86202 | 0.34 |
| Steve Phillippi Br. | Johnson | Watauga | 6/26/2017 | 17 | 36.49853 | -81.84345 | 36.50314 | -81.84737 | 0.65 |
| Forge Creek | Johnson | Watauga | 6/27/2017 | 31 | 36.50080 | -81.70377 | 36.50957 | -81.70281 | 1.06 |
| Tank Hollow | Johnson | S. Fork Holston | 6/28/2017 | 30 | 36.58361 | -81.82011 | 36.57914 | -81.81309 | 0.82 |
| Chalk Branch | Johnson | S. Fork Holston | 6/29/2017 | 30 | 36.58146 | -81.83353 | 36.57426 | -81.82413 | 1.17 |
| Maple Branch | Johnson | S. Fork Holston | 6/29/2017 | 30 | 36.57946 | -81.83662 | 36.59338 | -81.83544 | 0.71 |
| Fagall Branch | Johnson | S. Fork Holston | 7/18/2017 | 31 | 36.57096 | -81.85557 | 36.56033 | -81.85629 | 1.44 |
| Parks Branch | Johnson | S. Fork Holston | 7/19/2017 | 27 | 36.54977 | -81.87799 | 36.53899 | -81.86947 | 1.49 |
| Johnson Blevins Br. | Johnson | S. Fork Holston | 7/19/2017 | 27 | 36.53017 | -81.89432 | 36.52722 | -81.88926 | 0.64 |
| Jim Wright Branch | Johnson | S. Fork Holston | 7/20/2017 | 31 | 36.50219 | -81.91977 | 36.50024 | -81.91499 | 0.58 |
| E. F. Beaverdam Ck. | Johnson | S. Fork Holston | 7/18/2017 | 31 | 36.49242 | -81.92599 | 36.49010 | -81.92170 | 0.55 |
| W. F. Beaverdam Ck. | Johnson | S. Fork Holston | 7/20/2017 | 23 | 36.49430 | -81.94041 | 36.48877 | -81.94367 | 0.73 |
| Valley Creek | Johnson | S. Fork Holston | 6/28/2017 | 30 | 36.61056 | -81.68159 | 36.60626 | -81.68311 | 0.56 |
| Hoot Owl Hollow | Johnson | S. Fork Holston | 6/27/2017 | 33 | 36.53867 | -81.79425 | 36.54720 | -81.80154 | 1.20 |
| Rockhouse Run | Sullivan | S. Fork Holston | 7/21/2017 | 30 | 36.60291 | -81.89132 | 36.59964 | -81.88749 | 0.57 |

2.10 LITTLE JACOB CREEK BROOK TROUT ENHANCEMENT

Native Brook Trout were reintroduced to Little Jacob Creek—a South Holston Lake tributary on the CNF in Sullivan Co.(Figure 2-17)—in September 2000 by translocating 180 fish from Fagall Branch, Heaberlin Branch, and East Fork Beaverdam Creek (Habera et al. 2001b). All three source populations are Beaverdam Creek tributaries in the South Fork Holston River watershed. Brook Trout were released into the 970-m stream reach between 756 m and 817 m elevation (see Brook Trout introduction zone Figure 2-17) without removing the existing wild Rainbow Trout population in this area (2,735 fish/ha; 31 kg/ha). Successful Brook Trout reproduction was verified in August 2001 (22 age-0 fish collected) and again in August 2003. The 2003 survey produced 24 Brook Trout (including 12 age-0 fish) within the introduction zone, as well as six age-0 Brook Trout further downstream, thus Brook Trout were considered successfully established in Little Jacob Creek at that time (Habera et al. 2004).



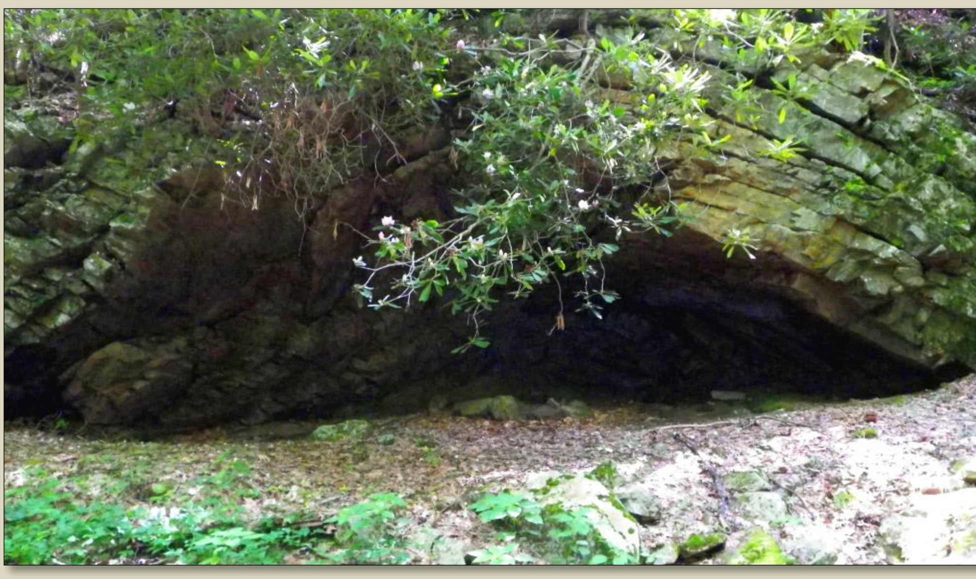
Rainbow Trout were removed from 1.6 km of Little Jacob Creek upstream of this series of cascades in 2016-2017.

Brook Trout were present throughout the introduction zone in November 2010, with 17 adults and 43 age-0 fish collected at five qualitative sample points. A cascade series (see photo) at 689 m (2,260') was also located in 2011 that could serve as a Rainbow Trout barrier and permit conversion of the 1.6-km reach upstream to allopatric native Brook Trout. Brook Trout distribution had gained ~260 m by July 2011, extending down to 730 m (2,390'), or just below the rock house (Figure 2-18). Total Brook Trout distribution in Little Jacob Creek in 2011 was 1.2 km, although most of it was shared with Rainbow Trout.

Extremely low stream flows in 2016 and 2017 provided an excellent opportunity to enhance the Little Jacob Creek Brook Trout population by extending it down to the cascade barrier and removing sympatric Rainbow Trout (by electrofishing) throughout the 1.6 km area upstream. About 400 Rainbow Trout were removed in 2016 and nearly 50 Brook Trout were also observed. Two separate removals were conducted in 2017 (June and October). No age-0 Rainbow Trout were found from the cascade through the introduction zone during the June effort, while 49 adult Rainbow Trout were removed from that area and 27 Brook Trout were observed. Additionally, 122 Rainbow Trout were removed from the 300-m reach extending from the cascade barrier down to the culvert at the USFS road (FR 4002) crossing. One Brook Trout was also captured in that area. Three electrofishing passes in October 2017 removed 33 adult and 4 age-0 Rainbow Trout from the culvert up to the cascade barrier. Only two adult Rainbow

Trout (no age-0) and 10 adult Brook Trout were found above the cascade barrier in a single electrofishing pass up to the cave.

This year's work suggests efforts to remove Rainbow Trout from the 1.6-km reach above the cascade and transition that area to an allopatric Brook Trout population were successful. Rainbow Trout reproduction there was eliminated following the 2016 effort and remaining adult Rainbow Trout were removed in 2017. However, Brook Trout abundance decreased in Little Jacob Creek in 2017, as it did in most other streams, likely as a result of the severe drought in 2016. Additional Brook Trout from the original source streams (Fagall Branch, Heaberlin Branch and East Fork Beaverdam Creek) should be collected in August or September (pre-spawn) and translocated to supplement the existing population, particularly in the lower section (cave to road crossing). An additional Rainbow Trout removal effort in reach between the road crossing and the cascade barrier will be made in 2018, followed by periodic monitoring to determine the effectiveness of the culvert as a barrier. Instream temperature loggers will also be deployed within the next five years to monitor water temperatures during the summer months.



The cave or "rockhouse" along Little Jacob Creek (elevation 735 m or 2,410').

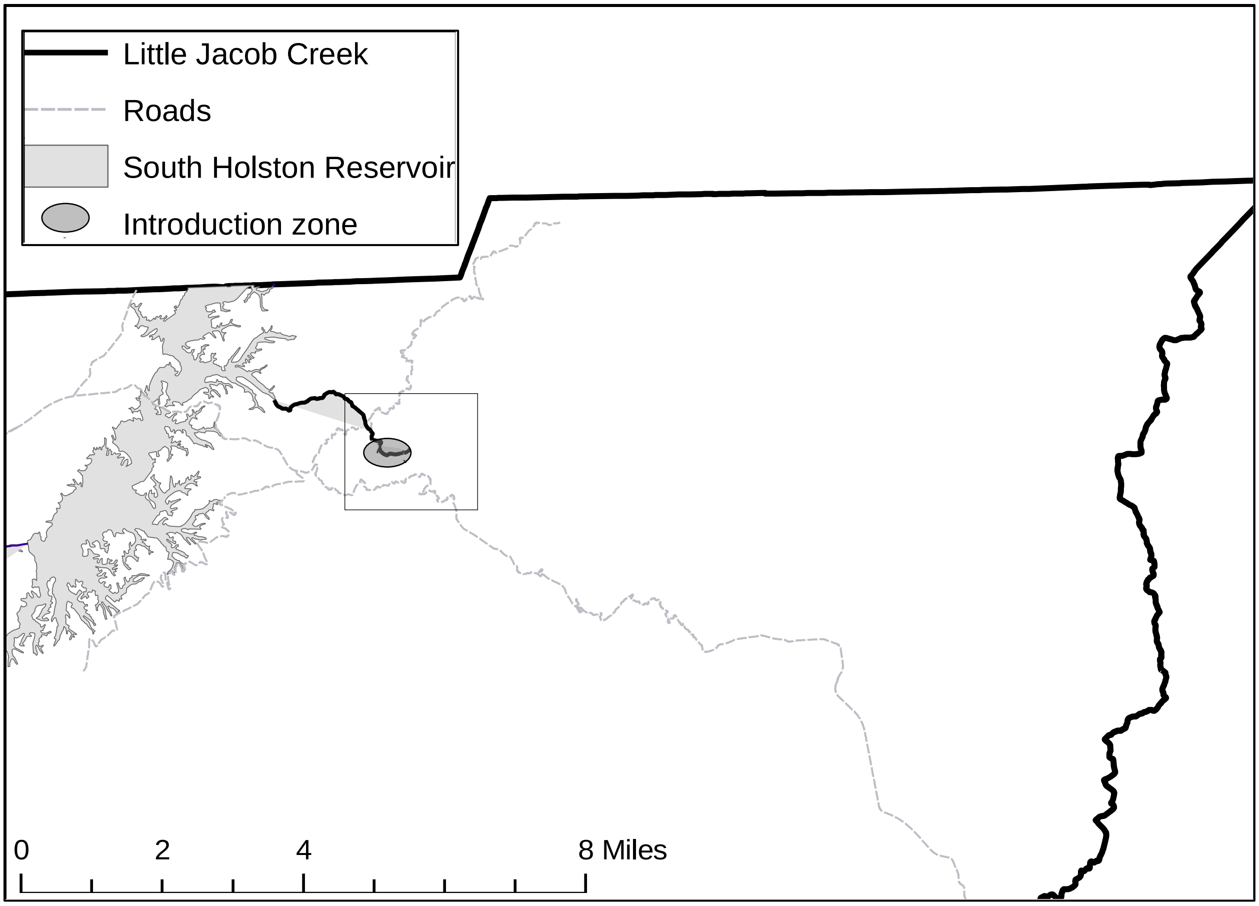



Figure 2-17. Map of Little Jacob Creek management area denoted by black rectangular box.

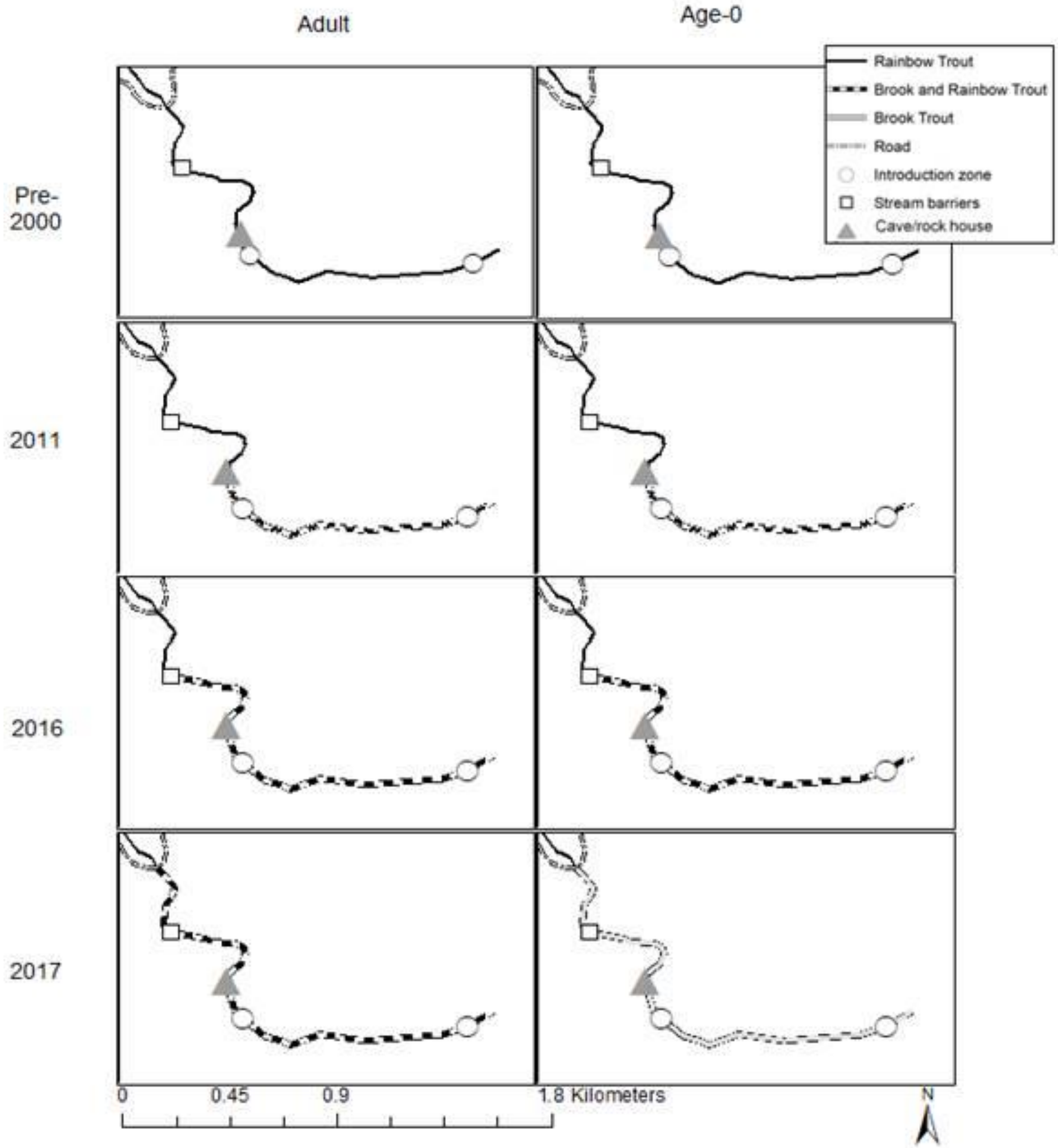



Figure 2-18. Distribution of Rainbow Trout (black line), Rainbow Trout and Brook Trout (dashed black and white line), and Brook Trout from pre-2000 to 2017 in Little Jacob Creek. Pre-2000 is before the Brook Trout were translocated into Little Jacob Creek. Stream (cascade) barrier is denoted by a white square. The cave or rock house, just below the introduction zone (stream area between white circles) is denoted by a gray triangle.

## 2.11 LITTLE STONY CREEK BROOK TROUT RESTORATION

A project was initiated during fall 2014 to restore native Brook Trout in Little Stony Creek (Habera et al. 2015a). Little Stony Creek is a tributary to Watauga Lake in Carter County (Figure 2.21). Its headwaters flow from Pond Mountain and Walnut Mountain in the Pond Mountain Wilderness Area. Except for small segments at its upper and lower ends, the entire stream is located within the CNF. Previous accounts of Little Stony Creek (Shields 1950; Tatum 1968) did not mention Brook Trout, although they would have occurred there historically.

The basic plan for this restoration project was to evaluate current Rainbow Trout abundance, remove Rainbow Trout through intensive backpack electrofishing, stock native Brook Trout from Left Prong Hampton Creek, then evaluate trout abundance and distribution. Additional Brook Trout translocation and Rainbow Trout removal will be conducted as necessary.

Two barriers on this stream are being used to facilitate the Brook Trout restoration project: an upper or cascade barrier at 841 m (2,760'; Figure 2-22) and lower waterfall barrier at 732 m (2,400'; Figure 2-22). Rainbow Trout were present from Watauga Lake to the upper (cascade) barrier in 2014; however, no trout were found above this barrier. The lower barrier was considered sufficient to prevent movement of trout upstream from the lake and back into the restoration area. The stream was divided into a lower zone (Zone 1, Figure 2-22) containing the 1.4-km of stream between the upper (cascade) and lower barriers (Rainbow Trout present as of 2014) and an upper zone (Zone 2) located above the upper cascade barrier (no trout were present in 2014). Zone 1 was further subdivided into three reaches (Figure 2-22): 1) a 1.0-km downstream reach extending from the lower barrier up to the road crossing (Little Stony Creek Road bridge); 2) a 0.4-km upstream reach extending from the road crossing to the upper barrier; and 3) a 0.35 km tributary reach consisting of Maple Springs Branch from its confluence with Little Stony Creek to a small cascade beyond the Little Stony Creek Road crossing. A fixed 150-m sample site was located in the downstream reach of Zone 1, 290 m upstream of the barrier to determine pre-restoration Rainbow Trout abundance and track establishment of the Brook Trout population.

Removal of Rainbow Trout from the upper portion of the Little Stony Creek Brook Tout restoration zone in 2015.

A three-pass depletion sample in September 2014 at the fixed site produced a Rainbow Trout biomass estimate of 23 kg/ha—similar to the 27 kg/ha estimate for a site ~800 m downstream of the lower barrier in 1993 (Strange and Habera 1994). Rainbow Trout were then removed by three electrofishing efforts (using two units) throughout Zone 1 during September and October 2014. Native Brook Trout propagated at the Tennessee Aquarium Conservation Institute (TNACI) from adults collected from Left Prong Hampton Creek were then stocked into Zones 1 and 2. About 350 Brook Trout (mostly fingerlings) were released into Zone 1 in October 2014, January 2015, and April 2015. Another 150 fingerlings were stocked in Zone 2 in April 2015

A native Brook Trout from the restored population in Little Stony Creek.

Brook Trout survival was evaluated in June 2015 and another Rainbow Trout removal effort was made. Only 27 Rainbow Trout (all sub-adults and adults) were captured in 2015, most of which (n = 19) were in the downstream reach, indicating the effectiveness of the 2014 removal efforts. Brook Trout survival was good in the upstream reach, as 64 Brook Trout of varying sizes were collected. Brook Trout (n = 10) also colonized the tributary reach for about 350 m (Figure 2-23) and two additional Rainbow Trout were removed there. A small cascade near the end of Brook Trout colonization may limit further upstream movement in this reach. In the future, some fish could be moved upstream of the small cascade to make additional habitat available. Only 32 Brook Trout were captured in the downstream reach, although the initial stocking density in this longer reach (1 km) was lower than the upper reach. Consequently, 80 surplus Brook Trout fingerlings produced at the TNACI were stocked in this reach in July 2015. No evaluation of Zone 2 was conducted in 2015, nor was there any evaluation of the entire project area in 2016.

Brook Trout survival, reproduction, and distribution were evaluated again in 2017 and remaining Rainbow Trout were removed from Zones 1 and 2 in July and October using single pass electrofishing. Only one adult Brook Trout was found in the fixed monitoring site in July, thus no abundance estimate sample was conducted. Rainbow Trout were found only in the downstream reach and, as in 2015, no age-0 Rainbow Trout were captured. Two electrofishing passes were made in the downstream reach, with 10 adult Rainbow Trout removed during the July effort and 5 removed in October. This indicates that Rainbow Trout removal from Zone 1 is essentially complete.

Overall, the number of Brook Trout collected in Zones 1 and 2 increased compared to the 2015 survey (Figure 2-19). However, Brook Trout density in the lower half of the downstream reach of Zone 1 remains low and only one fish was captured in the 450-m reach above the lower barrier. This may be due to original stocking densities or other factors, but additional Brook Trout from Left Prong Hampton Creek will be necessary to complete establishment of the population in the downstream reach, particularly the area downstream of the monitoring site.

An 870-m reach within Zone 2 (elevation 3170’ to 3090’) that extended upstream and downstream of the original stocking location was surveyed in October 2017. Both adult and age-0 Brook Trout were captured throughout this area, indicating successful reproduction and recruitment. Brook Trout distribution in Zone 2 should continue to expand through the remaining 0.7 km downstream until it connects with the population in Zone 1. No further stocking in Zone 2 is anticipated at this time.

Given the low density of the Brook Trout population in the lower portion of the Little Stony Creek restoration area, supplemental stocking will be necessary to complete the project in a timely manner. Therefore, about 25 pairs of adult Brook Trout were collected from Left Prong Hampton Creek in October 2017 to be spawned at TNACI. These fish and their progeny will be stocked in Little Stony Creek in 2018 to help establish a Brook Trout population in the current low-density reach. A check for any remaining Rainbow Trout in the lower half of the downstream reach of Zone 1 should also be made in 2018, followed by quantitative sampling at the monitoring site in 2019 and periodically thereafter. Instream temperature loggers might also be deployed within the next five years to monitor water temperatures, particularly during the summer months.

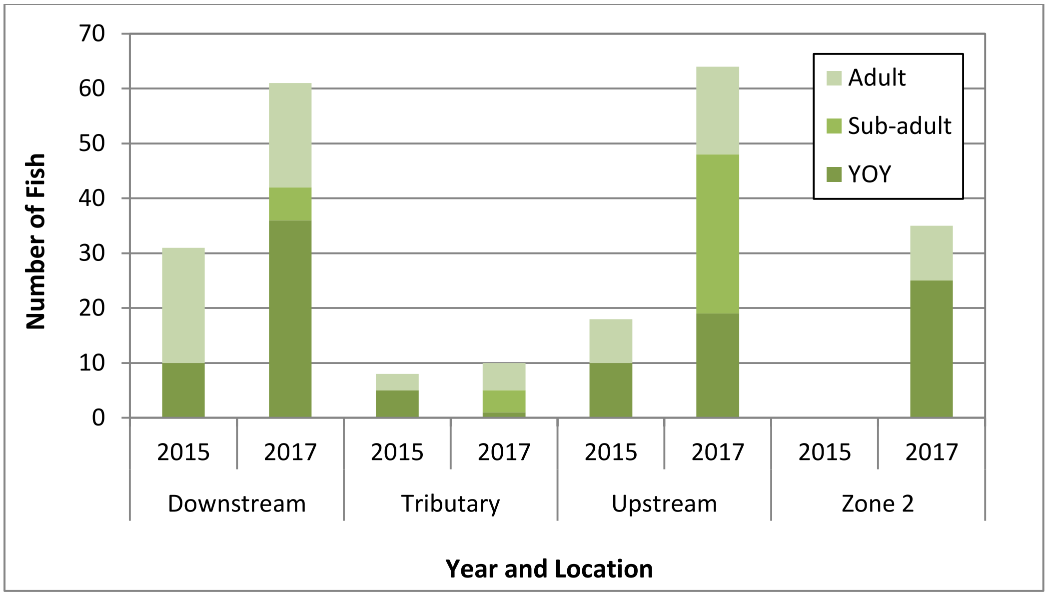



Figure 2-19. Number of Brook Trout caught at each location in 2015 and 2017.

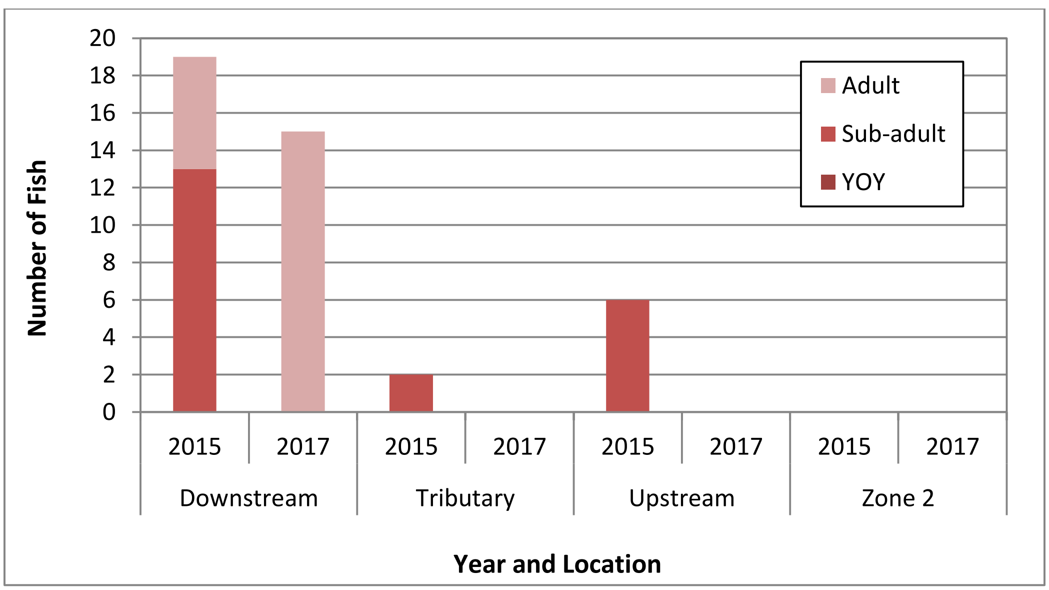



Figure 2-20. Number of Rainbow Trout caught at each location in 2015 and 2017.

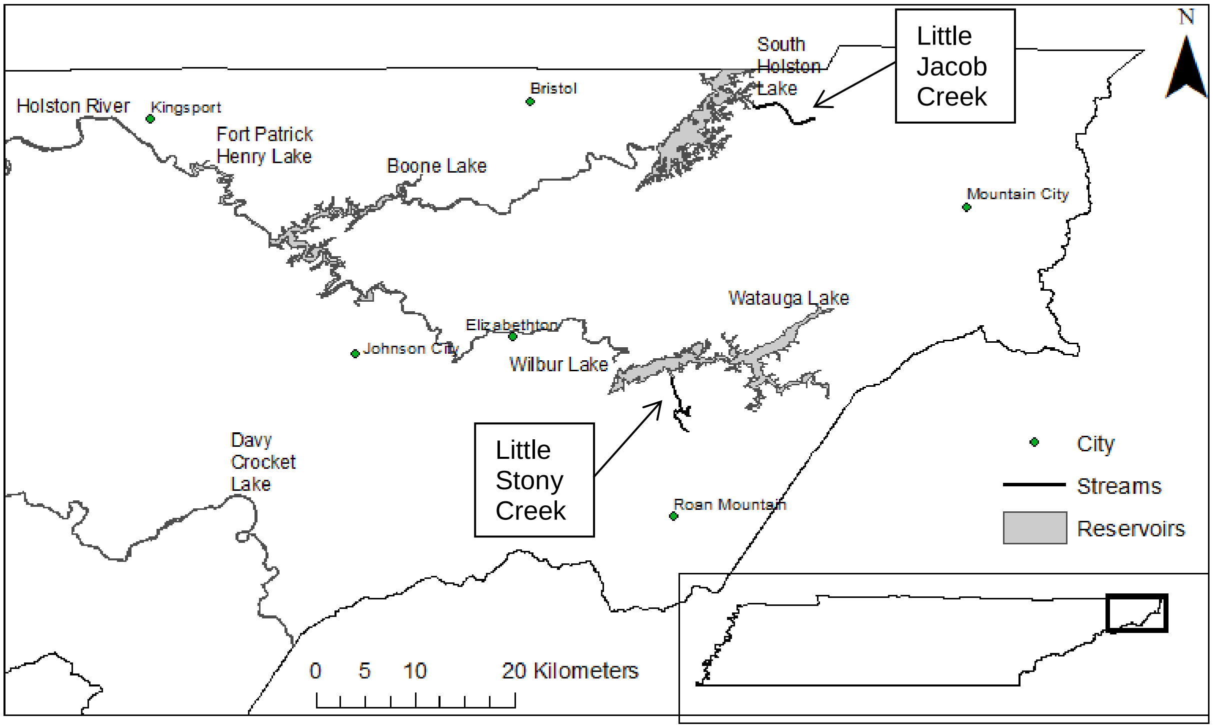



Figure 2-21. Location of Little Stony Creek in Eastern Tennessee.

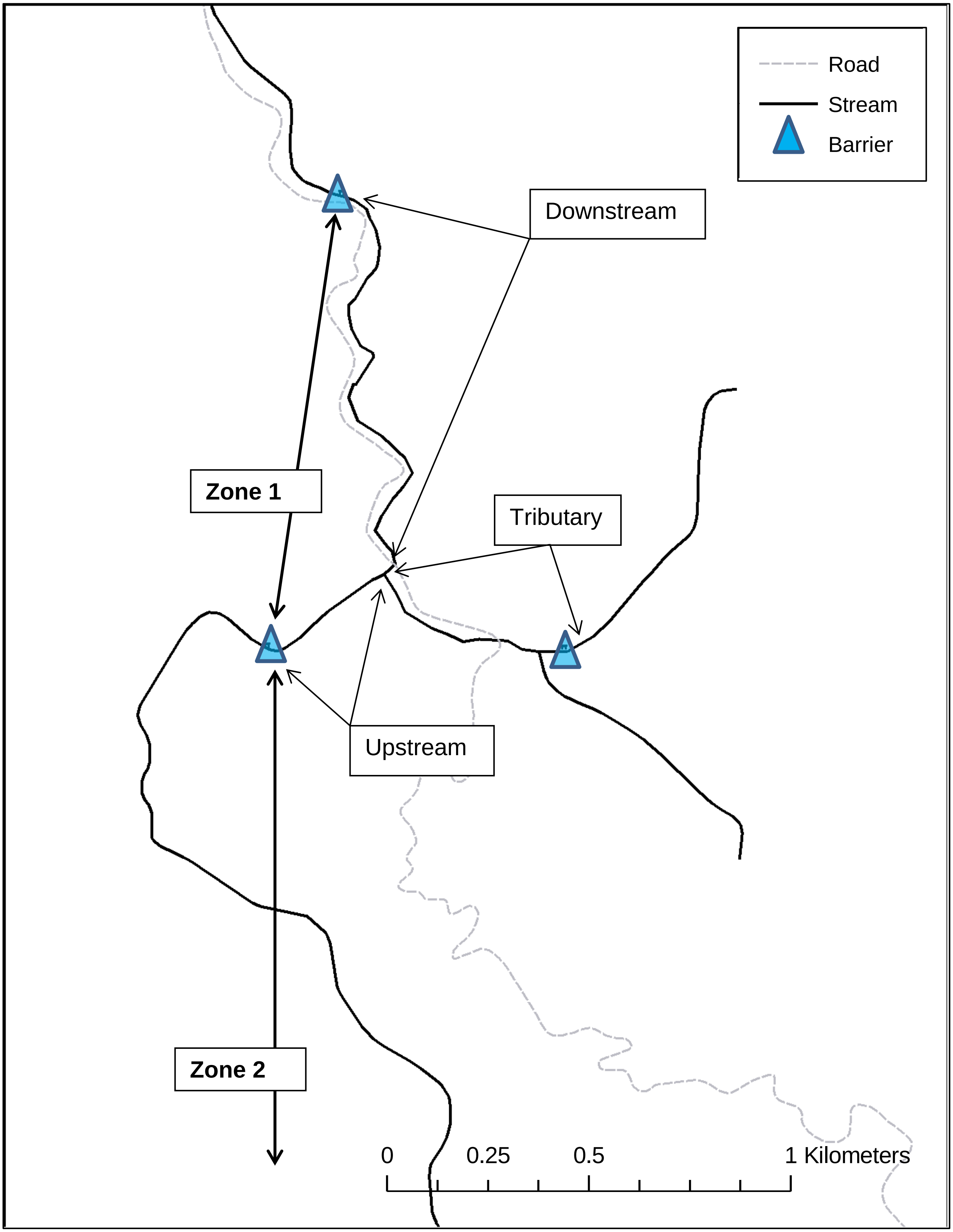



Figure 2-22. Location of the Brook Trout restoration zones on Little Stony Creek.

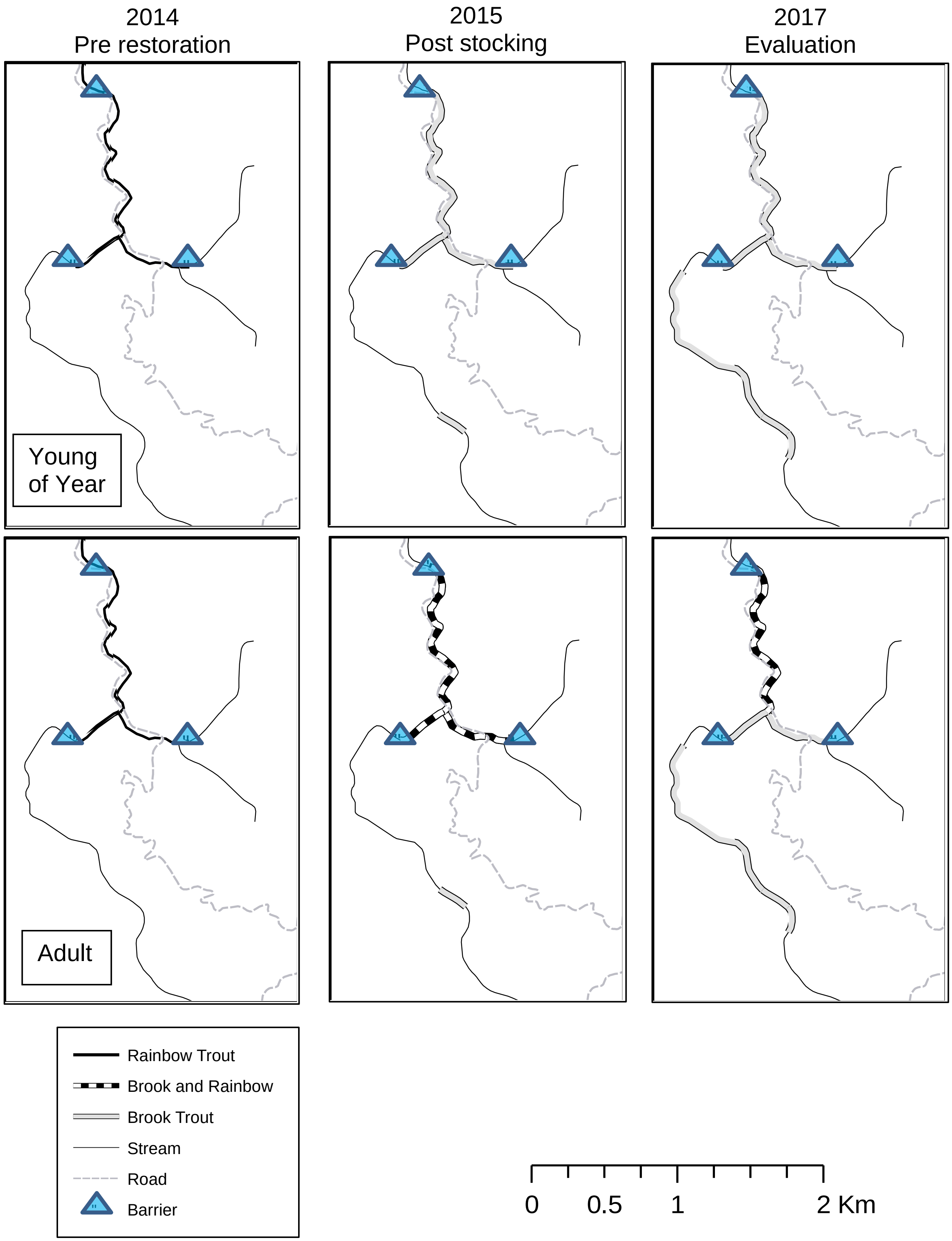



Figure 2-23. Distribution of adult and young of year Rainbow and Brook trout in 2014 (pre-restoration), 2015 (post-stocking of Brook Trout) and 2017 (evaluation).

# 3. TAILWATER ACCOUNTS

Region IV's tailwater trout fisheries present unique fishery management problems and opportunities for which no standard solutions or practices apply (Hill 1978). The problems inherent in sampling tailwaters, such as their large size, fluctuating flows, and the lack of any practical means for maintaining closed populations, make it difficult at best to collect quantitative data from these systems. Additionally, natural reproduction is typically insignificant, so most tailwater trout populations are also largely hatchery-supported, with abundances and size/age-class densities related to stocking rates. In two cases however (the South Holston and Wilbur tailwaters), natural reproduction is substantial, requiring a different set of management strategies. Annual tailwater monitoring in Region IV began in 1991 (Bivens et al. 1992), but the initial efforts (prior to 1999) provided limited information. Consequently, TWRA sponsored more intensive studies focusing on assessment of trout abundance, the fate of stocked fish, natural reproduction, movements, and angler use in the Norris, South Holston, and Wilbur tailwaters (e.g., Bettoli and Bohm 1997; Bettoli 1999; Bettoli et al. 1999; Bettinger and Bettoli 2000; Bettoli 2002; Bettoli 2003a; Bettoli 2003b; Hutt and Bettoli 2003; Meerbeek and Bettoli 2005; Bettoli 2006; Holbrook and Bettoli 2006; Bettoli 2007; Damer and Bettoli 2008).

## 3.1 SAMPLING METHODS AND CONDITIONS

Sampling effort for the Norris, Cherokee, South Holston, and Wilbur tailwaters annually consists of 600-s (pedal time) runs at each of 12 monitoring stations with boat-mounted electrofishing systems (120 pulses/s DC, 4-5 amps). The smaller Ft. Patrick Henry and Boone tailwaters are sampled using 900-s runs at 4 stations. Electrofishing on these tailwaters (except Norris) is conducted during the day with generation by one unit (turbine). Only trout are collected during these efforts. Tailwater sampling conditions and effort are summarized below:

Table 3-1. Tailwater sampling conditions and efforts.

| Tailwater | Year annual monitoring began | Sample time | Stations | Approximate flow | Total effort (h) |
|---|---|---|---|---|---|
| Norris | 1999 | Night | 12 | 114 $m^3$/s (4,000 cfs) | 2.0 |
| Cherokee | 2003 | Day | 12 | 114 $m^3$/s (4,000 cfs) | 2.0 |
| Ft. Patrick Henry | 2002 | Day | 4 | 88 $m^3$/s (3,100 cfs) | 1.0 |
| Wilbur | 1999 | Day | 13[1] | 71 $m^3$/s (2,500 cfs) | 2.0[2] |
| Boone | 2009 | Day | 4 | 88 $m^3$/s (3,100 cfs) | 1.0 |
| South Holston | 1999 | Day | 12 | 71 $m^3$/s (2,500 cfs) | 2.0 |

[1]An extra site was added in 2010 to help evaluate the Quality Zone.
[2]Does not include effort (600 s) at the additional QZ site.

## 3.2 TAILWATER MONITORING

Six Region IV tailwater trout fisheries (Norris, Cherokee, Wilbur, Ft. Patrick Henry, Boone, South Holston; Figure 1-1) are monitored annually. Updated management plans have been finalized for the Norris, Wilbur, and South Holston tailwaters (Habera et al. 2014b; 2015b; 2015c). Sampling is conducted each year in late February or March (except Cherokee) to provide an assessment of the overwintering trout populations present before stocking begins. The Cherokee tailwater (Holston River) stations are sampled in the fall (October), as trout survival over the summer is a more important issue for that fishery. Catch per unit effort (CPUE) for each species at each site (fish/h), as well as means for each tailwater, are calculated annually to monitor trout abundance trends.

### 3.2.1 Norris (Clinch River)

**Study Area**

The Clinch River originates in southwestern Virginia and enters Tennessee in Hancock County. Norris Dam impounds the Clinch River 197 km (122 mi) downstream in Anderson County, forming 13,846-ha (34,213-acre) Norris Reservoir. Hypolimnetic discharges created coldwater habitat and rainbow trout were stocked in the tailwater shortly after completion of the dam in 1936 (Tarzwell 1939). The Tennessee Game and Fish Commission stocked trout during 1950-1970 and managed the river as a year-round fishery (Swink 1983). Chronic low dissolved oxygen levels and a lack of minimum flow limited development of the trout fishery (Boles 1980; Yeager et al. 1987) and were addressed by TVA's Reservoir Release Improvements Program (TVA 1980). Dissolved oxygen concentrations were improved initially by fitting the turbines with a hub baffle system (Yeager et al. 1987). Later (1995 and 1996), both turbines were replaced with a more efficient autoventing system (Scott et al. 1996), which maintains dissolved oxygen around 6 mg/L. A minimum flow of 5.7 $m^3/s$ (200 CFS) was established in 1984 and has been maintained since then by a re-regulation weir located about 3.2 km (2 mi) downstream of the dam (Yeager et al. 1987). The weir was upgraded in 1995 to increase its holding capacity and improve public access (Bettoli and Bohm 1997).

Improvements in dissolved oxygen and minimum flows in the Norris tailwater increased the abundance and distribution of benthic invertebrates, as well as trout carrying capacity and trout condition (Yeager et al. 1987; Scott et al. 1996). The tailwater currently supports a popular 20-km (12.5-mi) fishery for Rainbow Trout, Brown Trout, and Brook Trout. Put-and-take and put-and-grow management is accomplished by annually stocking both fingerling and adult trout (Habera et al. 2014). Bettoli and Bohm (1997) documented a small amount of natural reproduction by rainbow trout, but recruitment to the tailwater fishery was considered to be minimal. Some of this natural reproduction may come from Clear Creek, which large rainbow trout enter to spawn each winter. Banks and Bettoli (2000) and Holbrook and Bettoli (2006) attributed the lack of Brown Trout reproduction in the Norris tailwater to poor or dewatered spawning substrate and unsuitable flows and water temperatures during spawning season. Some of these factors probably limit successful rainbow trout reproduction as well.

The first intensive study of the Norris tailwater trout fishery (1995-1997) produced an overwinter biomass estimate of 112 kg/ha composed of about 80% rainbow trout and 20% Brown Trout (Bettoli and Bohm 1997). Tennessee's only other tailwaters with higher trout biomass estimates at that time were South Holston and Wilbur (Bettoli 1999). Bettoli and Bohm (1997) also reported a relatively low return rate for stocked rainbow trout (19%) and very few Brown Trout were observed in the creel. Most adult (208-330 mm) rainbow trout cohorts stocked in the tailwater were found to be limited more by natural mortality than by angler harvest. Trout stocked as adults exhibited energetically inefficient behaviors (e.g., rapid, long-range movements) which led to poor creel-return rates and survival (Bettinger and Bettoli 2002). Consequently, the fishery is primarily supported by fingerling rainbow trout stocking (Bettoli and Bohm 1997; Bettinger and Bettoli 2000). High growth rates of fingerling-stocked rainbow trout (about 20 mm/month) allow the tailwater to produce quality-sized fish within a relatively short time (Bettoli and Bohm 1997). Growth of stocked Brown Trout is slower (12 mm/month; Meerbeek and Bettoli 2005).

The locations of TWRA's 12 monitoring stations on the Norris tailwater, sampled on 22 February 2017, are provided in Figure 3-1. Additional sample location and effort details are summarized in Table 3-1. Sampling at Station 12 was discontinued after 488 s because of extreme fog.

## Results and Discussion

The 2017 Norris tailwater sample produced 451 trout weighing nearly 165 kg (Table 3-2). The catch included 388 Rainbow Trout (86%) and 63 Brown Trout (14%); no Brook Trout were captured again in 2017, but none were available for stocking in 2015 and only 2,200 were stocked in 2016. Relative abundances of rainbow and Brown Trout by weight were 76% and 24%, respectively. Total catch and relative abundances of Rainbow Trout and Brown Trout (number and weight) were similar to corresponding values for 2016 (Habera et al. 2017), although mean weight decreased 17% for Rainbow Trout (to 323 g/fish) and 2% for Brown Trout (to 628 g/fish) relative to 2016.

Rainbow Trout ranged from 117-577 mm and Brown Trout ranged from 155-680 mm (Table 3-2). The atypical numbers of Rainbow Trout in the 102-mm and 127-mm size classes (Figure 3-2) were the result of stocking most of the 2017 fingerling allocation in November 2016 (133,000) because of deteriorating water quality conditions at Dale Hollow National Fish Hatchery. Over one-third (37%) of Rainbow Trout >178 mm were in the 356-508 mm (14-20 in.) protected length range or PLR (Figure 3-2). A smaller proportion of Brown Trout >178 mm (26%) was within the PLR, but nine Brown Trout >508 mm were also captured, along with two rainbows in this size range. These larger fish were primarily present at stations 7-12 (Table 3-2).

The 2017 mean electrofishing catch rates for all trout ≥178 mm (201 fish/h), as well as for Rainbow Trout (173 fish/h) and Brown Trout (31 fish/h) individually were almost unchanged from 2016 (Figure 3-3). The mean catch rate for Brown Trout ≥178 mm has relatively stable at 25-35 fish/h since 2012 (Figure 3-3). The mean electrofishing catch rate for trout within the PLR (356-508 mm) reached 80 fish/h in 2014-2016 and declined only slightly to 73 fish/h in 2017 (Figure 3-

3). The current Norris tailwater management plan (Habera et al. 2014b) maintains a mean PLR catch rate objective of 28 fish/h for 2014-2019 and is certainly being achieved. The increasing relative stock density of trout 356 mm (14 in.) and larger (RSD-14) indicates that trout population size structures have been shifted toward larger fish since 2010 (Figure 3-4), as CPUE for trout ≥178 mm has been relatively stable (150-200 fish/h) and annual stocking rates have been relatively consistent (see below). An RSD-14 value of 50 indicates that 50% of all stock-size trout—those at least 254 mm (10 in.) in length—are 356 mm (14 in.) or larger and would be double the pre-PLR average of 25.

Typically, Norris has the highest stocking rate of any Tennessee tailwater. It was stocked with 216,000 trout during calendar year 2017 (Figure 3-5). About 64% (139,000) of these were Rainbow Trout, most of which (100,000) were fingerlings. The remainder was Brown Trout (40,000; 19%) and Brook Trout (37,500; 17%). Because of deteriorating water quality conditions at Dale Hollow National Fish Hatchery in November 2016 (drought related), it was necessary to stock much of the 2017 fingerling Rainbow Trout allocation early. Consequently, the 2016 fingerling Rainbow Trout stocking rate substantially exceeded the rate prescribed in the Norris tailwater management plan (160,000; Habera et al. 2014b), thus the 2017 stocking rate was reduced (Figure 3-5). Recent Brook Trout shortages at Dale Hollow were such that none were stocked in Norris in 2015 and only 2,000 were stocked in 2016. Generally, though, stocking rates have been consistent since 2010 (Figure 3-5).

Roving creel surveys conducted by TWRA in 2013 (Black 2014) and 2015 (Black 2015) indicated that pressure, trips, and catch increased somewhat during that two-year period while harvest and mean trip length declined slightly:

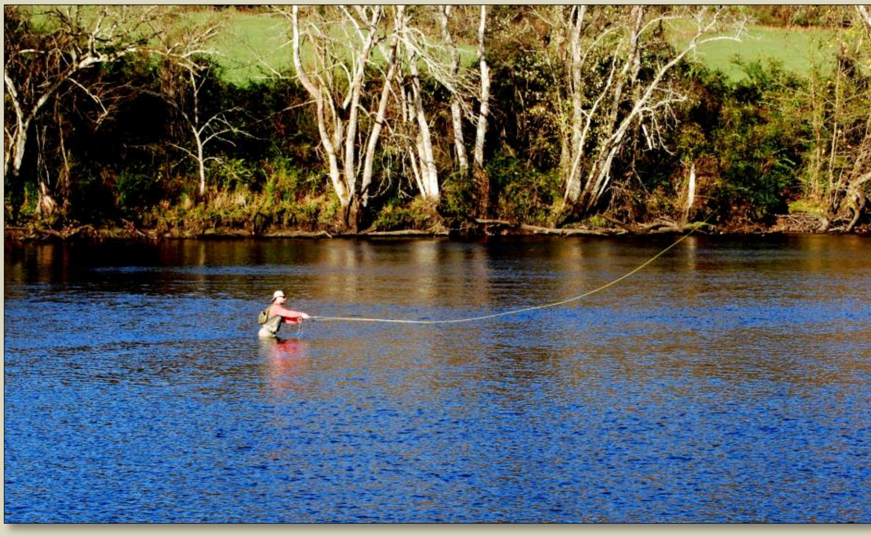
| Year | Pressure (h) | Mean Trip length (h) | Trips | Catch[a] | Harvest[a] |
|---|---|---|---|---|---|
| 2013 | 48,317 | 3.94 | 12,249 | 52,114 (56) | 11,946 (55) |
| 2015 | 56,427 | 3.25 | 17,348 | 65,098 (70) | 10,237 (73) |

[a]Values in parentheses are percentages represented by Rainbow Trout. Brook Trout were 19% of the catch and 15% of harvest in 2013, but only 1% of the catch and 0.1% of harvest in 2015.

The average trout catch rate was similar in 2013 (1.08 fish/h) and 2015 (1.15 fish/h), while average catch per trip decreased from just over to just under 4 fish. Catch rates over 0.7 fish/h are generally considered representative of good fishing (McMichael and Kaya 1991; Wiley et al. 1993). Average harvest was low in 2013 (0.98 fish/trip) and decreased to 0.60 fish/trip in 2015. Catch and harvest of Brook Trout declined significantly from 2013 to 2015, but none were available for stocking in 2015. Norris tailwater anglers overwhelmingly (76%) supported the PLR regulation and 85% rated TWRA's management of this fishery as good or excellent during the 2013 survey. A new angler survey was conducted on the Norris tailwater in 2017 and results will be available for inclusion in the 2018 report.

## Management Actions and Recommendations

TWRA's management goal for the Norris tailwater focuses on maintaining the quality trout fishery that has developed there since 2008 (Habera et al. 2014b). Accordingly, the primary strategy for attaining this goal is to maintain the abundance of quality-sized (≥356 mm or 14 in.) trout through the 356-508 mm (14-20 in.) protected length range (PLR or 'slot limit') regulation. Slot limits promote growth of smaller fish by reducing competition through angler harvest (Anderson 1976), which may be more easily accomplished in tailwater fisheries maintained by stocking (e.g., Norris), where 'year class strength' can be controlled. Slot limits have been shown to improve size structures of sport fish populations including Largemouth Bass *Micropterus salmoides* (Wilde 1997) and trout (Luecke et al. 1994; Power and Power 1996). Accordingly, the Norris tailwater PLR regulation has successfully improved (and maintained) trout population size structure, and anglers have recognized this by overwhelmingly expressing their support for the PLR (2013 survey). The status of the Norris tailwater trout fishery should be tracked through continued annual electrofishing surveys and periodic creel surveys.



Norris tailwater angler (photo by Paul Shaw, TWRA).

## Norris Tailwater

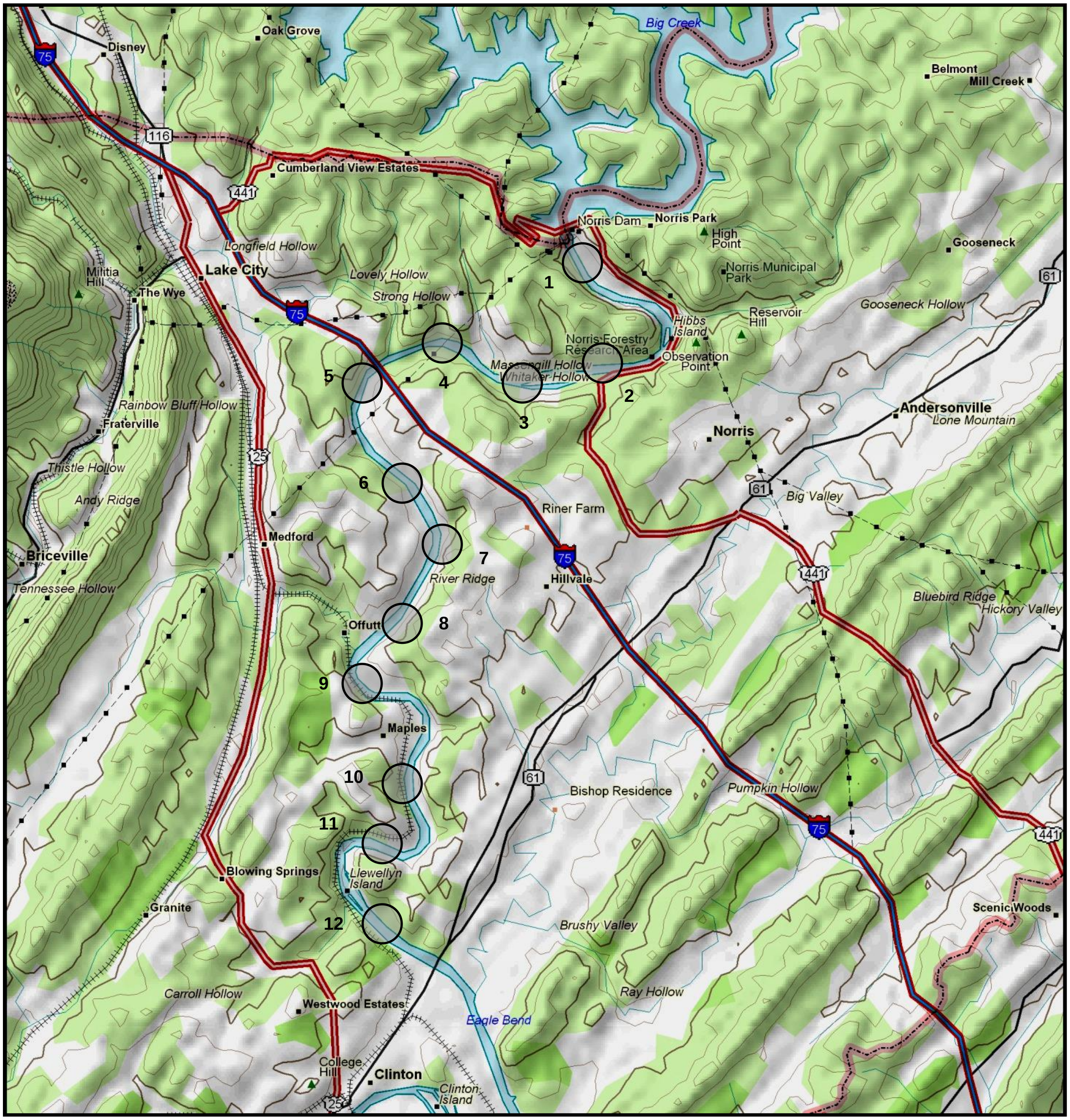



Figure 3-1. Locations of the Norris tailwater (Clinch River) monitoring stations.

Table 3-1. Location and sampling information for the 12 stations on the Norris tailwater, 22 February 2017.

| Station | Site Code | County | Quadrangle | Coordinates | Reach Number | River Mile | Effort (s) | Output |
|---|---|---|---|---|---|---|---|---|
| 1 | 420170101 | Anderson | Norris 137 NE | 36.22222N-84.09250W | 06010207-19,1 | 79.7 | 600 | 150 V DC<br>120 PPS, 4 A |
| 2 | 420170102 | Anderson | Norris 137 NE | 36.20466N-84.08651W | 06010207-19,1 | 77.2 | 600 | 530 V DC<br>120 PPS, 5 A |
| 3 | 420170103 | Anderson | Norris 137 NE | 36.20370N-84.10006W | 06010207-19,1 | 76.3 | 600 | 530 V DC<br>120 PPS, 5 A |
| 4 | 420170104 | Anderson | Norris 137 NE | 36.20654N-84.12265W | 06010207-19,1 | 75.6 | 600 | 530 V DC<br>120 PPS, 5 A |
| 5 | 420170105 | Anderson | Lake City 137 NW | 36.20433N-84.12580W | 06010207-19,0 | 74.4 | 600 | 530 V DC<br>120 PPS, 5 A |
| 6 | 420170106 | Anderson | Lake City 137 NW | 36.19722N-84.12778W | 06010207-19,0 | 74.1 | 600 | 150 V DC<br>120 PPS, 4 A |
| 7 | 420170107 | Anderson | Norris 137 NE | 36.18611N-84.11667W | 06010207-19,0 | 73 | 600 | 150 V DC<br>120 PPS, 5 A |
| 8 | 420170108 | Anderson | Norris 137 NE | 36.17500N-84.11806W | 06010207-19,0 | 72.2 | 600 | 150 V DC<br>120 PPS, 4 A |
| 9 | 420170109 | Anderson | Norris 137 NE | 36.16028N-84.12028W | 06010207-19,0 | 70.4 | 600 | 150 V DC<br>120 PPS, 4 A |
| 10 | 420170110 | Anderson | Norris 137 NE | 36.14681N-84.11853W | 06010207-19,0 | 69.5 | 600 | 530 V DC<br>120 PPS, 5 A |
| 11 | 420170111 | Anderson | Norris 137 NE | 36.14306N-84.11750W | 06010207-19,0 | 69.1 | 600 | 150 V DC<br>120 PPS, 4 A |
| 12 | 420160312 | Anderson | Lake City 137 NW | 36.13151N-84.12628W | 06010207-19,0 | 67.2 | 488 | 530 V DC<br>120 PPS, 5 A |

Table 3-2. Catch data for the12 electrofishing stations on the Norris tailwater sampled 22 February 2017.

| Station | Species | Total catch | Size range (mm) | Total weight (g) | % Abundance (number) | % Abundance (weight) |
|---|---|---|---|---|---|---|
| 1 | Rainbow | 6 | 190-440 | 2,314 | 35 | 29 |
| | Brown | 11 | 176-515 | 5,756 | 65 | 71 |
| **Totals** | | **17** | | **8,070** | **100** | **100** |
| 2 | Rainbow | 62 | 117-450 | 8,912 | 89 | 85 |
| | Brown | 8 | 155-300 | 1,579 | 11 | 15 |
| **Totals** | | **70** | | **10,491** | **100** | **100** |
| 3 | Rainbow | 59 | 130-443 | 16,932 | 76 | 73 |
| | Brown | 19 | 240-459 | 6,353 | 24 | 27 |
| **Totals** | | **78** | | **23,285** | **100** | **100** |
| 4 | Rainbow | 26 | 120-470 | 8,219 | 96 | 98 |
| | Brown | 1 | 250 | 172 | 4 | 2 |
| **Totals** | | **27** | | **8,391** | **100** | **100** |
| 5 | Rainbow | 37 | 168-477 | 14,767 | 97 | 91 |
| | Brown | 1 | 531 | 1,428 | 3 | 9 |
| **Totals** | | **38** | | **16,195** | **100** | **100** |
| 6 | Rainbow | 22 | 306-483 | 11,136 | 92 | 96 |
| | Brown | 2 | 227-333 | 466 | 8 | 4 |
| **Totals** | | **24** | | **11,602** | **100** | **100** |
| 7 | Rainbow | 29 | 153-577 | 12,812 | 83 | 59 |
| | Brown | 6 | 265-608 | 8,790 | 17 | 41 |
| **Totals** | | **35** | | **21,602** | **100** | **100** |
| 8 | Rainbow | 41 | 186-463 | 13,752 | 91 | 91 |
| | Brown | 4 | 229-410 | 1,340 | 9 | 9 |
| **Totals** | | **45** | | **15,092** | **100** | **100** |
| 9 | Rainbow | 25 | 240-515 | 11,030 | 89 | 68 |
| | Brown | 3 | 384-635 | 5,108 | 11 | 32 |
| **Totals** | | **28** | | **16,138** | **100** | **100** |
| 10 | Rainbow | 29 | 150-479 | 10,400 | 85 | 66 |
| | Brown | 5 | 278-680 | 5,288 | 15 | 34 |
| **Totals** | | **34** | | **15,688** | **100** | **100** |
| 11 | Rainbow | 23 | 191-445 | 6,294 | 100 | 100 |
| **Totals** | | **23** | | **6,294** | **100** | **100** |
| 12 | Rainbow | 29 | 150-424 | 8,659 | 91 | 73 |
| | Brown | 3 | 391-562 | 3,254 | 9 | 27 |
| **Totals**[1] | | **32** | | **11,913** | **100** | **100** |
| **Total Rainbow** | | 388 | 117-577 | 125,227 | 86 | 76 |
| **Total Brown** | | 63 | 155-680 | 39,534 | 14 | 24 |
| **Overall** | | **451** | | **164,761** | **100** | **100** |

[1]Sample at Station 12 was ended early (488 s) because of extreme fog.

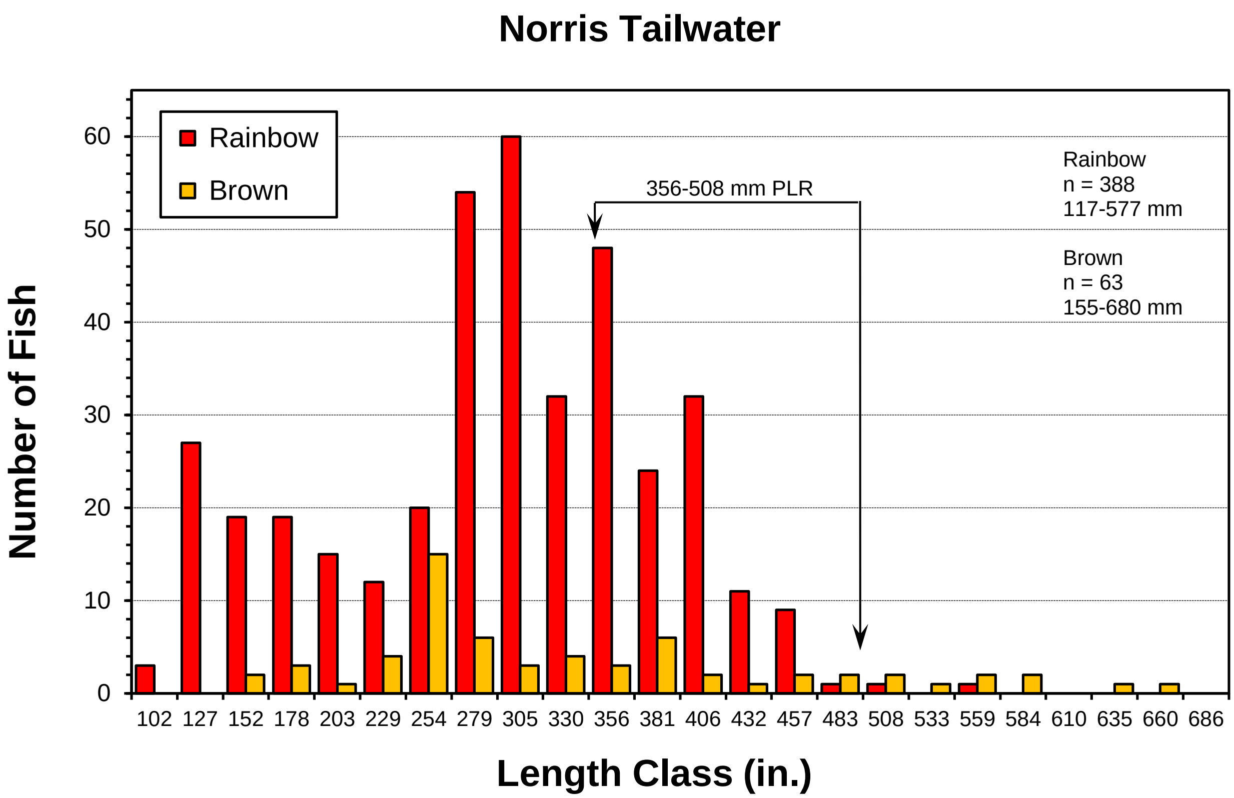
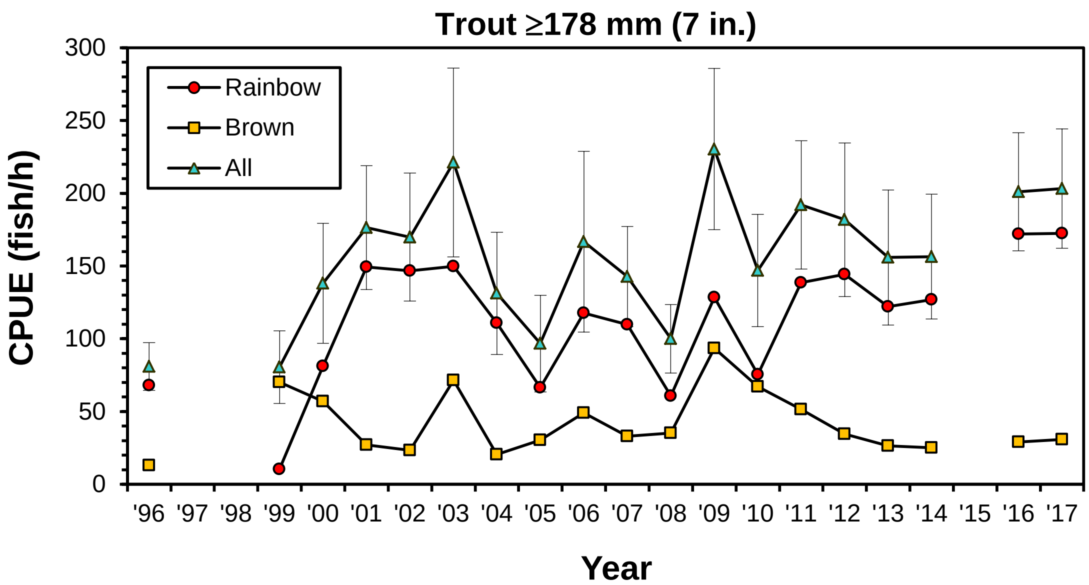



Figure 3-2. Length frequency distributions for trout from the Norris tailwater monitoring stations in 2017.

# Norris Tailwater



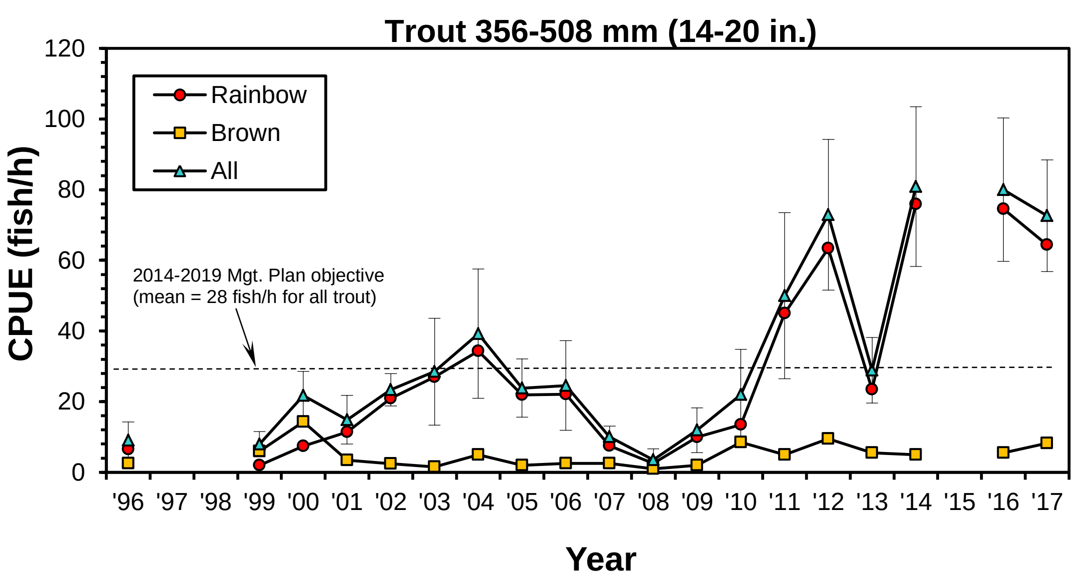




Figure 3-3. Mean trout CPUEs for the Norris tailwater samples. Bars indicate 90% confidence intervals. The 356-508 mm PLR regulation was established in 2008.

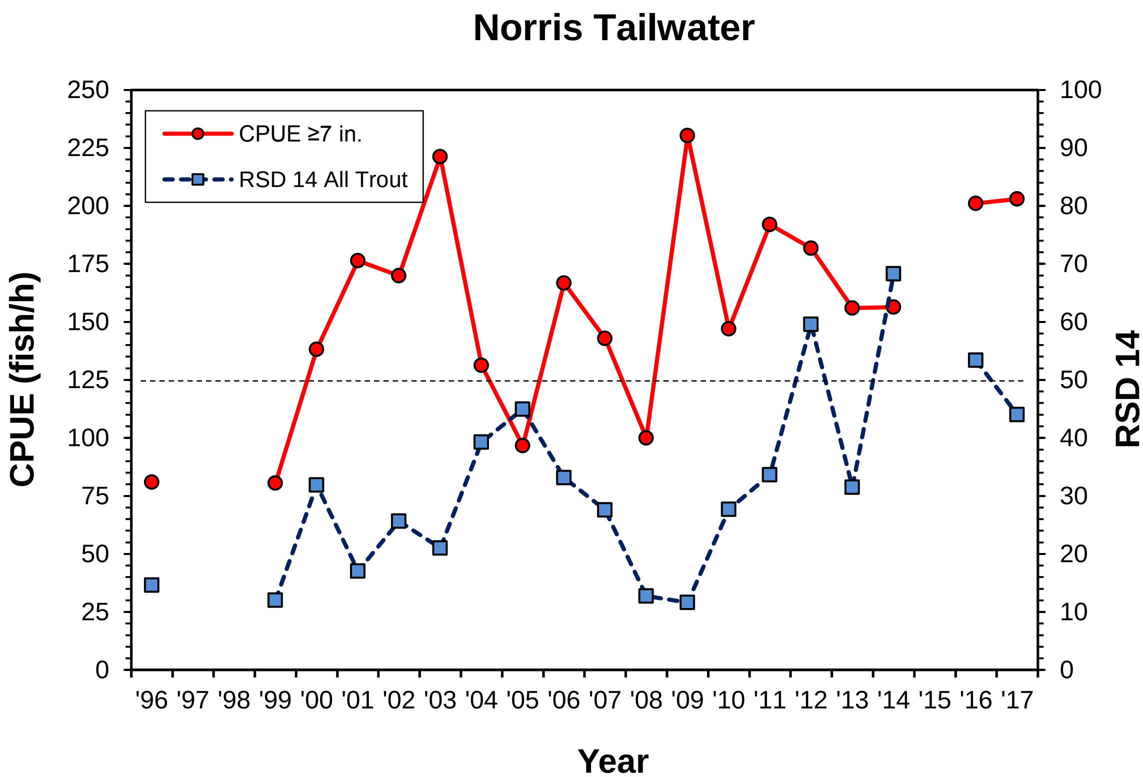



Figure 3-4. RSD-14 Norris tailwater trout compared with corresponding CPUE for fish ≥178 mm. Dashed line indicates an RSD-14 of 50—50% of all stock-size trout (≥254 mm or 10 in.) are ≥356 mm (14 in.).

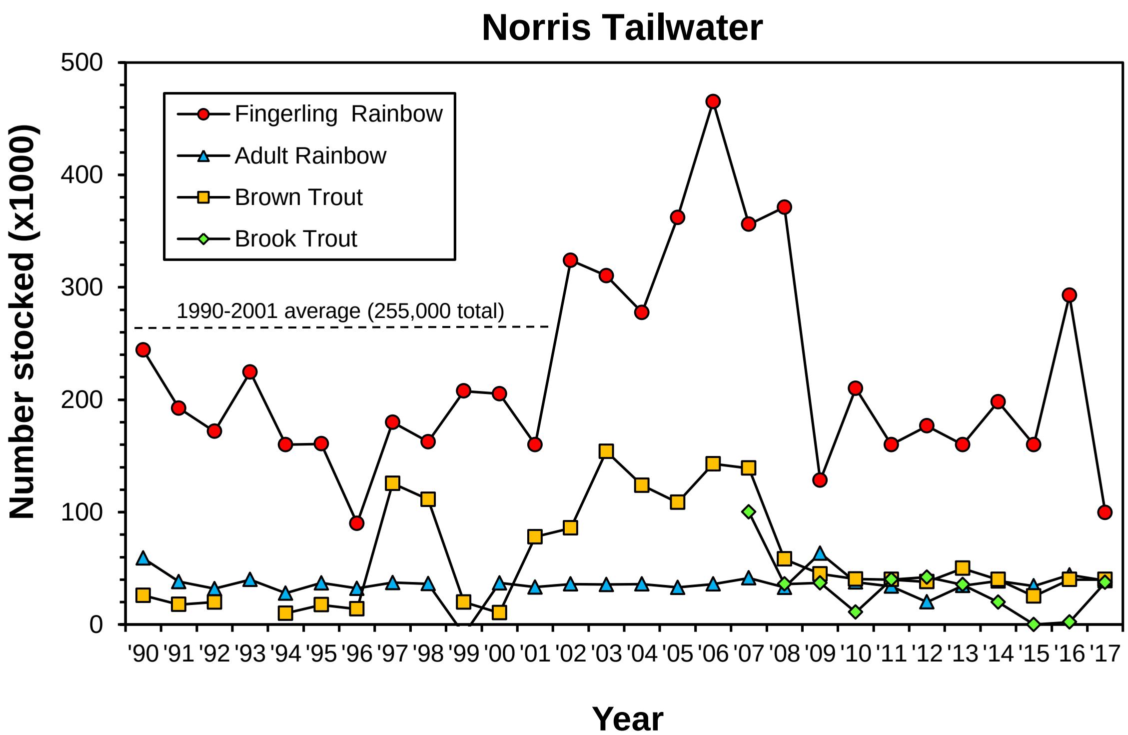



Figure 3-5. Recent trout stocking rates for the Norris tailwater. Current management plan stocking allocations are 160,000 fingerling Rainbow Trout, 37,000 adult Rainbow Trout, 20,000-40,000 Brown Trout, and 20,000 Brook Trout annually (~237,000 trout/year). Most of the 2017 fingerling Rainbow Trout allocation was stocked in November 2016 (133,000) because of deteriorating water quality conditions at Dale Hollow National Fish Hatchery. The 2017 stocking rate was reduced to 100,000.

3.2.2 Cherokee (Holston River)

**Study Area**

Cherokee Dam impounds 12,272-ha (30,300-acre) Cherokee Reservoir on the Holston River near Jefferson City. The dam is located about 83 km (52 mi.) upstream of the confluence of the Holston and French Broad rivers in Knoxville and the reservoir has an 8,879-$km^2$ (3,428-$mi.^2$) watershed. Historically, low dissolved oxygen (DO) levels (Higgins 1978) and the lack of a minimum flow in the Cherokee tailwater impacted its aquatic communities. TVA established a minimum flow of 9.2 $m^3/s$ (325 cfs) in 1988 as part of its release improvements program, then began to address low DO levels in 1995 (Scott et al. 1996). Dissolved oxygen levels in the tailwater were improved by installation of a liquid oxygen injection system in the forebay area of the reservoir and through turbine venting aided with hub baffles (Scott et al. 1996). These improvements have helped TVA meet the DO target of 4.0 mg/L in the tailwater and as a result, fish and macroinvertebrate communities have substantially improved.

Cherokee tailwater.

Seasonal temperature regimes, in addition to water quality and quantity problems, were an impediment to fisheries management in the Cherokee tailwater for many years (Hill and Brown 1980). Pfitzer (1962) characterized temperatures as being too cold for warmwater fishes in the spring and too warm for trout in the summer. However, it was generally regarded as supporting a warmwater fish community (Scott et al. 1996; Hill and Brown 1980). TWRA stocked trout infrequently, releasing 39,000 Rainbow, Brown, and Brook Trout (fingerlings and adults) during 1951-1955, and 16,000 Brown Trout in 1974. All of these efforts likely had limited success as they took place prior to TVA's water quality improvements. Trout stocking became more consistent after 1995 and stocking rates were increased as water quality improved.

The upper 30 km (18.8 mi.) of the Cherokee tailwater, from the dam downstream to the vicinity of Nance Ferry, is now being managed as a put-and-take and put-and-grow trout fishery. It has become popular among area anglers and has drawn some pressure away from other Region IV tailwaters (particularly the Clinch River). Because of the warmer water and abundant food supply (particularly caddis flies), trout grow extremely well, providing the potential for a quality fishery. However, late summer temperatures can exceed and remain above 21° C (70° F) for weeks, creating a thermal 'bottleneck' that severely limits trout survival (i.e., carryover). Along with the relative scarcity of trout in October electrofishing surveys, the abundance of warmwater species (e.g., Buffalo *Ictiobus* sp., Gizzard Shad *Dorosoma cepedianum*, and Channel Catfish *Ictalurus punctatus)* indicate that the Cherokee tailwater provides marginal trout habitat during summer and early fall.

The 12 electrofishing monitoring stations on the Cherokee tailwater (Figure 3-6) were sampled again in October 2017 to evaluate the trout fishery following the elevated temperatures of late summer and early fall. Sample site locations and effort details are summarized in Table 3-3. Temperature data were also collected (measured hourly by Onset TidbiT® *v2* loggers) near Cherokee Dam and at Blue Spring during June-November 2017.

**Results and Discussion**

The 12 Cherokee tailwater electrofishing stations produced 22 trout (15 Rainbow Trout, 7 Brown Trout) from six stations in 2017 (Table 3-4). The overall mean catch rate for all trout ≥178 mm (11.0 fish/h; Figure 3-7) improved from 2016 and exceeded the long-term (2003-2017) average of 8.3 fish/h. The mean catch rates for trout ≥356 mm (9.5 fish/h) and ≥457 mm (2.0 fish/h) also increased relative to 2016 (Figure 3-7). The 2016 catch rates were substantially depressed because of the exceptionally warm water temperatures in the tailwater (Habera et al. 2017). Most Rainbow Trout (70%) collected during monitoring efforts in the Cherokee tailwater have been in the 330-406 mm (13-16 in.) size classes (including the 2017 sample), while most Brown Trout (70%) have been in the 229-279 mm (9-11 in.) range (Figure 3-8). It is evident that some trout of both species survive the September/October thermal bottleneck at least once, given the presence of fish >457 mm (18 in.) in most years (Figures 3-7 and 3-8).

Water temperatures near Cherokee Dam were exceptionally warm again in 2017—only exceed by those recorded in 2013 and 2016. Maximum daily water temperature reached 21° C on 7 August—18 days earlier than in 2016 and earlier than in any preceding year except 2013 (25 July). Maximum daily temperature remained above 21° C for 78 consecutive days (through 26 October; Figure 3-9), which again was more than any preceding year except 2013 (79). On average, (2005-2017), mean maximum temperature at this site reached 21° C on 26 August and remained above 21° C for 57 days (through mid-October; Figure 3-9). Although the daily maximum temperature often exceeded 25° C and occasionally reached 26° C in 2016, it reached 24° C only three times in 2017. Minimum water temperature reached 21° C on 24 August and exceeded 21° C for 50 of the next 55 days (Figure 3-9), thus there was no coldwater habitat during that period—longer than in any preceding year except 2016. During 2005-2017, minimum temperature exceeded 21° C an average of 23 days each year. Mean minimum temperature for the 13-year period reached or closely approached 21° C during a 19-day period (19 September through 7 October; Figure 3-9).

Maximum daily water temperature at the Blue Spring site (13 km below Cherokee Dam) reached 21° C on 17 June—earlier than in any year since monitoring began (2003) and over two months earlier than in 2016 (23 August). It often exceeded 21° C during 17 June through 4 August, then subsequently remained above 21° C for 81 consecutive days (through 24 October;

Figure 3-10). The 101 days that maximum daily temperature >21° C in 2017 exceeded the total for any previous monitoring year. Although maximum daily temperatures above 24° C (40 days) and 25° C (20 days) were relatively common in 2016, 24° C was exceeded on only 10 days in 2017. Overall (2003-2017), maximum daily temperature at this site reached 21° C on 16 August and remained above 21° C for 67 days (through 21 October; Figure 3-10). Minimum water temperature reached 21° C on 18 August in 2017—12 days earlier than in 2016—and remained above 21° C for 51 of the next 58 consecutive days (through October 15; Figure 3-10), thus there was essentially no coldwater habitat during that period. While minimum daily temperature exceeded 22° C on 42 days in 2016, this occurred on only 11 days in 2017. Overall (2003-2017), the Blue Spring area typically has no coldwater habitat (daily minimum water temperature is >21° C) during September and the first week of October (Figure 3-10). Water temperatures in the Cherokee tailwater typically return to trout-tolerant levels (<21° C) by mid- to late October (28 October in 2017; Figures 3-9 and 3-10).

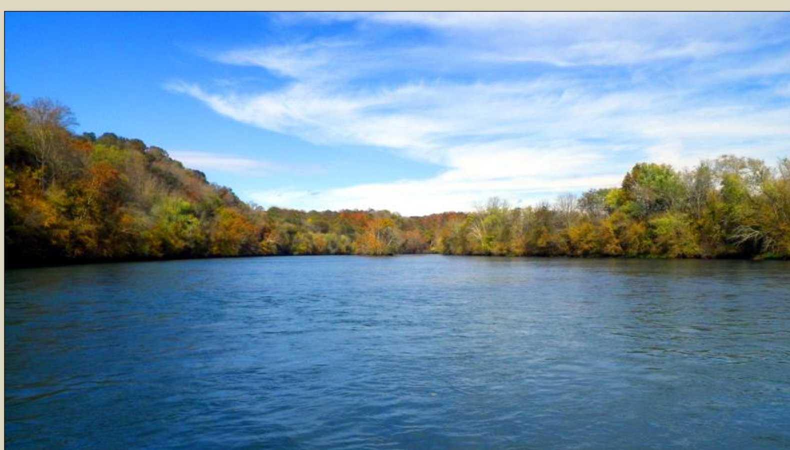
The Cherokee tailwater received 17,000 adult Rainbow Trout and 35,000 Brown Trout in 2017 (Figure 3-11). Stocking rates have averaged 18,000 adult Rainbow Trout and 28,000 Brown Trout (159-214 mm) annually during the past three years. Although Rainbow Trout stocking rates have been lower during 2015-2016 (Figure 3-11), electrofishing catch rates appear to be generally correlated with water temperature, which in turn is related to variability in flow from Cherokee Dam during June-October. Above average precipitation in some years (e.g., 2003, 2013, and 2017) results in higher average flows from Cherokee Dam, earlier depletion of cold water stored in the reservoir, and unsuitably warm tailwater temperatures for long periods of time. The reverse is true during dry years such as 2007 and 2008. Consequently, there is a relatively strong ($R^2$ = 0.66) inverse relationship ($2^{nd}$ order polynomial) between the number of days where minimum water temperature was ≥22° C at the Blue Spring site and the electrofishing catch rate ($\log_{10}$-transformed +1; Figure 3-12). In turn, there is also a relatively strong ($R^2$ = 0.52) positive relationship ($2^{nd}$ order polynomial) between higher water temperatures (expressed as the number of days where the minimum was ≥21° C at Blue Spring) and higher mean flow for March – August (Figure 3-13). There may also be a relationship (e.g., in 2016) where extended periods of low flows and high air temperatures in late summer combine to raise water temperatures to levels that impact trout survival.

## Management Recommendations

Trout in the Cherokee tailwater are subject to, on average, about a month (typically September) each year without coldwater habitat: minimum temperatures exceed 21° C and maximums often reach 24-25° C. Consequently, most survive less than a year, even with a relatively low harvest rate (Habera et al. 2015). However, some trout that are able to find thermal refugia such as groundwater upwellings or cooler tributaries (Baird and Krueger 2003) can survive through at least one summer/early fall—evident by the large (≥457 mm) fish that are captured in most years (Figure 3-8). Current stocking policy excludes the use of fingerling rainbows because of their low recruitment potential and avoids July-October because of high water temperatures (>21° C) during those months.

Despite limited trout carry-over caused by extended periods with water temperatures exceeding 21° C, the Cherokee tailwater is well worth managing as a trout fishery. Even with the summer/fall thermal bottleneck, trout angling opportunities are available during most months. The thermal regime and benthic community of the Cherokee tailwater make it more like a natural trout stream than other Tennessee tailwaters. The abundance of trichopterans (particularly *Cheumatopsyche* spp.; Habera et al. 2004) undoubtedly enhances trout growth and prolific mayfly and caddis hatches during the spring provide excellent flyfishing opportunities. Cherokee tailwater trout anglers caught an estimated 0.63 fish/h and 2.89 fish/trip in 2014 (88% Rainbow Trout), while harvesting 0.27 fish/h and 1.21 fish/trip (Black 2015).

Current angling regulations (i.e., general statewide for trout) are appropriate for maintaining this fishery. A majority of Cherokee tailwater anglers (72%) rated TWRA's management of this fishery as good or excellent during the 2014 survey (Habera et al. 2016). Anglers occasionally request special regulations (minimum size or slot limits), but they would be of little value as few fish protected by such measures would survive the summer thermal bottleneck. The 12 existing monitoring stations should be sampled annually to further develop the trout fishery database and annual water temperature monitoring (summer and fall) should also be continued to provide additional understanding of the relationship among temperature, flow, and trout abundance. These basic recommendations, along with stocking rate annual stocking rates, will be incorporated into a management plan for this tailwater (in preparation during 2018) to ensure its potential as a trout fishery is maximized.



Cherokee tailwater.

## Cherokee Tailwater

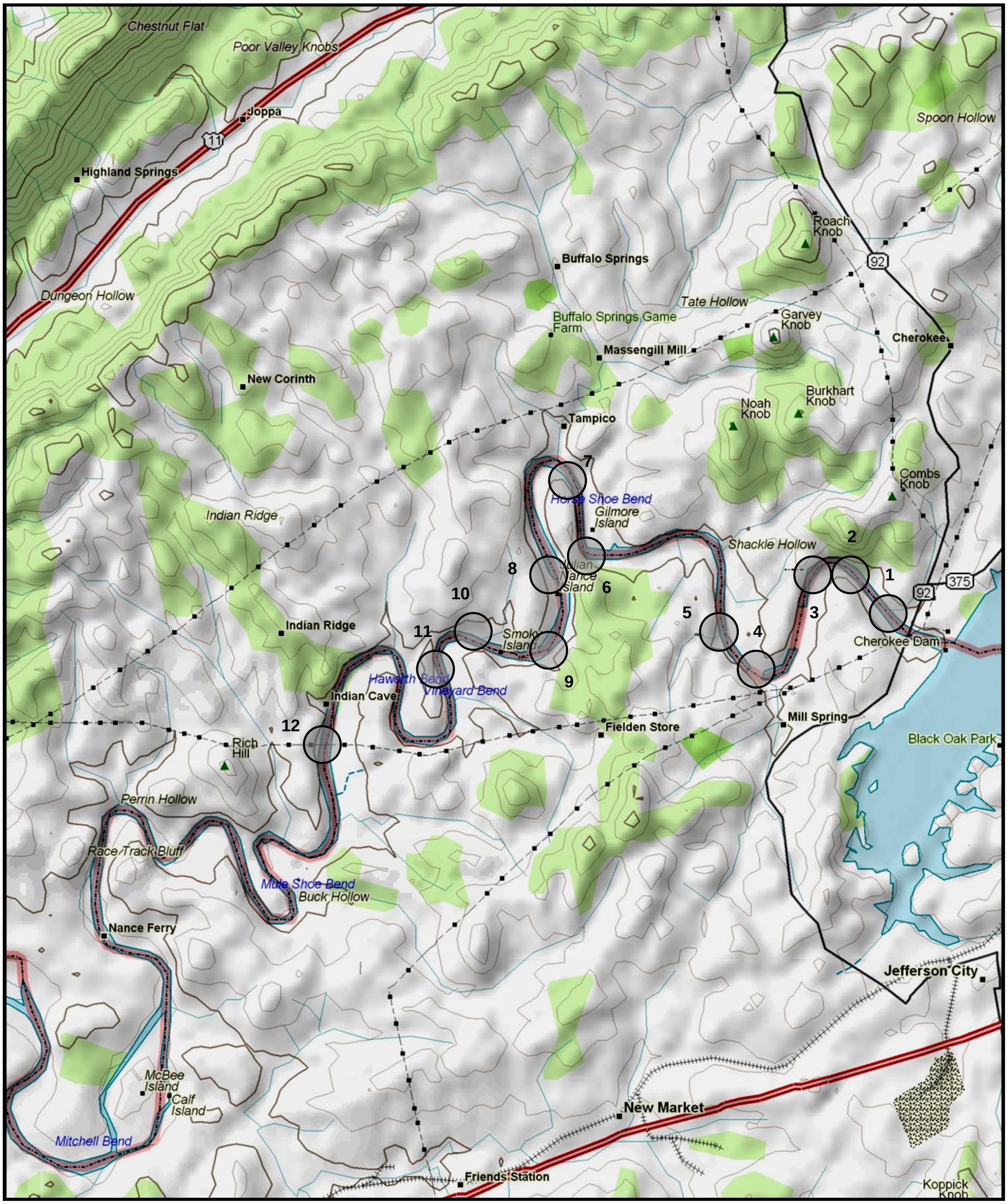



Figure 3-6. Locations of the Cherokee tailwater (Holston River) monitoring stations.

Table 3-3 Location and sampling information for the 12 stations on the Cherokee tailwater, 24 October 2017.

| Station | Site Code | County | Quadrangle | Coordinates | Reach Number | River Mile | Effort (s) | Output |
|---|---|---|---|---|---|---|---|---|
| 1 | 420173201 | Grainger / Jefferson | Joppa 155 NE | 36.16864N-83.50461W | 06010104-3,4 | 51.8 | 600 | 530 V DC 120 PPS, 5-6 A |
| 2 | 420173202 | Grainger | Joppa 155 NE | 36.17589N-83.51183W | 06010104-3,4 | 51.2 | 600 | 175 V DC 120 PPS, 4-6 A |
| 3 | 420173203 | Grainger | Joppa 155 NE | 36.17858N-83.51667W | 06010104-3,4 | 50.9 | 600 | 530 V DC 120 PPS, 5-6 A |
| 4 | 420173204 | Grainger / Jefferson | Joppa 155 NE | 36.16244N-83.52933W | 06010104-3,4 | 49.5 | 600 | 175 V DC 120 PPS, 4-6 A |
| 5 | 420173205 | Jefferson | Joppa 155 NE | 36.16767N-83.53564W | 06010104-3,4 | 49.0 | 600 | 530 V DC 120 PPS, 5-6 A |
| 6 | 420173206 | Grainger / Jefferson | Joppa 155 NE | 36.17978N-83.55542W | 06010104-3,4 | 47.0 | 600 | 175 V DC 120 PPS, 4-6 A |
| 7 | 420173207 | Jefferson | Joppa 155 NE | 36.18825N-83.56036W | 06010104-3,4 | 46.2 | 600 | 530 V DC 120 PPS, 5-6 A |
| 8 | 420173208 | Jefferson | Joppa 155 NE | 36.17658N-83.56161W | 06010104-3,4 | 44.7 | 600 | 175 V DC 120 PPS, 4-6 A |
| 9 | 420173209 | Jefferson | Joppa 155 NE | 36.16733N-83.56281W | 06010104-3,4 | 44.0 | 600 | 530 V DC 120 PPS, 5-6 A |
| 10 | 420173210 | Grainger / Jefferson | Joppa 155 NE | 36.16633N-83.57314W | 06010104-3,4 | 43.5 | 600 | 175 V DC 120 PPS, 4-6 A |
| 11 | 420173211 | Grainger | Joppa 155 NE | 36.16458N-83.58286W | 06010104-3,4 | 42.7 | 600 | 530 V DC 120 PPS, 5-6 A |
| 12 | 420173212 | Grainger | Joppa 155 NE | 36.15339N-83.60217W | 06010104-3,4 | 39.5 | 600 | 175 V DC 120 PPS, 4-6 A |

Table 3-4. Catch data for the12 electrofishing stations on the Cherokee tailwater sampled 24 October 2017.

| Station | Species | Total Catch | Size Range (mm) | Total weight (g) | % Abundance (number) | % Abundance (weight) |
|---|---|---|---|---|---|---|
| 1 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **0** | | **0** | **0** | **0** |
| 2 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 0 | 273-530 | 0 | 0 | 0 |
| **Totals** | | **0** | | **0** | **0** | **0** |
| 3 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 2 | -- | 1,874 | 100 | 100 |
| **Totals** | | **2** | | **1,874** | **100** | **100** |
| 4 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 1 | 403 | 585 | 100 | 100 |
| **Totals** | | **1** | | **585** | **100** | **100** |
| 5 | Rainbow | 2 | 380-415 | 1,214 | 100 | 100 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **2** | | **1,214** | **100** | **100** |
| 6 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **0** | | **0** | **0** | **0** |
| 7 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **0** | | **0** | **0** | **0** |
| 8 | Rainbow | 2 | 362-424 | 1,250 | 100 | 100 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **2** | | **1,250** | **100** | **100** |
| 9 | Rainbow | 4 | 376-405 | 2,451 | 57 | 36 |
| | Brown | 3 | 325-585 | 4,355 | 43 | 64 |
| **Totals** | | **7** | | **6,806** | **100** | **100** |
| 10 | Rainbow | 4 | 387-478 | 3,106 | 100 | 100 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **4** | | **3,106** | **100** | **100** |
| 11 | Rainbow | 1 | 392 | 563 | 50 | 62 |
| | Brown | 1 | 328 | 345 | 50 | 38 |
| **Totals** | | **2** | | **908** | **100** | **100** |
| 12 | Rainbow | 2 | 406-409 | 1,255 | 100 | 100 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **2** | | **1,255** | **100** | **100** |
| **Total Rainbow** | | 15 | 362-478 | 9,839 | 68 | 58 |
| **Total Brown** | | 7 | 273-585 | 7,159 | 32 | 42 |
| **Overall** | | **22** | | **16,998** | **100** | **100** |

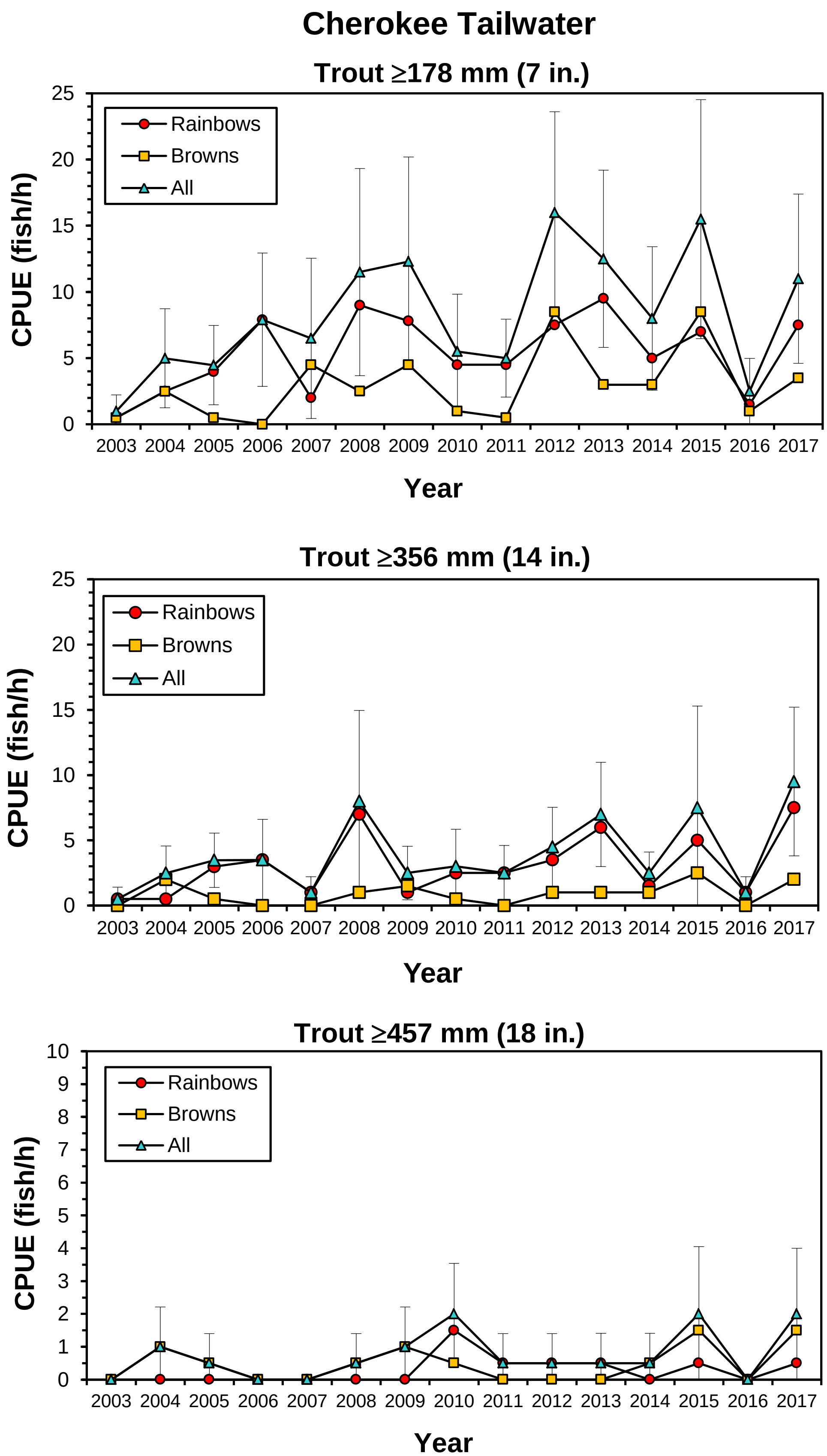
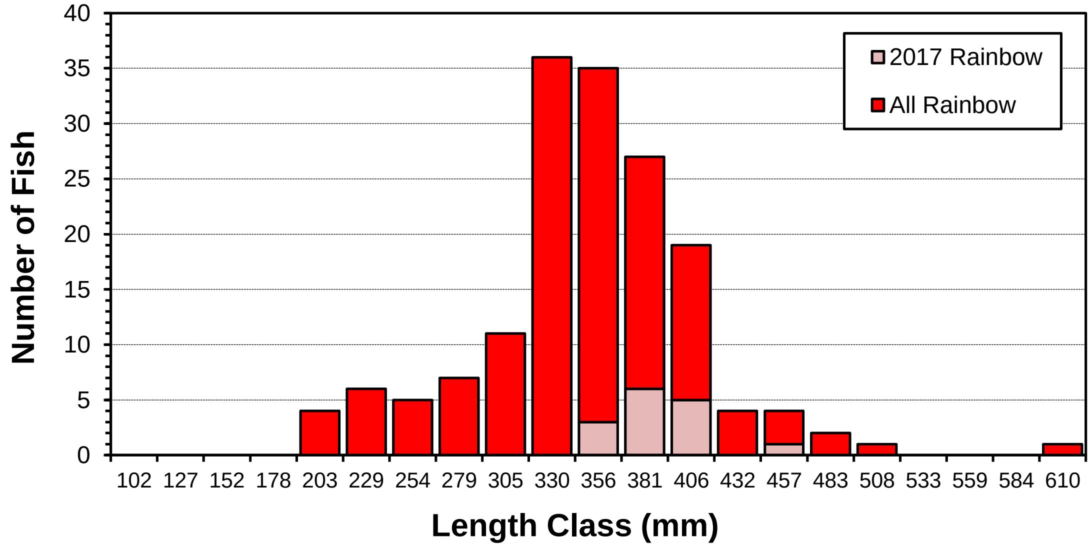



Figure 3-7. Mean trout CPUEs for the Cherokee tailwater samples. Bars indicate 90% confidence intervals.

## Cherokee Tailwater



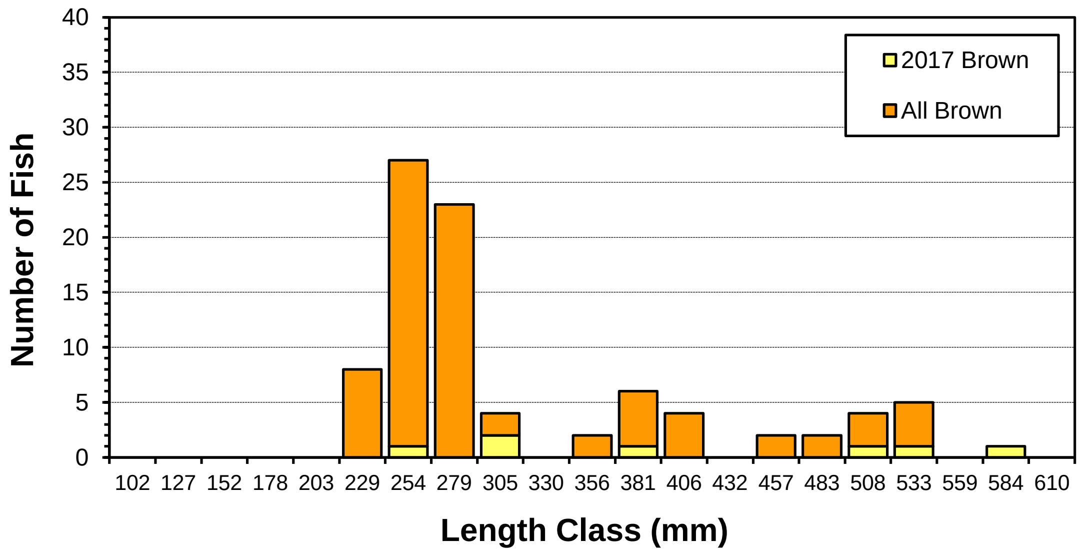
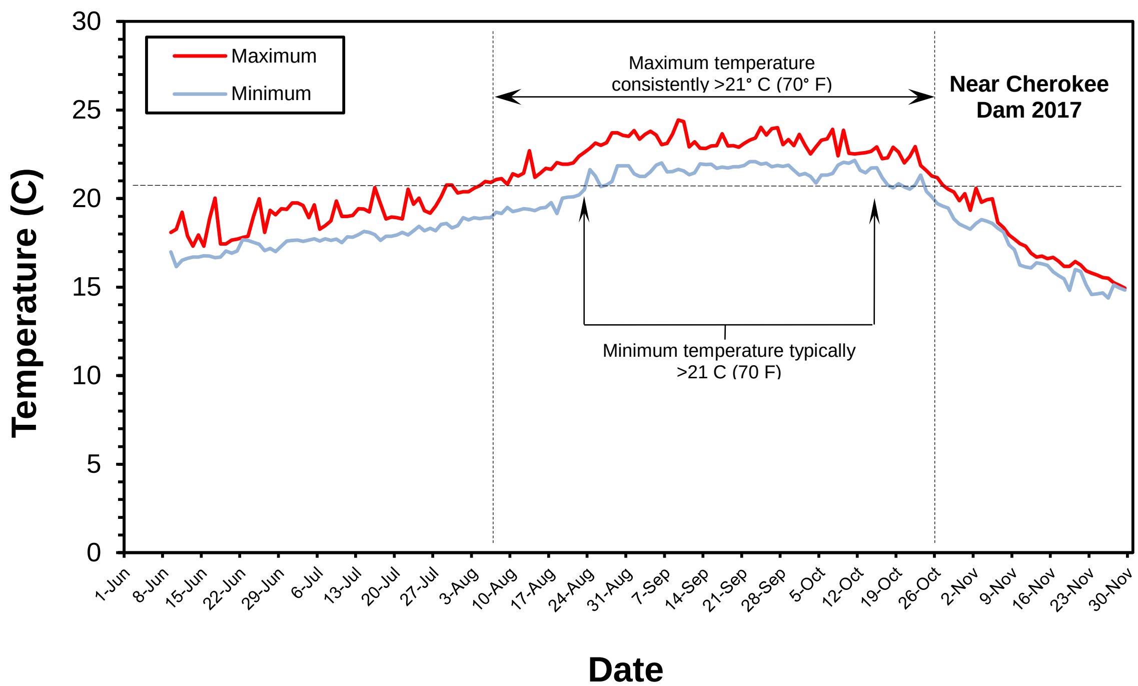




Figure 3-8. Length frequency distributions for trout from the Cherokee tailwater monitoring stations (2003-2017).

## Cherokee Tailwater



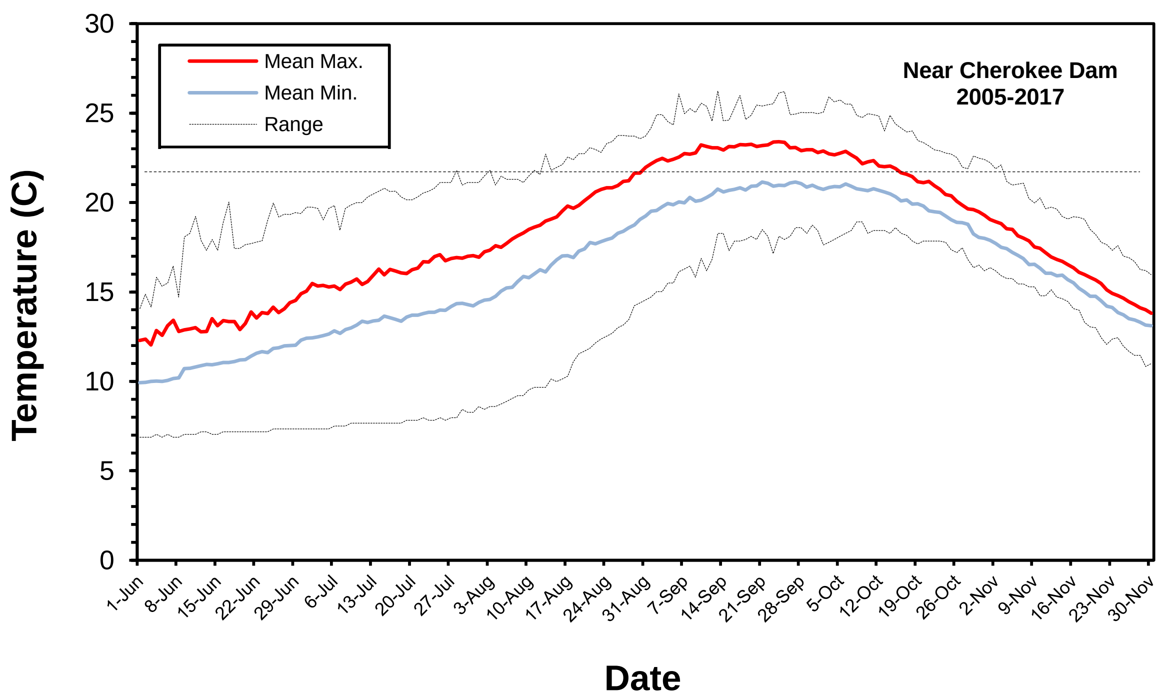




Figure 3-9. Daily temperature maxima and minima for June-November near Cherokee Dam (~1.6 km below the dam) in 2017 (upper graph) and 2005-2017 means (lower graph, with range).

## Cherokee Tailwater

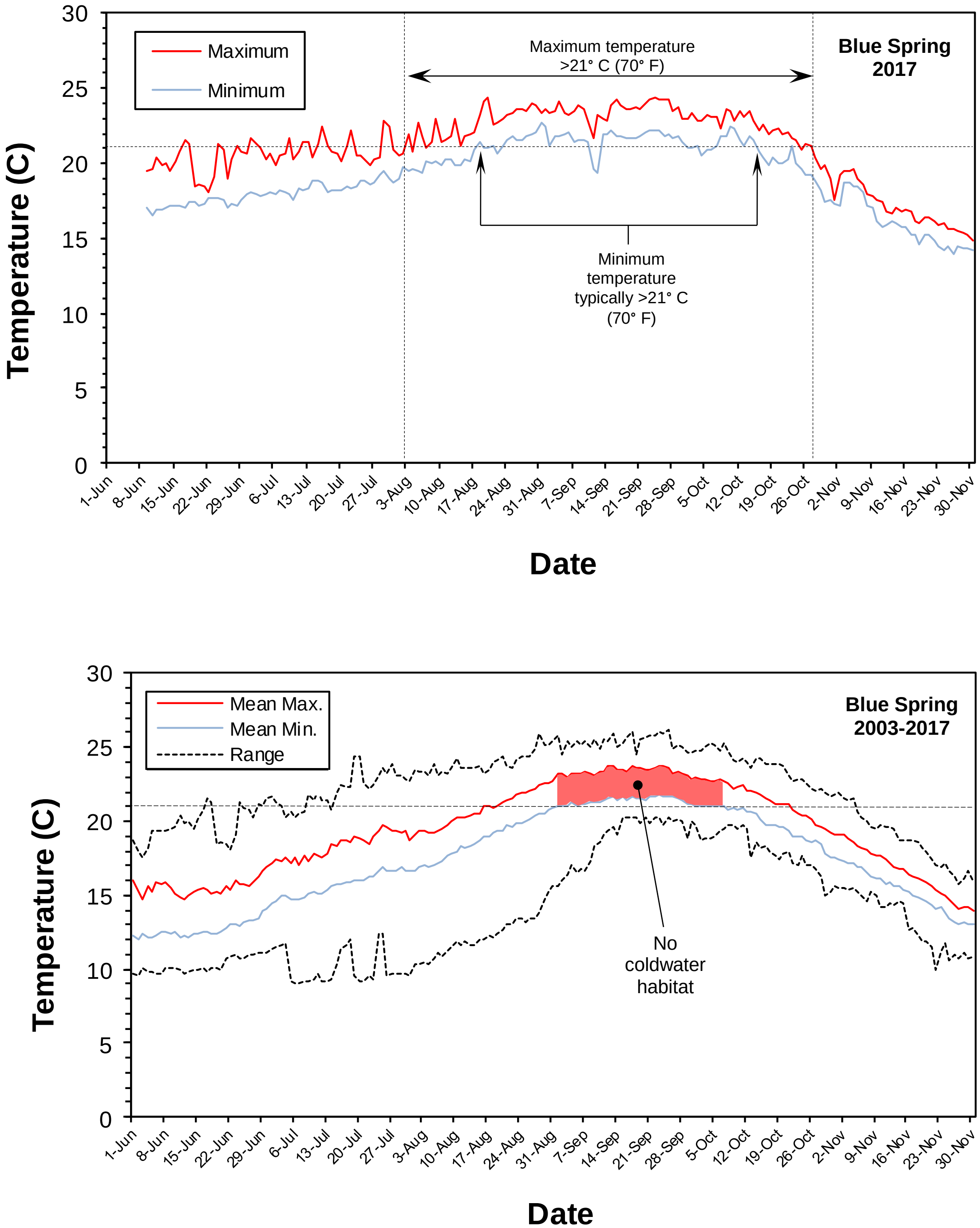



Figure 3-10. Daily temperature maxima and minima for June-November at Blue Spring (~13 km below the dam) in 2017 (upper graph) and 2003-2017 means (lower graph, with range).

## Cherokee Tailwater

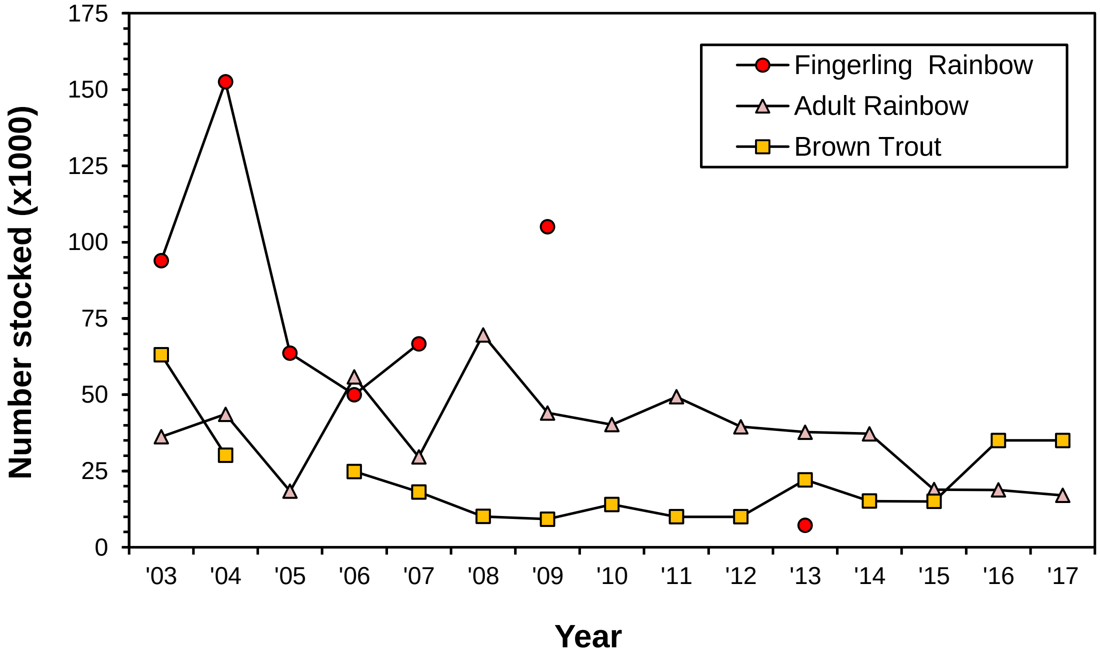



Figure 3-11. Recent trout stocking rates for the Cherokee tailwater. About 18,000 adult Rainbow Trout and 28,000 Brown Trout have been stocked annually since 2015.

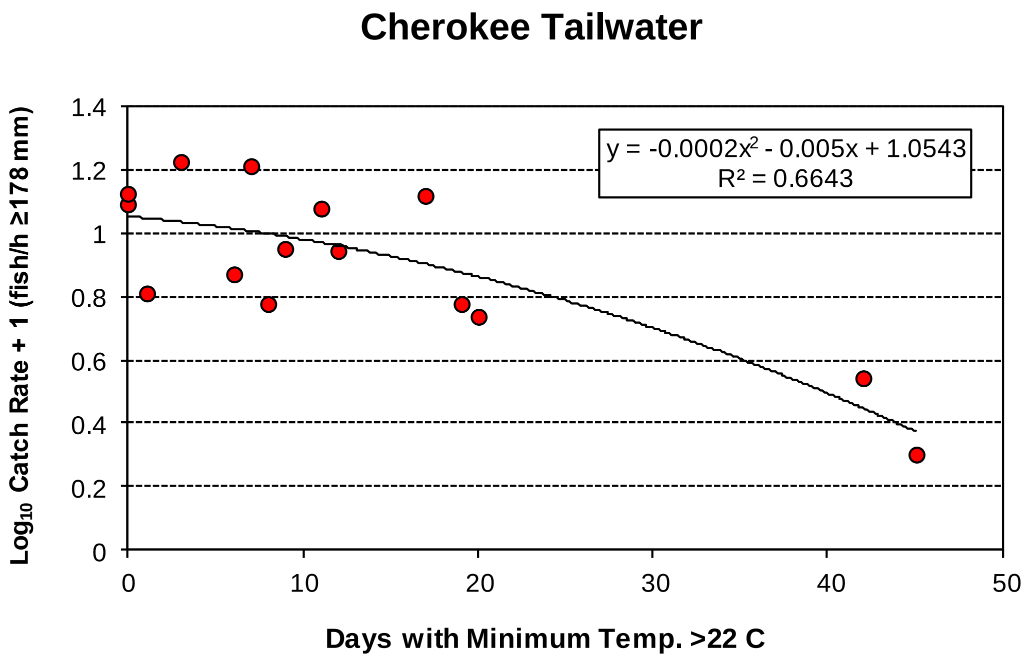



Figure 3-12. Inverse relationship between temperature (days during June-Oct. with minimum >22 C at Blue Spring) and October electrofishing catch rate for the Cherokee tailwater.

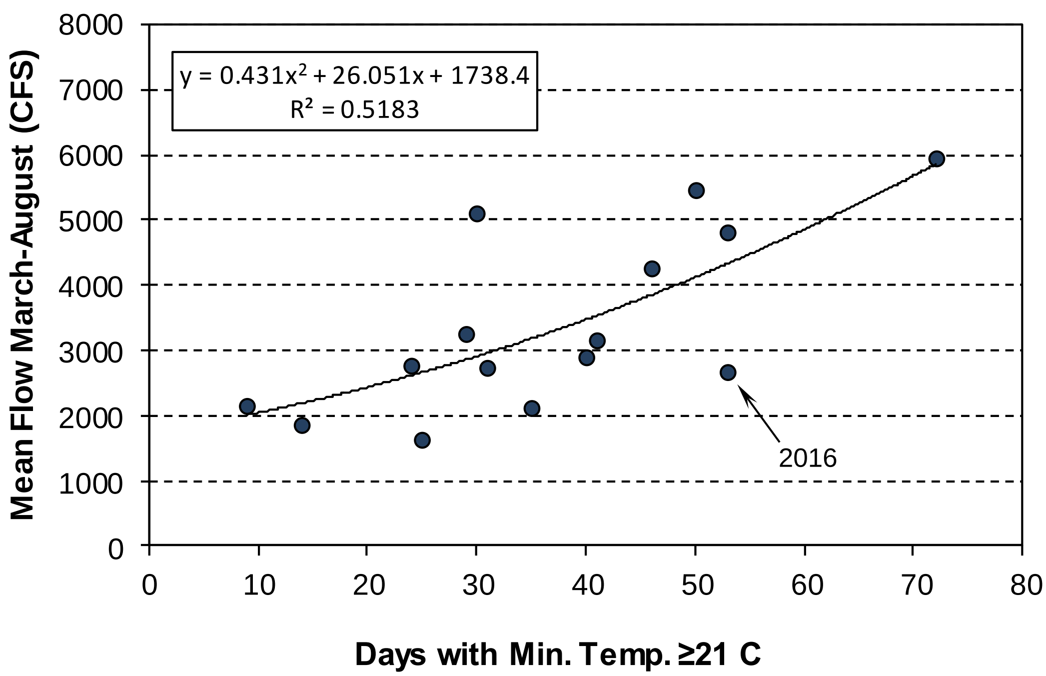



Figure 3-13. Relationship between mean flow (March-August) and temperature (days during June-October with minimum ≥21 C at Blue Spring) for the Cherokee tailwater.

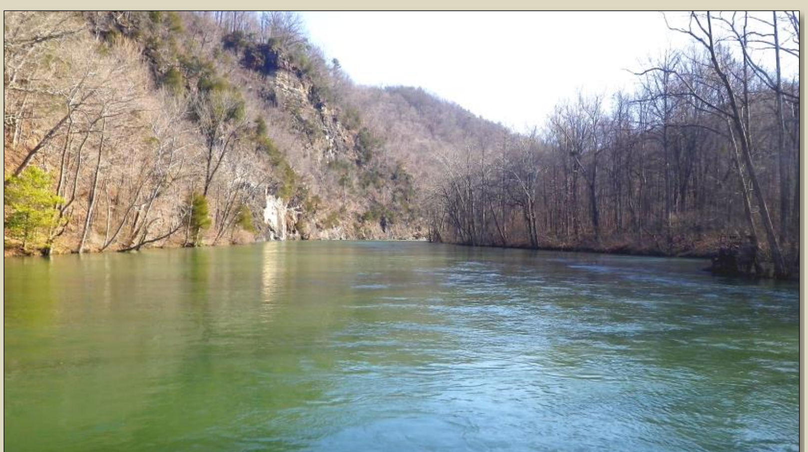
3.2.3 Wilbur (Watauga River)

**Study Area**

The Watauga River originates in the mountains of northwestern North Carolina and is impounded near Hampton, Tennessee (Carter County), forming Watauga Reservoir (2,603 ha). Most of the reservoir's watershed (1,213 $km^2$) is forested and much of the Tennessee portion lies within the CNF. Wilbur Dam is located 4.2 km (~2.6 mi.) downstream of Watauga Dam and impounds a small (29 ha or 72 acre) reservoir. The dam was completed in 1912 and is the second oldest in the TVA system (Ocoee No. 1 is the oldest). Despite its long history of degradation (Bivens 1988), the Watauga River between Elizabethton and Boone Reservoir supported one of the finest trout fisheries in the state by the 1990's through a combination of TVA's water quality improvements and TWRA's stocking program.

Bettoli (1999) estimated that the capacity of the Wilbur tailwater to overwinter trout (122 kg/ha) was second only to the South Holston tailwater. The trout fishery in the 16-km (10-mile) river section downstream of Elizabethton was severely damaged by toxic runoff associated with a fire at the North American Corporation in February 2000 (Habera et al. 2001b). Restoration of the trout fishery began immediately and was complete by 2005 (Habera et al. 2006).

The Wilbur tailwater currently supports a 26-km (16-mi.) fishery for rainbow and Brown Trout. Surface area of the tailwater at base flow is 135 ha (Bettoli 1999). Put-and-take and put-and-grow fisheries are provided by annually stocking fingerling and adult Rainbow Trout.



Upper Wilbur tailwater.

Additionally, successful natural reproduction (Banks and Bettoli 2000; Holbrook and Bettoli 2006) has led to the development of a substantial wild Brown Trout fishery, particularly in the upper half of the tailwater. Brown Trout stocking was discontinued throughout the tailwater in 2015. General trout angling regulations apply except in a 'Quality Zone' (QZ) extending 4.2 km (2.6 mi.) between Smalling Bridge and the CSX Railroad Bridge near Watauga (Figure 3-9). A two-fish creel limit and 356-mm minimum size limit are in effect within the QZ and only artificial lures are permitted. A 2013 TWRA creel survey indicated that Wilbur tailwater trout anglers catch an average of 1.68 fish/h and 6 fish/trip, while harvesting 0.89 fish/trip. (Black 2014).

The 13 monitoring stations on the Wilbur tailwater (Figure 3-14) were sampled on 9 March 2017. The purpose of the additional station (10.5; Figure 3-14) is to help evaluate the QZ as prescribed in the previous Wilbur tailwater management plan (Habera et al. 2009b). Data from this station are used only for comparing electrofishing catch rates inside and outside the QZ. Location and sampling effort details for all stations are provided in Table 3-5.

**Results and Discussion**

The 12 Wilbur tailwater monitoring stations produced 645 trout weighing over 145 kg in 2017 (Table 3-6)—the largest sample collected since monitoring began in 1999. Total catch increased 20% relative to 2016 as the result of further increases in the number of Brown Trout captured throughout the tailwater (Table 3-6). Total biomass for the 2017 sample increased 34%, reflecting increases in both the overall catch and the catch of larger trout (≥356 mm). The 2017 catch included 516 Brown Trout (Table 3-4) —the most captured in any sample to date and the highest proportion of the sample (80%) since 2000. Bettoli (1999) estimated that Brown Trout represented 60% of overwintering trout density in the Wilbur tailwater during 1998-1999. Since 2001, the relative abundance of Brown Trout has been in the 65-78% range. Most Brown Trout (79%) and Rainbow Trout (76%) in 2017 were in the 178-305 mm size range (Figure 3-15) and were most likely age-1 and age-2 fish.


Wilbur tailwater sampling.

The mean catch rate for all trout ≥178 mm nearly reached 300 fish/h in 2017 (Figure 3-16). The increase relative to 2016 was the result of a 60% increase in the Brown Trout catch rate (Figure 3-16). The new Wilbur tailwater management plan (Habera et al. 2015b) prescribes developing a wild Brown Trout fishery throughout the tailwater by discontinuing all Brown Trout stocking (effective in 2015). This strategy will be considered successful if a mean Brown Trout catch rate of 40 fish/h (≥178 mm) can be maintained in the lower portion of the tailwater (Stations 8-12) during 2015-2020 (Habera et al. 2015b). The 2017 Brown Trout catch rate in that area was 67 fish/h and has averaged 46 fish/h since 2015.

The mean catch rate for larger trout (≥356 mm) in 2017 exceeded 20 fish/h again (Figure 3-16)—the long-term average since restoration was considered complete in 2005. The mean catch rate for the largest trout (≥457 mm) remained at 4.0 fish/h in 2017 (Figure 3-16). Most of the trout in this size range are browns, as few Rainbow Trout ≥457 mm have been captured to date. Weiland and Hayward (1997) observed that failure of Rainbow Trout to reach large sizes in some tailwaters may be related to diet overlap among size class and limited capacity to intraspecifically partition food resources (in contrast to Brown Trout). Dodrill et al. (2016) found that prey size, as well as abundance and quality, limits maximum size for drift-foraging Rainbow Trout in tailwaters. Bioenergetically, larger Rainbow Trout would prefer to select larger prey items, but these can be scarce in tailwater systems (Dodrill et al. 2016). Flinders and Magoulick (2017) observed that large Rainbow Trout (>400 mm) in Arkansas tailwaters experienced a food-availability bottleneck during winter that caused daily ration to fall below minimum maintenance requirements, even with lower water temperatures and reduced metabolic costs.

Recently, mean catch rates for trout ≥356 mm in the QZ (Stations 10, 10.5, and 11) have been somewhat higher than corresponding catch rates at the other 10 stations. (Figure 3-17). However, there has been substantial overlap of the 90% confidence limits for both areas in most years (Figure 3-17) because of substantial catch rate variability among the QZ sites related to habitat quality. While not conclusive, these data provide no clear indication that the QZ regulations are enhancing abundance of larger trout in that area, although they do suggest a general increase in the electrofishing catch rate of trout ≥356 mm throughout the tailwater since 2005. The most recent angler harvest rate for the Wilbur tailwater was relatively low (0.94 fish/trip), but separate data were not available for the QZ. However, focusing harvest on larger trout size classes through minimum length limits (rather than protecting them) may actually promote recruitment and growth overfishing (Sánchez-Hernández 2016) and thereby limit attainment of management objectives.

The Wilbur tailwater was stocked with 41,000 adult Rainbow Trout during 2017 (Figure 3-18) as basically directed in the current management plan (Habera et al. 2015b). The prescribed annual fingerling Rainbow Trout stocking rate is 50,000, but an additional 53,000 fingerlings were inadvertently stocked in 2017 (Figure 3-18). Brown Trout stocking was discontinued in 2015 and Brook Trout stocking was discontinued in 2009 (after eight years) because of extremely low survival (0.1 – 4.4% over 100 d), slow growth (4-15 mm per month), and excessive predation by Brown Trout (Damer and Bettoli 2008).

Roving creel surveys on the Wilbur tailwater conducted by TWRA in 2013 (Black 2014) and 2016 (Black 2017) indicated that pressure, trips, and mean trip length, along with estimated catch and harvest increased substantially during that three-year period:

| Year | Pressure (h) | Mean Trip length (h) | Trips | Catch[a] | Harvest[a] |
|---|---|---|---|---|---|
| 2013 | 61,764 | 3.88 | 15,909 | 103,233 (68) | 14,234 (86) |
| 2016 | 112,627 | 4.90 | 22,965 | 213,673 (71) | 21,477 (88) |

[a]Values in parentheses are percentages represented by Rainbow Trout.

The average trout catch rate also increased from 1.67 fish/h in 2013 to 1.90 fish/h in 2016, while average catch per trip increased from 6.5 in 2013 to 9.3 per trip in 2016. By comparison, catch rates over 0.7 fish/h are generally considered representative of good fishing (McMichael and Kaya 1991; Wiley et al. 1993). Average harvest was low in 2013 (0.89 fish/trip) and remained below 1 fish/trip in 2016 (0.94/trip). Rainbow Trout and Brown Trout abundance were relatively stable during 2013-2016 (Figure 3-16), and proportions of both species represented in catch and harvest estimates remained relatively unchanged.

A majority of Wilbur tailwater anglers interviewed in 2013 (67%) expressed their support for the QZ regulations and 60% opposed replacing it with a tailwater-wide PLR (slot limit) with no bait restrictions (Habera et al. 2015a). A substantial majority (98%) also rated TWRA's management of the Wilbur tailwater trout fishery as good or excellent at that time. In 2016, 273 Wilbur tailwater anglers were asked if they fished in the QZ during the past three years and if so, whether or not they caught more large (≥356 mm) trout there than elsewhere in the tailwater. Anglers who had fished the QZ were also asked if they would favor changing regulations there to a PLR (e.g., 356-457 mm or 14-18 in.) with no bait restrictions and a 7-fish creel (with one >457 mm). Ninety anglers (33%) reported that they had fished the QZ since 2013, with 44% of those indicating that they did catch more large trout there. Even though a majority of anglers did not experience a higher catch rate for large trout in the QZ, most (81%) did not support the proposed regulation change. This opinion differed little between those who did catch more large fish in the QZ (83% un-supportive) and those who did not (80% unsupportive). A new angler survey will be conducted on the Wilbur tailwater in 2018 and results will be available for inclusion in the 2019 report.

## Management Recommendations

The goal of the current (2015-2020) Wilbur tailwater management plan is to maintain a quality trout fishery throughout the tailwater capable of providing a variety of opportunities to the anglers who enjoy this resource (Habera et al. 2015b). Two of its basic objectives—managing for a wild Brown Trout fishery throughout the tailwater and maintaining Rainbow Trout stocking rates (and the Rainbow Trout fishery)—are being achieved. The third—consideration of a regulation change in the QZ to a PLR—has also been addressed and currently most anglers do not support a regulation change (e.g., to a PLR), even if they do not experience higher catch rates for larger trout.

Because of the presence of whirling disease *Myxobolus cerebralis* in nearby Virginia and North Carolina trout fisheries and the popularity of the Wilbur tailwater with anglers from those areas, 60 Rainbow Trout and 12 Brown Trout captured during 2017 were submitted to the U.S. Fish and Wildlife Service's Fish Health Lab in Warm Springs, GA to be screened for this pathogen. Whirling disease was confirmed in both species and TWRA will move forward with information and education efforts directed at preventing the spread of spores and infected fish, as well as screening of additional trout fisheries in 2018.

# Wilbur Tailwater

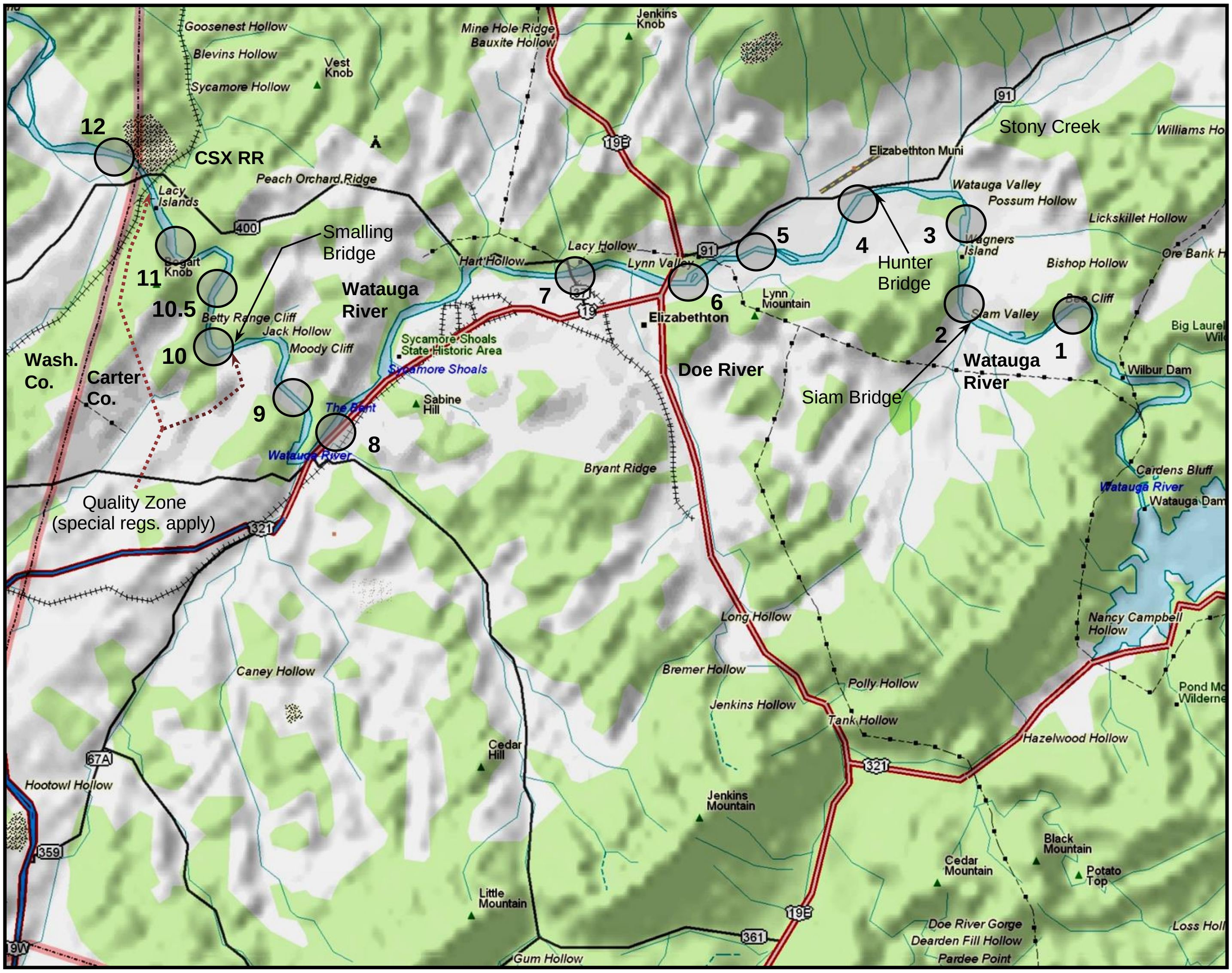



Figure 3-14. Locations of the Wilbur tailwater (Watauga River) monitoring stations. Station 10.5 was added in 2010 to help evaluate the Quality Zone (which also includes stations 10 and 11).

Table 3-5. Location and sampling information for the 13 electrofishing stations on the Wilbur tailwater, 9 March 2017.

| Station | Site Code | County | Quadrangle | Coordinates | Reach Number | River Mile | Effort (s) | Output |
|---|---|---|---|---|---|---|---|---|
| 1 | 420170301 | Carter | Elizabethton 207 SW | 36.35194N-82.13306W | 06010103-19,0 | 33.0 | 600 | 400 V DC<br>120 PPS, 4 A |
| 2 | 420170302 | Carter | Elizabethton 207 SW | 36.34806N-82.14861W | 06010103-19,0 | 32.0 | 600 | 884 V DC<br>120 PPS, 5 A |
| 3 | 420170303 | Carter | Elizabethton 207 SW | 36.36361N-82.15444W | 06010103-19,0 | 30.3 | 600 | 400 V DC<br>120 PPS, 4 A |
| 4 | 420170304 | Carter | Elizabethton 207 SW | 36.36833N-82.16861W | 06010103-18,0 | 29.5 | 600 | 884 V DC<br>120 PPS, 5 A |
| 5 | 420170305 | Carter | Elizabethton 207 SW | 36.35833N-82.17944W | 06010103-18,0 | 28.4 | 600 | 400 V DC<br>120 PPS, 4 A |
| 6 | 420170306 | Carter | Elizabethton 207 SW | 36.35500N-82.20333W | 06010103-18,0 | 27.0 | 600 | 884 V DC<br>120 PPS, 5 A |
| 7 | 420170307 | Carter | Elizabethton 207 SW | 36.36028N-82.22694W | 06010103-12,2 | 25.9 | 600 | 400 V DC<br>120 PPS, 4 A |
| 8 | 420170308 | Carter | Johnson City 198 SE | 36.33222N-82.26694W | 06010103-12,2 | 22.4 | 600 | 884 V DC<br>120 PPS, 5 A |
| 9 | 420170309 | Carter | Johnson City 198 SE | 36.33389N-82.26917W | 06010103-12,0 | 21.8 | 600 | 400 V DC<br>120 PPS, 4 A |
| 10 | 420170310 | Carter | Johnson City 198 SE | 36.34556N-82.28306W | 06010103-12,0 | 20.0 | 600 | 884 V DC<br>120 PPS, 5 A |
| 10.5 | 420170311 | Carter | Johnson City 198 SE | 36.35150N-82.28730W | 06010103-12,0 | 19.4 | 600 | 400 V DC<br>120 PPS, 4 A |
| 11 | 420170312 | Carter | Johnson City 198 SE | 36.35750N-82.29056W | 06010103-10,0 | 18.7 | 600 | 400 V DC<br>120 PPS, 4 A |
| 12 | 420170313 | Carter | Johnson City 198 SE | 36.37361N-82.30250W | 06010103-10,0 | 17.3 | 600 | 884 V DC<br>120 PPS, 5 A |

Station 10.5 was added in 2010 to help evaluate the Quality Zone (also includes Stations 10 and 11).

Table 3-6. Catch data for the 13 electrofishing stations on the Wilbur tailwater sampled 9 March 2017.

| Station | Species | Total Catch | Size Range (mm) | Total Weight (g) | % Abundance (number) | % Abundance (weight) |
|---|---|---|---|---|---|---|
| 1 | Rainbow | 10 | 173-335 | 1,554 | 13 | 8 |
| | Brown | 67 | 170-433 | 17,123 | 87 | 92 |
| **Totals** | | **77** | | **18,677** | **100** | **100** |
| 2 | Rainbow | 4 | 154-305 | 474 | 5 | 3 |
| | Brown | 72 | 122-395 | 14,507 | 95 | 97 |
| **Totals** | | **76** | | **14,981** | **100** | **100** |
| 3 | Rainbow | 10 | 128-306 | 1,053 | 15 | 12 |
| | Brown | 55 | 142-332 | 7,494 | 85 | 88 |
| **Totals** | | **65** | | **8,547** | **100** | **100** |
| 4 | Rainbow | 9 | 212-312 | 1,452 | 11 | 8 |
| | Brown | 76 | 117-498 | 16,385 | 89 | 92 |
| **Totals** | | **85** | | **17,837** | **100** | **100** |
| 5 | Rainbow | 11 | 160-446 | 1,878 | 9 | 10 |
| | Brown | 110 | 122-391 | 16,752 | 91 | 90 |
| **Totals** | | **121** | | **18,630** | **100** | **100** |
| 6 | Rainbow | 12 | 173-349 | 2,068 | 22 | 20 |
| | Brown | 42 | 136-385 | 8,332 | 78 | 80 |
| **Totals** | | **54** | | **10,400** | **100** | **100** |
| 7 | Rainbow | 8 | 208-343 | 1,535 | 18 | 12 |
| | Brown | 37 | 175-421 | 11,333 | 82 | 88 |
| **Totals** | | **45** | | **12,868** | **100** | **100** |
| 8 | Rainbow | 26 | 140-405 | 5,272 | 70 | 61 |
| | Brown | 11 | 280-375 | 3,382 | 30 | 39 |
| **Totals** | | **37** | | **8,654** | **100** | **100** |
| 9 | Rainbow | 7 | 226-367 | 1,811 | 47 | 43 |
| | Brown | 8 | 270-349 | 2,420 | 53 | 57 |
| **Totals** | | **15** | | **4,231** | **100** | **100** |
| 10 | Rainbow | 16 | 194-340 | 4,270 | 57 | 40 |
| | Brown | 12 | 154-590 | 6,534 | 43 | 60 |
| **Totals** | | **28** | | **10,804** | **100** | **100** |
| **-** | | | | | | |
| 10.5 | Rainbow | 3 | 238-253 | 461 | 11 | 4 |
| | Brown | 5 | 167-440 | 1,412 | 18 | 13 |
| **Totals** | | **8** | | **1,873** | **29** | **17** |
| 11 | Rainbow | 9 | 300-400 | 4,251 | 32 | 30 |
| | Brown | 19 | 188-509 | 9,925 | 68 | 70 |
| **Totals** | | **28** | | **14,176** | **100** | **100** |
| 12 | Rainbow | 7 | 250-434 | 3,148 | 50 | 56 |
| | Brown | 7 | 290-346 | 2,446 | 50 | 44 |
| **Totals** | | **14** | | **5,594** | **100** | **100** |
| **Total Rainbow[1]** | | 129 | 128-446 | 28,766 | 20 | 20 |
| **Total Brown[1]** | | 516 | 117-590 | 116,633 | 80 | 80 |
| **Overall totals[1]** | | **645** | | **145,399** | **100** | **100** |

[1]Overall totals do not include Station 10.5, which was added in 2010 to help evaluate the Quality Zone (stations 10, 10.5, and 11 are in the QZ).

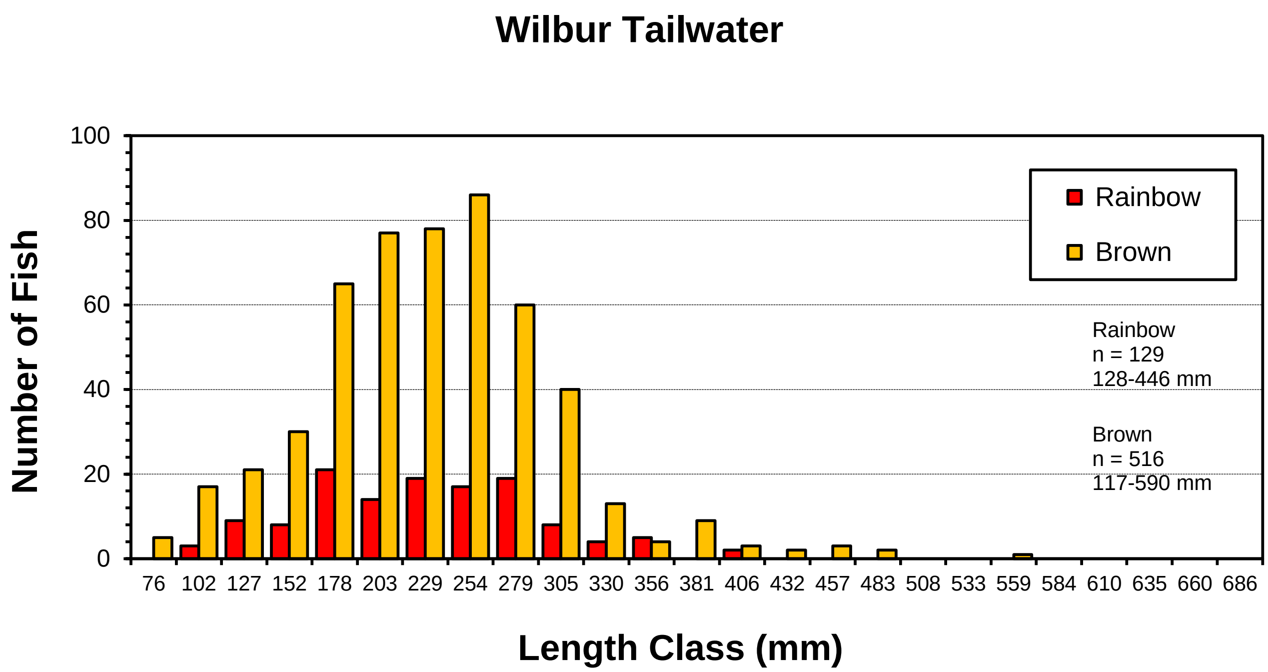



Figure 3-15. Length frequency distributions for trout from the Wilbur tailwater monitoring stations in 2017 (excluding Station 10.5).

## Wilbur Tailwater

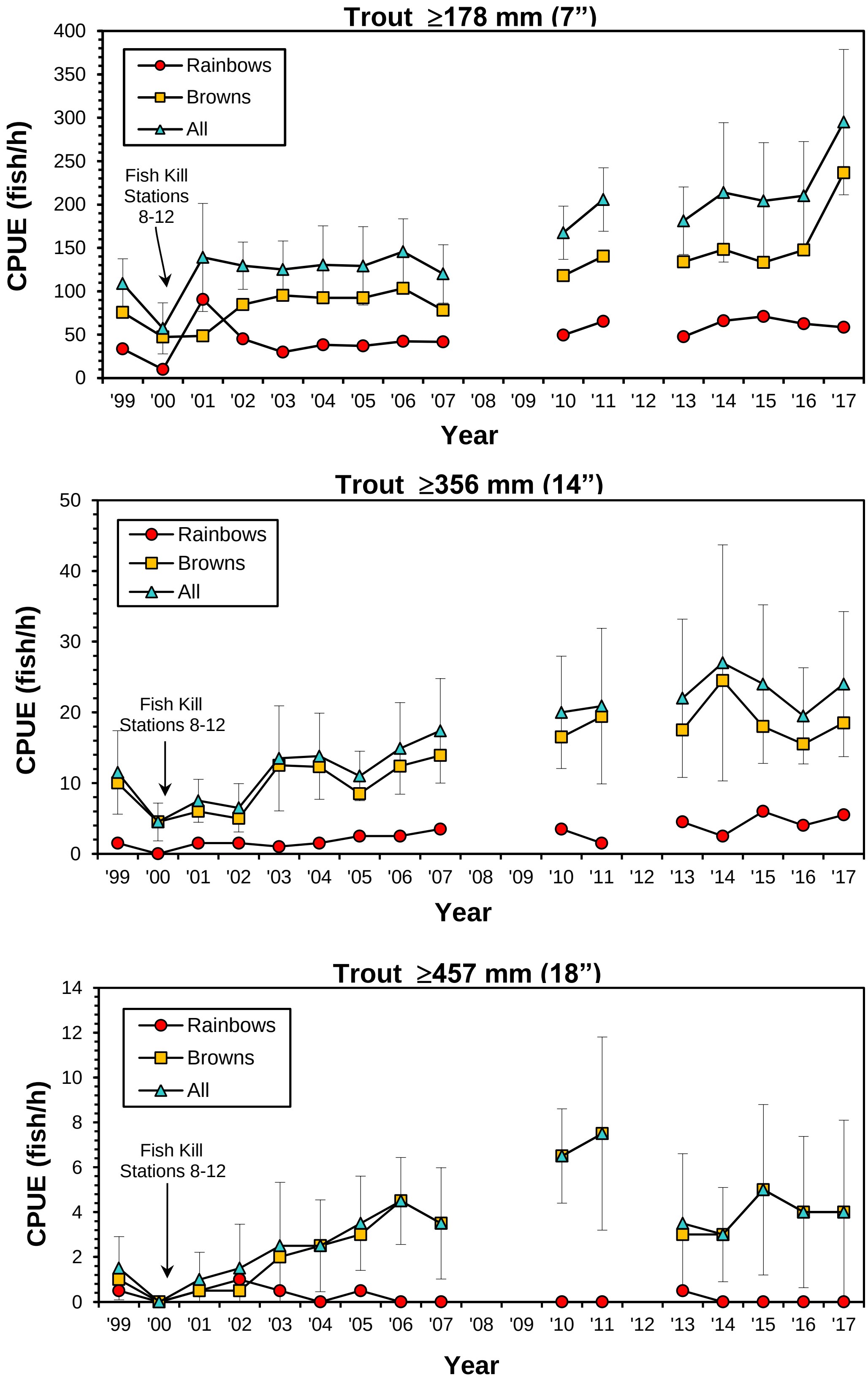



Figure 3-16. Mean trout CPUEs for the Wilbur tailwater samples. Bars indicate 90% confidence intervals.

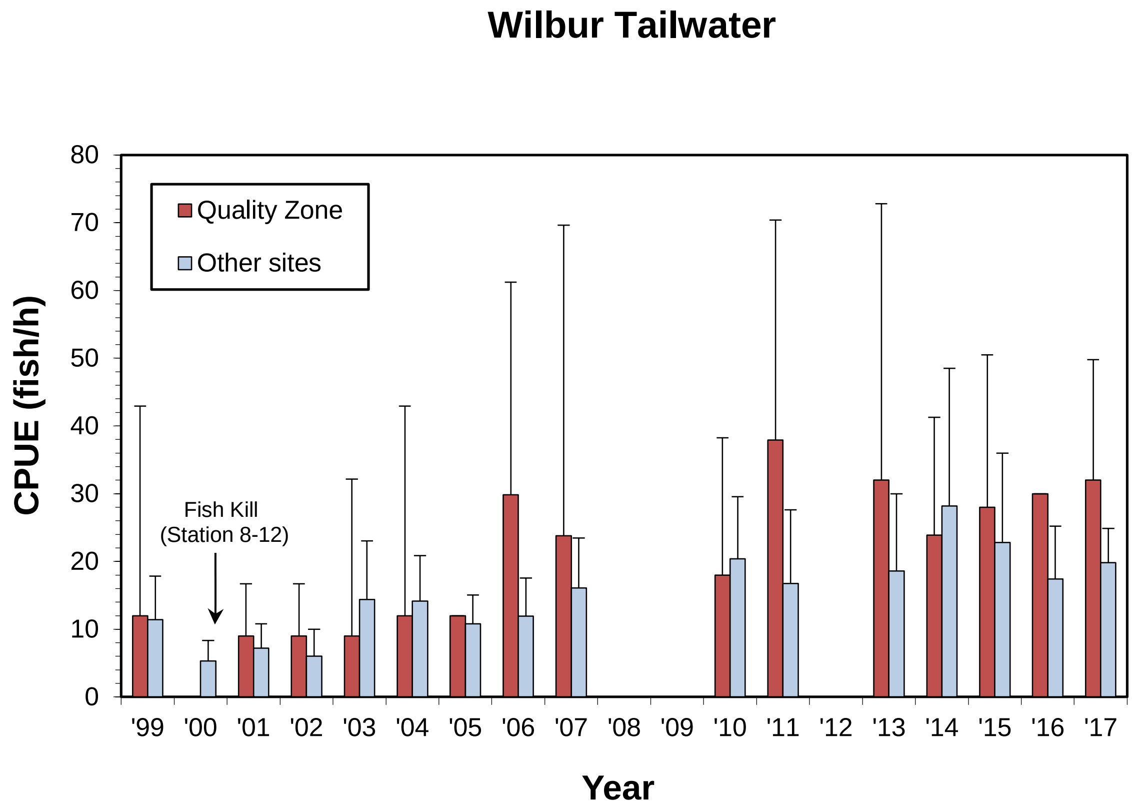



Figure 3-17. Mean trout CPUEs for trout ≥356 mm from the Quality Zone (QZ; sites 10, 10.5, and 11) and the other ten sites on the Wilbur tailwater. Bars indicate 90% upper confidence limits.

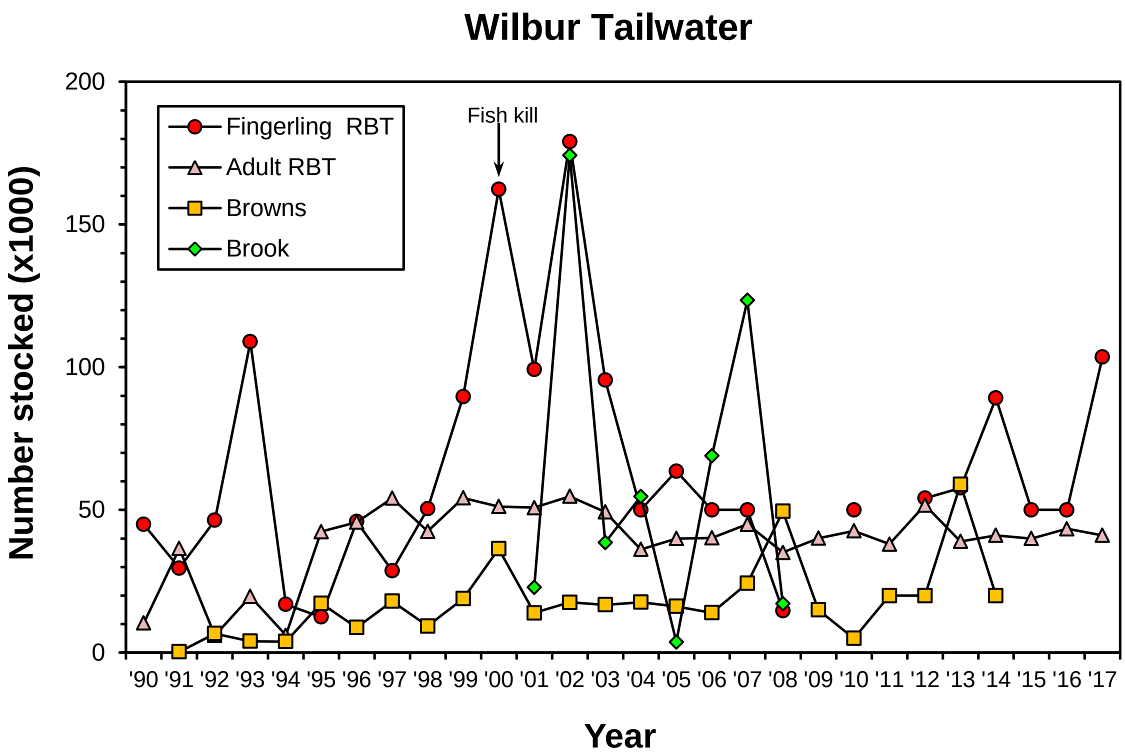



Figure 3-18. Recent trout stocking rates for the Wilbur tailwater. Annual stocking rates under the current management plan (2015-2020) are 40,000 adult rainbow trout and 50,000 fingerling rainbows.

.

3.2.4 Fort Patrick Henry (South Fork Holston River)

**Study Area**

Ft. Patrick Henry Dam impounds a small (362 ha) reservoir (Ft. Patrick Henry Lake) on the South Fork of the Holston River near Kingsport. TVA maintains a minimum flow of 11.3 $m^3$/s (400 cfs) downstream of the dam, where the river provides an important industrial water supply. The upper 4.7 km (2.9 mi.) of the Ft. Patrick Henry tailwater (Figure 3-19) is managed as a put-and-take and put-and-grow trout fishery with annual stockings of adult and fingerling Rainbow Trout and sub-adult (152-178 mm) Brown Trout. Sample site locations and effort details are summarized in Table 3-7.

**Results and Discussion**

The four Ft. Patrick Henry tailwater electrofishing stations produced 115 trout weighing over 61 kg in 2017 (Table 3-8). Trout biomass for 2017 decreased from the 2016 total (79 kg), which exceeded all previous monitoring samples. Fewer large (≥356 mm) Rainbow Trout in the 2017 sample caused the decrease. Rainbow Trout ranged from 232-554 mm and fish in the 229-279 mm (9-11 in.) and 381-432 mm (15-17 in.) size classes were most abundant (Figure 3-20). More Rainbow Trout ≥508 mm (20 in.) were captured in 2016 (16) than in any earlier sample (maximum was 8 in 2015), but only three were captured in 2017. The 29 Brown Trout captured in 2017 ranged from 140-392 mm and made up only 5% of the sample biomass (Table 3-8). Brown Trout ≥457 mm (18 in.) are occasionally present in Ft. Patrick Henry monitoring samples, but only one has been captured since 2013.

Sampling the Ft. Patrick Henry tailwater (G Loucks, TWRA).

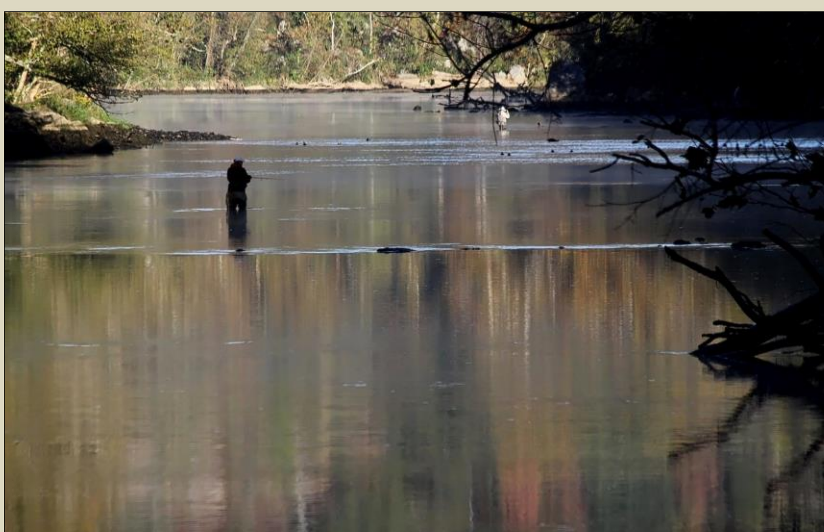
The mean catch rate for all trout ≥178 mm increased slightly to 106 fish/h in 2017 (Figure 3-21), which is well above the long-term (2002-2015) average of 77 fish/h. However, the catch rate for trout ≥356 mm decreased to 44 fish/h and the mean catch rate for the largest trout (≥457 mm or 18 in.) declined again to 18 fish/h (Figure 3-21), but remained above the long-term average of 10 fish/h. The abundance of trout ≥457 mm had been substantially depressed during 2004-2010 (0 to 4 fish/h), but has improved since then, averaging nearly 18 fish/h (Figure 3-21).

Stocking rates have been more stable since 2008 (Figure 3-22), with 5,300 adult Rainbow Trout, 7,500 fingerling Rainbow Trout, and 25,000 Brown Trout stocked in 2017. Overall, an average of 11,000 adult Rainbow Trout, 6,800 fingerling Rainbow Trout, and 19,500 Brown Trout has been stocked during the previous five years (Figure 3-22).

An angler survey was conducted on the Ft. Patrick Henry tailwater in 2017 and results (including estimated pressure, catch, and harvest) will be available for inclusion in the 2018 report. As part of this survey, anglers were asked to rate their satisfaction with the trout fishery on a scale of 1 (poor) to 5 (excellent). Interestingly, over one third (37%) of the 276 anglers responding to this question offered no opinion, and several mentioned that they did not know what TWRA does to manage the fishery. The majority (57%), however, rated the fishery as good or excellent.

## Management Recommendations

Despite its relatively small size, the Ft. Patrick Henry tailwater provides an excellent trout fishery that consistently produces large, extremely well-conditioned trout. Mean relative weight ($W_r$) is 107 (SE=0.47) for Rainbow Trout and 107 (SE=0.97) for Brown Trout, with numerous fish of both species exceeding 130. This fishery is currently subject to statewide trout angling regulations and no changes are recommended at this time. The current adult Rainbow Trout and Brown Trout stocking rates should at least be maintained. Also, the four sampling stations should be sampled annually to obtain information useful for the future management of this fishery. These basic recommendations are being incorporated into a trout fishery management plan for the Ft. Patrick Henry and Boone tailwaters (in preparation during 2017-2018) to ensure that they continue to achieve their potential for providing exceptional angling opportunities for quality-sized trout.



Ft. Patrick Henry tailwater anglers (G. Loucks, TWRA).

## Ft. Patrick Henry Tailwater

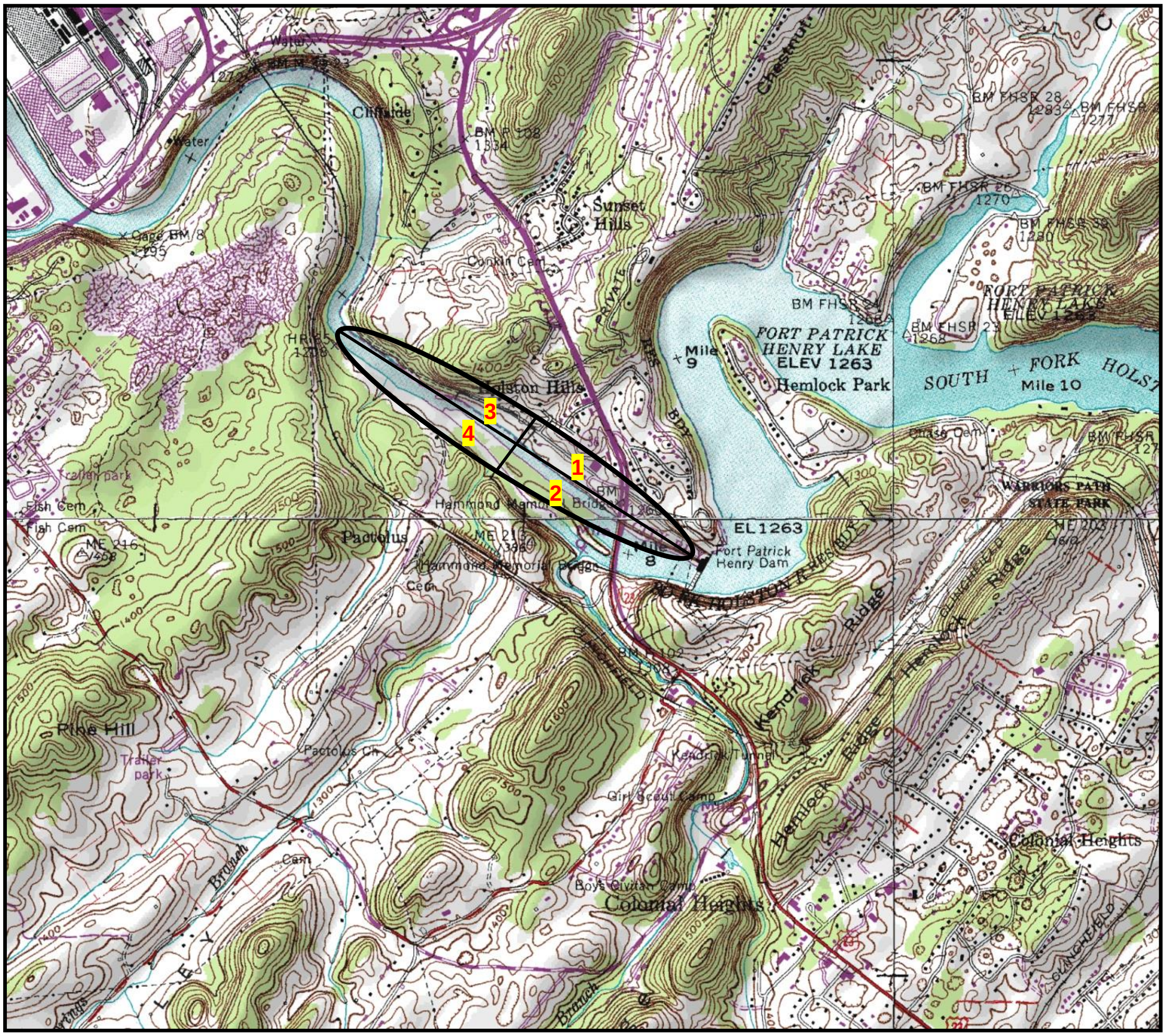


Figure 3-19. Location of the Ft. Patrick Henry tailwater (South Fork Holston River) monitoring stations.

Table 3-7. Location and sampling information for the four stations on the Ft. Patrick Henry tailwater, 16 March 2017.

| Station | Site Code | County | Quadrangle | Coordinates | Reach Number | River Mile | Effort (s) | Output |
|---|---|---|---|---|---|---|---|---|
| 1 | 420170501 | Sullivan | Kingsport 188 SE | 36.49972N-82.51278W | 06010102-4,1 | 8.0 | 900 | 200 V DC 120 PPS, 4 A |
| 2 | 420170502 | Sullivan | Kingsport 188 SE | 36.49917N-82.51278W | 06010102-4,1 | 8.0 | 900 | 884 V DC 120 PPS, 4-5 A |
| 3 | 420170503 | Sullivan | Kingsport 188 SE | 36.50583N-82.52306W | 06010102-4,0 | 7.4 | 900 | 200 V DC 120 PPS, 4 A |
| 4 | 420170504 | Sullivan | Kingsport 188 SE | 36.50556N-82.52333W | 06010102-4,0 | 7.4 | 900 | 884 V DC 120 PPS, 4-5 A |

Table 3-8. Catch data for the four electrofishing stations on the Ft. Patrick Henry tailwater sampled 16 March 2017.

| Station | Species | Total Catch | Size Range (mm) | Total Weight (g) | % Abundance (number) | % Abundance (weight) |
|---|---|---|---|---|---|---|
| 1 | Rainbow | 12 | 232-584 | 7,683 | 52 | 92 |
| | Brown | 11 | 140-392 | 703 | 48 | 8 |
| **Totals** | | **23** | | **8,386** | **100** | **100** |
| 2 | Rainbow | 27 | 268-555 | 18,749 | 84 | 98 |
| | Brown | 5 | 172-224 | 452 | 16 | 2 |
| **Totals** | | **32** | | **19,201** | **100** | **100** |
| 3 | Rainbow | 11 | 260-584 | 6,646 | 55 | 92 |
| | Brown | 9 | 165-196 | 566 | 45 | 8 |
| **Totals** | | **20** | | **7,212** | **100** | **100** |
| 4 | Rainbow | 36 | 232-530 | 25,196 | 90 | 96 |
| | Brown | 4 | 172-392 | 1,058 | 10 | 4 |
| **Totals** | | **40** | | **26,254** | **100** | **100** |
| **Total Rainbow** | | **86** | 232-584 | **58,274** | 75 | 95 |
| **Total Brown** | | **29** | 140-392 | **2,779** | 25 | 5 |
| **Overall totals** | | **115** | | **61,053** | **100** | **100** |

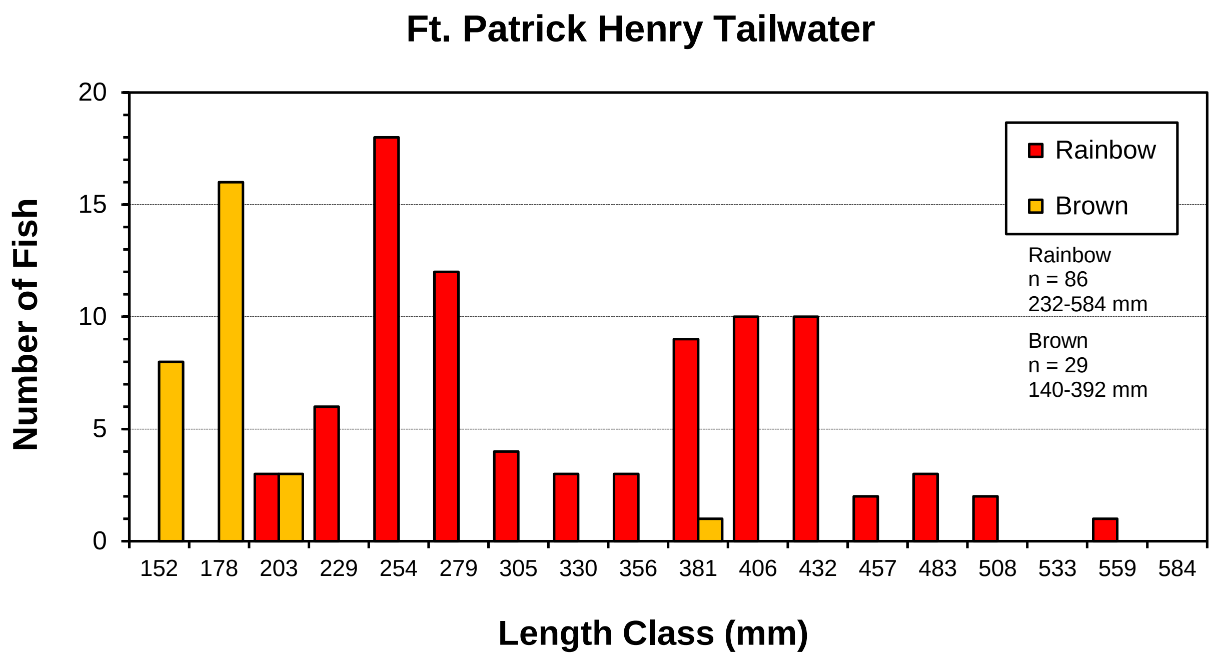



Figure 3-20. Length frequency distributions for trout from the Ft. Patrick Henry tailwater monitoring stations in 2017.

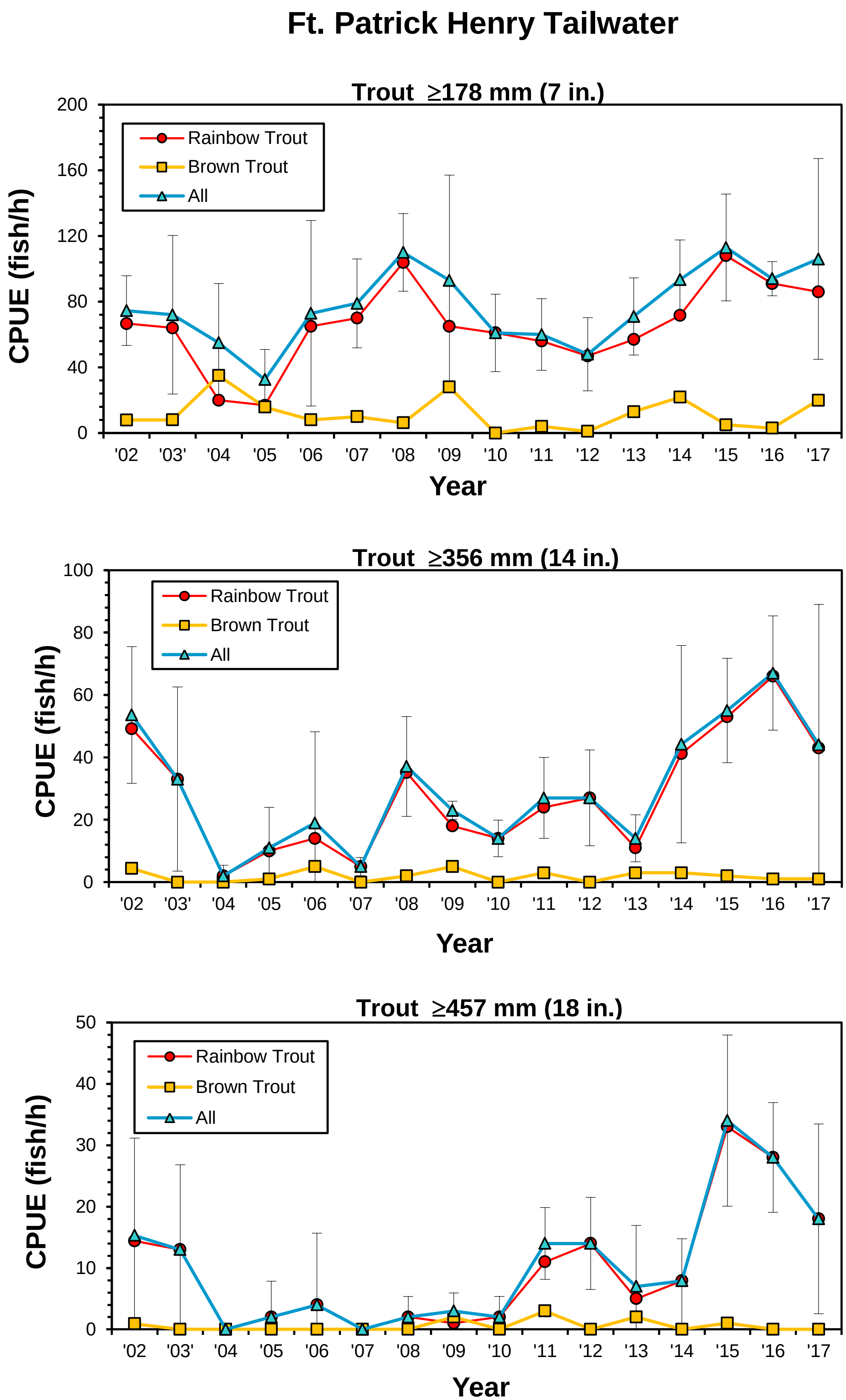



Figure 3-21. Mean trout CPUEs for the Ft. Patrick Henry tailwater samples. Bars indicate 90% confidence intervals.

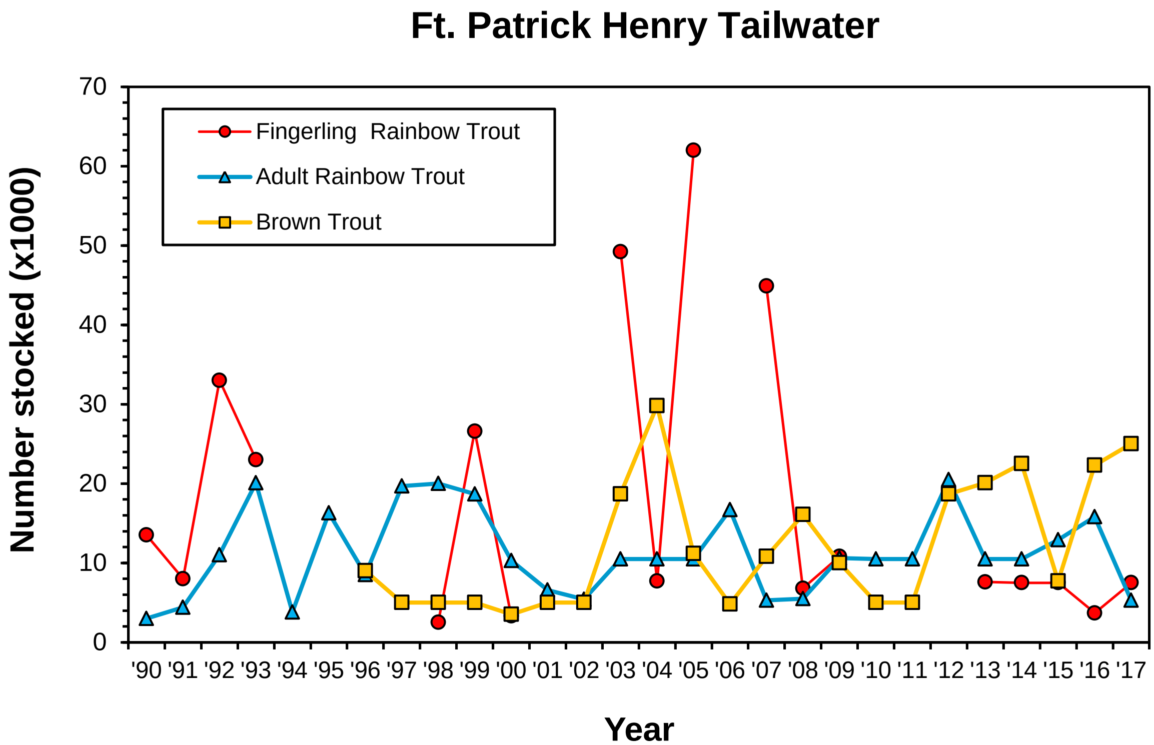



Figure 3-22. Recent trout stocking rates for the Ft. Patrick Henry tailwater. The average annual stocking rate during the past three years (2014-2016) was 19,300 rainbows and 17,500 brown trout.

3.2.5 Boone (South Fork Holston River)

## Study Area

Boone Dam impounds a 1,782 ha (4,400 acre) reservoir (Boone Lake) on the South Fork of the Holston and Watauga rivers in Sullivan and Washington counties near Johnson City and Kingsport. Both the South Holston and Wilbur tailwaters, which support two of Tennessee's premier trout fisheries, flow into Boone Lake. A short (~1 km) tailwater exists downstream of Boone Dam at the upper end of Ft. Patrick Henry Lake. The dam has three autoventing turbines which help improve dissolved oxygen levels in the water released from Boone Dam. This tailwater and Ft. Patrick Henry Lake provide coldwater habitat that was historically stocked with adult Rainbow Trout. TWRA's preliminary investigations of this tailwater in 2008 indicated the presence of a good Rainbow Trout fishery along with a few Brown Trout, which likely were migrants from the South Holston or Wilbur tailwaters upstream. Evidence of some natural reproduction by Rainbow Trout (58-85 mm fish) was also detected in 2008 during sampling at base flow. Accordingly, four electrofishing stations (Figure 3-23) were established in 2008 and the Boone tailwater was added to the annual monitoring program in 2009. Sample site locations and effort details are summarized in Table 3-9.

A large Brown Trout captured during 2017 Boone tailwater monitoring.

## Results and Discussion

The four Boone tailwater monitoring stations produced 109 trout (61 Rainbow Trout, 29 Brown Trout, and 19 Brook Trout) weighing over 49 kg in 2017 (Table 3-10). More Brook Trout were captured in 2017 than in all previous samples (one in 2013, 2014, and 2015). Total trout catch increased 20% relative to 2016 and catch biomass increased 23%. The biomass increase was the primarily the result of more large Brown Trout in the 2017 sample (mean weight 723 g vs. 555 g in 2016). Brown Trout up to 722 mm (28.4 in.) were captured in 2017 (Figure 3-24), and 7 fish were >457 mm (18 in.)—the most in any sample since monitoring began in 2008. Brown Trout were added to the stocking program in 2008 and while they have not become abundant, several fish over 600 mm (23.6 in.) have been captured in previous samples, indicating that those browns that do survive have excellent growth potential in this tailwater. Rainbow Trout have typically exhibited a bimodal size distribution, and the 279-305 mm (11-12 in.) and 356-381 mm (14-15 in.)

size classes  were most abundant in 2017 (Figure 3-24).  However, no Rainbow Trout ≥406 mm (16 in.) were captured for the first time since monitoring began in 2008.  Brook trout, stocked in 2009, 2012, 2014, and 2017 have also grown exceptionally well (three fish >356 mm or 14 in. have been captured), but none >303 mm were captured in 2017 (Figure 3-24).

The mean electrofishing catch rate for all trout ≥178 mm from the Boone tailwater increased again in 2017 to 109 fish/h (Figure 3-25), which is above the long-term average of 77 fish/h.  The lack of Rainbow Trout ≥406 mm caused a decline in the catch rate for trout ≥356 mm to 21 fish/h in 2017—the lowest catch rate obtained for these fish except for the 2014 sample (Figure 3-25).  The increased catch of large Brown Trout in 2017 resulted in a higher catch rate for trout ≥457 mm (7 fish/h; Figure 3-25).


A Brook Trout from the 2017 Boone tailwater sample.

Historically, only adult Rainbow Trout were stocked in the Ft. Patrick Henry Lake (Boone tailwater) at annually-variable rates, averaging 9,700/year during 1990-2007 (Figure 3-26). Since 2007, adult Rainbow Trout stocking rates have averaged 8,600, although only 4,000 were stocked in 2017 (Figure 3-26). Fingerling Rainbow Trout were added to the stocking program in 2008 and have been stocked most years since then (Figure 3-26), although their effectiveness here or in the Ft. Patrick Henry tailwater has not yet been evaluated.  Given the Boone tailwater's potential to produce large fish, Brown Trout were also added to the program in 2008 and since then, ~14,000 (primarily 203 mm) have been stocked annually, including 30,000 in 2017 (Figure 3-26).  Brook trout have been stocked occasionally since 2009 (Figure 3-26) and so far have shown limited survival, but good growth potential.

Repairs to address seepage at the earthen portion of Boone Dam continued in 2017 and require the extended drawdown of Boone Lake to an elevation of 412 m (1,352')—3.1 m (10') below winter pool.  TVA maintains a monitoring station in the tailwater near the dam that records several water quality parameters at 5-min. intervals.  There were no issues with elevated water temperatures in 2015 or 2016 (Habera et al. 2016, Habera et al. 2017).  The Boone tailwater reach of the South Fork Holston River is listed under TDEC's water usage classifications (Chapter 0400-40-04; TDEC 2013) and water quality standards (Chapter 0400-40-03; TDEC 2015) as trout water with a minimum dissolved oxygen (DO) criterion of 6 mg/l.  Although there were no DO issues in 2015 (Habera et al. 2016), DO levels below 6.0 mg/l occurred on all but 7 days during May-July 2016 (often for over 12 h) and on most days in October.  Dissolved oxygen did not fall below 3.0 mg/l in 2016, but it was in the 4 mg/l range on 46 days during May-July.  Despite these DO depressions in 2016 (likely related to drought conditions and reduced flows during summer and fall 2016), the 2017 trout fishery monitoring results do not indicate any particular effect on the Boone tailwater trout fishery. TVA's 2017 water quality monitoring results indicated no particular issues with water temperature. Daily high temperatures exceeded 21°C during the afternoon of 17 July and briefly on only four other days. Dissolved oxygen levels were generally better than in 2016, with observations <6 mg/l occurring on 20 days in July, but only nine days during August-October. Dissolved oxygen fell below 4.0 mg/l on one day in 2017 (to 3.8 mg/l on 5 July) and was in the 4 mg/l range on only 6 days during July. These conditions are unlikely to have had any notable effects on the trout fishery. TVA projects that repairs to the dam will be completed sometime during 2020-2022.

## Management Recommendations

The Boone tailwater supports a relatively small trout fishery, but one that consistently—like the Ft. Patrick Henry tailwater downstream—produces large, well-conditioned trout. Mean $W_r$ is 106 for Rainbow Trout (SE=0.57), 109 for Brown Trout (SE=1.61), and 96 for Brook Trout (SE= 2.89). This fishery is currently subject to statewide trout angling regulations and no changes are recommended at this time. The current trout stocking rates should be adjusted as more is learned about this tailwater (particularly survival and recruitment of fingerling Rainbow Trout) and then maintained. Brook Trout should also be included when possible, as trophy-sized fish can clearly be produced—an option not available with most other Brook Trout fisheries available to the public. Additionally, the four monitoring stations should be sampled annually to obtain information necessary for the future management of this fishery. These basic recommendations will be incorporated into a trout management plan for the Boone and Ft. Patrick Henry tailwaters (in preparation during 2017-2018) to ensure that they continue to achieve their potential to provide exceptional angling opportunities for quality-sized trout. TWRA will also continue to work cooperatively with TVA to ensure that the Boone Lake drawdown does not impact the tailwater trout fishery (or the other sport fisheries in the lake).

## Boone Tailwater

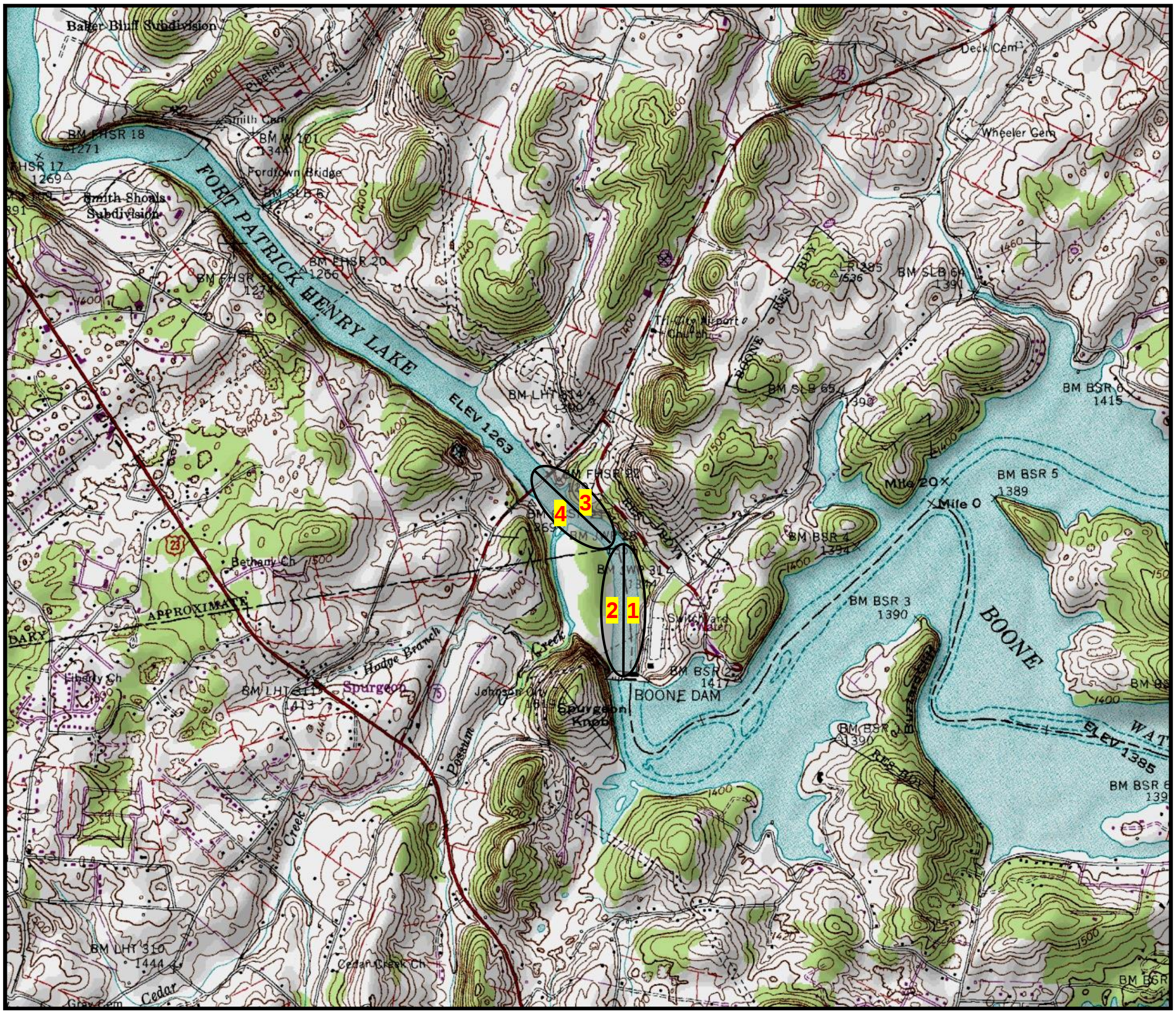



Figure 3-23. Location of the Boone tailwater (South Fork Holston River) monitoring stations.

Table 3-9 Location and sampling information for the four stations on the Boone tailwater, 16 March 2017.

| Station | Site Code | County | Quadrangle | Coordinates | Reach Number | River Mile | Effort (s) | Output |
|---|---|---|---|---|---|---|---|---|
| 1 | 420170401 | Sullivan | Boone Dam 198 NW | 36.44302N-82.43746W | 06010102-5,1 | 18.5 | 900 | 200 V DC 120 PPS, 4 A |
| 2 | 420170402 | Washington | Boone Dam 198 NW | 36.44344N-82.43823W | 06010102-5,1 | 18.5 | 900 | 884 V DC 120 PPS, 5 A |
| 3 | 420170403 | Sullivan | Boone Dam 198 NW | 36.44589N-82.43883W | 06010102-5,1 | 18.2 | 900 | 200 V DC 120 PPS, 4 A |
| 4 | 420170404 | Sullivan | Boone Dam 198 NW | 36.44589N-82.43887W | 06010102-5,1 | 18.2 | 900 | 884 V DC 120 PPS, 5 A |

Table 3-10. Catch data for the four electrofishing stations on the Boone tailwater sampled 16 March 2017.

| Station | Species | Total Catch | Size Range (mm) | Total Weight (g) | % Abundance (number) | % Abundance (weight) |
|---|---|---|---|---|---|---|
| 1 | Rainbow | 4 | 275-324 | 1,191 | 18 | 11 |
| | Brown | 11 | 173-602 | 7,891 | 50 | 76 |
| | Brook | 7 | 209-303 | 1,329 | 32 | 13 |
| **Totals** | | **22** | | **10,411** | **100** | **100** |
| 2 | Rainbow | 17 | 246-400 | 8,208 | 52 | 77 |
| | Brown | 8 | 169-314 | 902 | 24 | 8 |
| | Brook | 8 | 236-295 | 1,518 | 24 | 14 |
| **Totals** | | **33** | | **10,628** | **100** | **100** |
| 3 | Rainbow | 12 | 284-393 | 5,245 | 52 | 36 |
| | Brown | 9 | 178-722 | 8,945 | 39 | 62 |
| | Brook | 2 | 248-252 | 332 | 9 | 2 |
| **Totals** | | **23** | | **14,522** | **100** | **100** |
| 4 | Rainbow | 28 | 268-400 | 9,976 | 90 | 73 |
| | Brown | 1 | 676 | 3,240 | 3 | 24 |
| | Brook | 2 | 247-290 | 420 | 6 | 3 |
| **Totals** | | **31** | | **13,636** | **100** | **100** |
| **Total Rainbow** | | **61** | 246-400 | **24,620** | 56 | 50 |
| **Total Brown** | | **29** | 169-722 | **20,978** | 27 | 43 |
| **Total Brook** | | **19** | 209-303 | **3,599** | 17 | 7 |
| **Overall totals** | | **109** | | **49,197** | **100** | **100** |

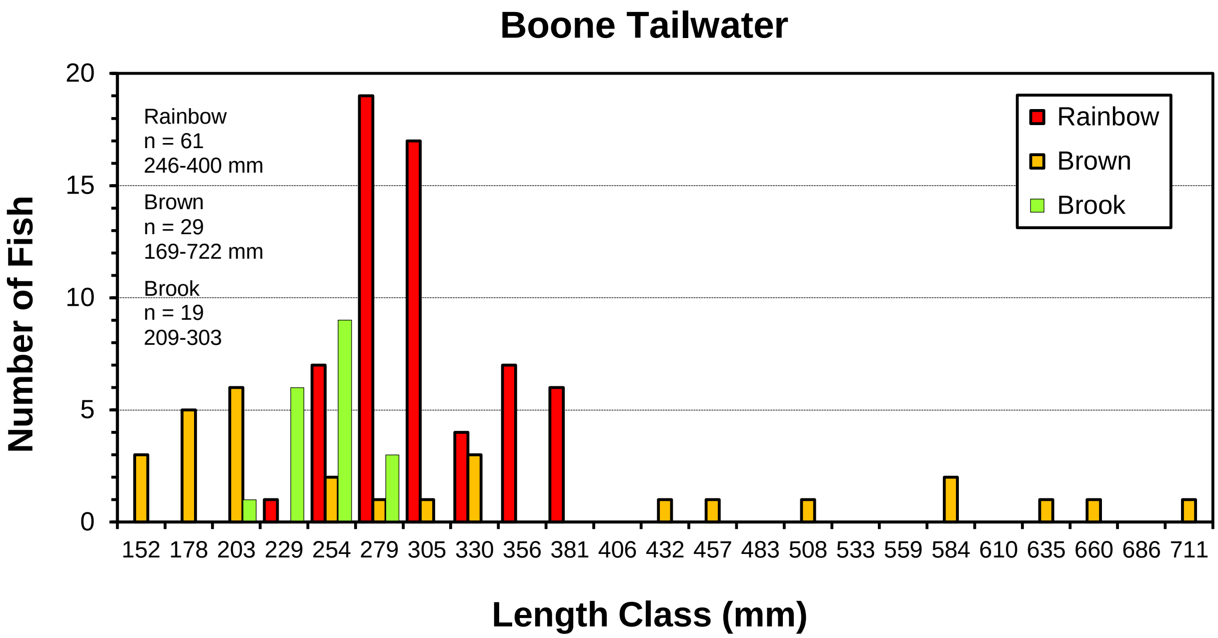



Figure 3-24. Length frequency distributions for trout from the Boone tailwater monitoring stations in 2017.

# Boone Tailwater

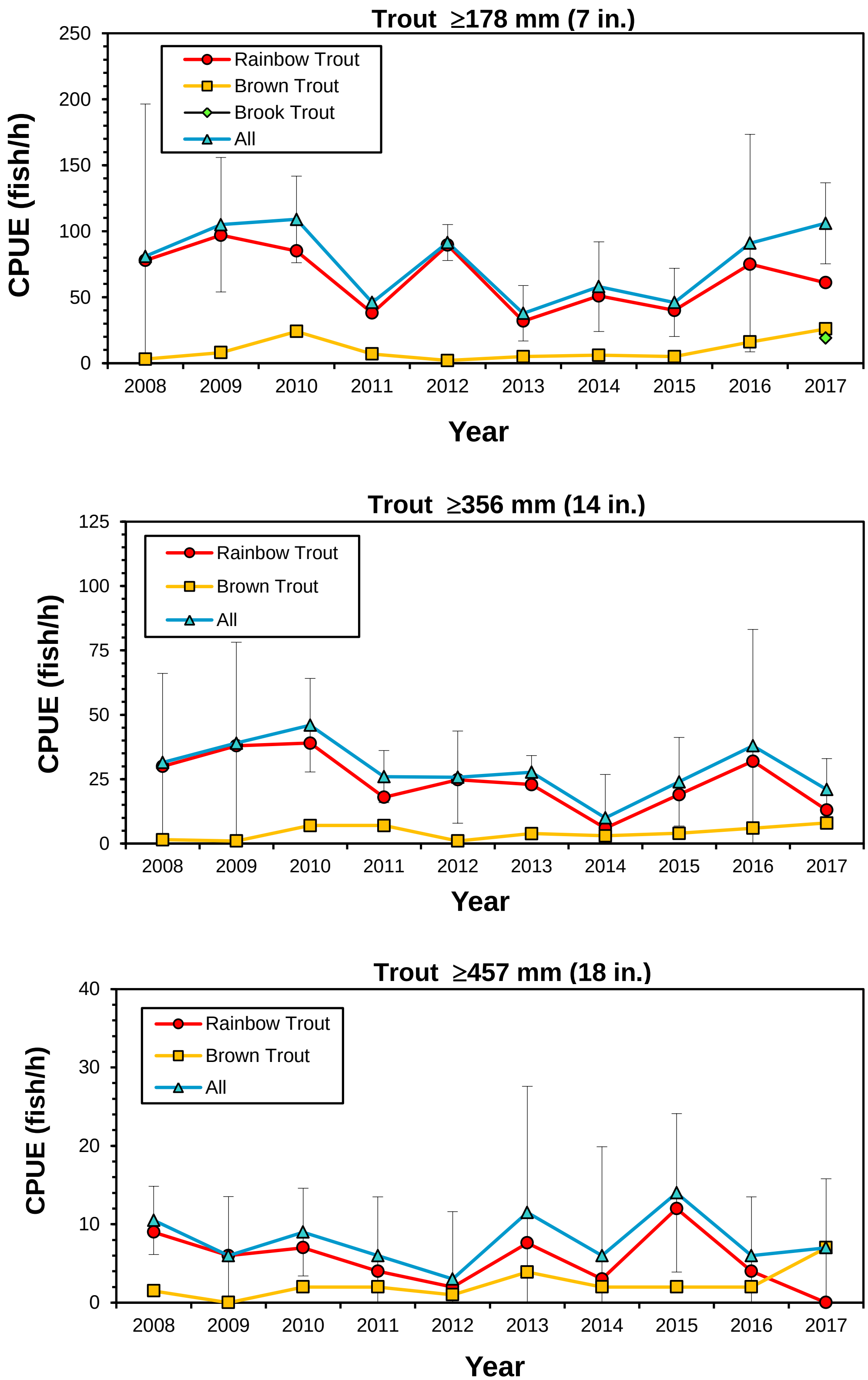



Figure 3-25. Mean trout CPUEs for the Boone tailwater samples. Bars indicate 90% confidence intervals.

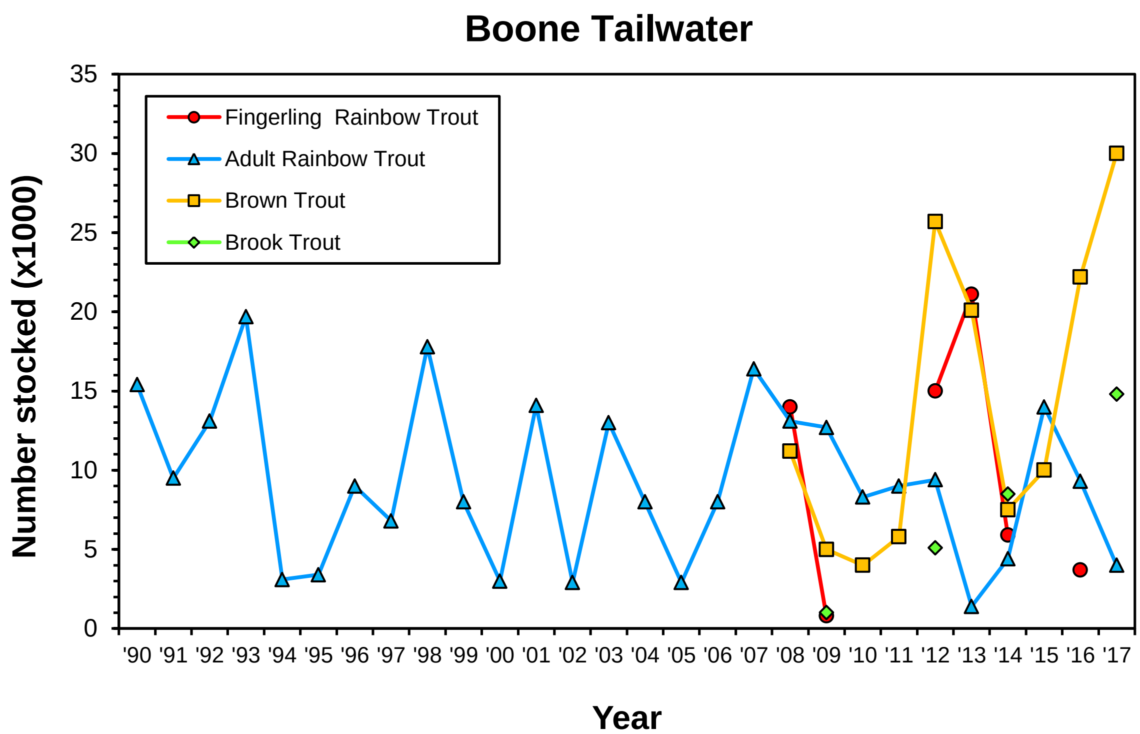



Figure 3-26. Recent trout stocking rates for Ft. Patrick Henry Lake / Boone tailwater. An average of 6,600 adult Rainbow Trout, 6,100 fingerling Rainbow Trout, 18,000 Brown Trout, and 4,700 Brook Trout was stocked during 2013-2017.

### 3.2.6 South Holston (South Fork Holston River)

**Study Area**

The South Holston tailwater extends ~22.5 km (13.7 mi.) from South Holston Dam to Boone Reservoir. The tailwater was created in 1951 when TVA completed construction of the dam at South Fork Holston River Mile (SFHRM) 49.8 in Sullivan County, Tennessee. The reservoir upstream of the dam has a drainage area of 1,821 $km^2$ and extends upstream for 38.1 km into Washington County, Virginia. Much of the watershed is forested and includes portions of the CNF (Tennessee) and the Jefferson National Forest (Virginia). The tailwater has an average width of 61 m and a surface area of about 137 ha.

TVA addressed low DO levels during summer and fall and a lack of minimum flow in the tailwater by constructing an aerating labyrinth weir at SFHRM 48.5 in 1991 as part of its Reservoir Releases Improvement Program. The weir maintains a minimum flow of 2.55 $m^2/s$ (90 CFS) and recovers approximately 40-50% of the oxygen deficit as water passes over it (Yeager et al. 1993). The turbine is typically pulsed twice daily to maintain the weir pool and these releases are aerated via turbine venting aided with hub baffles. The weir and turbine improvements combine to help maintain the target DO concentration of 6 ppm.

The first trout stockings in the South Holston tailwater occurred in 1952 and included fingerling and adult Rainbow Trout and Brook Trout. Subsequently, annual stockings of adult and fingerling Rainbow Trout, as well as sub-adult Brown Trout maintained put-and-take and put-and-grow fisheries. Investigations conducted for TWRA by Bettoli et al. (1999) documented substantial natural reproduction (particularly by Brown Trout) and an overwintering biomass (80% Brown Trout) of 170-232 kg/ha. Later, Meerbeek and Bettoli (2005) measured an overwintering Brown Trout biomass of 207 kg/ha during 2003-2004 (highest among all Tennessee tailwaters). Mork's (2011) study of large (>460 mm) Brown Trout movement in the Boone Lake system verified that some South Holston fish use the reservoir in winter and spring (but not fish from the Wilbur tailwater) and that there was no intermingling of fish from those two populations. No Brown Trout have been stocked in the South Holston tailwater since 2003 because of the excellent wild Brown Trout fishery that has developed. Rainbow Trout continue to be managed as both a put-and-take and put-and-grow fishery by stocking 40,000 adults and 50,000 fingerlings annually (Habera et al. 2015c).

Management strategy for the South Holston tailwater shifted to a focus on the wild Brown Trout fishery with better biological information and corresponding angler support. All snagging was banned in 1999 and two major trout spawning areas were closed to fishing during November-January. These measures were taken to protect large Brown Trout during the spawning season and to facilitate development of a self-sustaining fishery. A 406-559 mm (16-22 in.) protected length range (PLR) or "slot limit" was established for the entire tailwater in 2000 with the goal of shifting population structure toward larger fish and protecting spawners (primarily Brown Trout). Slot limits of this type have been shown to be effective at improving trout population size structures (Luecke et al. 1994; Power and Power 1996).

TWRA established two monitoring sites on the South Holston tailwater in 1995 (Bivens et al. 1996) and sampled these annually during the summer (at base flow) to begin compiling a database on the existing trout fishery. These sites were replaced in 1999 with the 12 stations (Figure 3-27) and protocol established by Bettoli et al. (1999). Current sample site location and effort details are summarized in Table 3-11.

### Results and Discussion

The 12 South Holston tailwater monitoring stations produced 584 trout weighing 160 kg in 2017 (Table 3-12). Brown Trout catch declined again—11% relative to 2016—and biomass decreased 10%. Brown Trout represented 88% of the sample by number and 87% by biomass in 2017, which is similar to samples from recent years. Thirty-two sub-adult Brown Trout ≤127 mm were captured in 2017—the most since 2012. This relatively crude indicator of year class strength (for the preceding year) suggests that a relatively large cohort may be entering the population, which contributes to density-dependent effects on growth and recruitment, particularly given the low levels of angler exploitation.

Brown Trout exhibited a bimodal length frequency distribution, with modes at the 152- and 279-mm classes (Figure 3-28). Fish in the 229-330 mm (9-13 in.) size classes represented 59% of the total Brown Trout sample in 2016 and again in 2017 (Figure 3-28), which is down from the peak average of 69% during 2011-2015. There was also better recruitment into the size classes approaching the PLR (356 and 381 mm) again in 2017, although the catch for fish in the PLR decreased from 20 in 2016 to 15 in 2017 (Figure 3-28). The average PLR catch for 2010-2017 is 20 fish, but was twice as high (48) during 2004-2009.

Relative stock density for all trout ≥406 mm (RSD-16) —based on a stock size of 254 mm (Willis et al. 1993)—declined slightly to 4 in 2017, but has remained at ≤5 since 2010 (Figure 2-29). Prior to any influence from the PLR regulations (1997, 1999-2000) RSD-16 averaged 15 with a corresponding mean CPUE of 106 fish/h (≥178 mm). Following establishment of the PLR, RSD-16 reached 18 in 2006 (Figure 2-29), but has declined since then (Figure 2-29) as total CPUE has generally ranged from 250-400 fish/h (≥178 mm). Current trout population size structures, therefore, do not indicate a shift toward larger fish—one of the original intents of the PRL. The Norris tailwater PLR (356-508 mm or 14-20 in.), by comparison, has successfully altered trout population size structures in favor of lager fish and maintained that shift (see Section 3.2.1). Recent angler surveys indicate that the trout harvest rate for both tailwaters is low (Norris, 0.98 fish/trip; South Holston, 1.04 fish/trip), with pressure at Norris (12,249 trips) about half that estimated for South Holston (24,285 trips; Black 2014, 2015).

Mean CPUE for trout ≥178 mm (total) declined again to 254 fish/h in 2017—the lowest level since 2006 (Figure 3-30). The 2017 mean catch rate for Brown Trout ≥178 mm (219 fish/h; Figure 3-30) also decreased again, but still somewhat exceeds the range considered in the new management plan to be more conducive to recruitment into the PLR (150-200 fish/h; Habera et al. 2015c). The mean catch rate for Rainbow Trout ≥178 mm was 35 fish/h in 2017 (Figure 3-30) and 43 fish/h for the past three years—relatively close to the current management plan objective is ≥50 fish/h (Habera et al. 2015c). Trout ≥356 mm are considered to be "quality"-sized fish and the mean catch rate for these fish peaked at 72 fish/h in 2005, but has generally declined since then, although there has been an increase from 23 to 43 fish/h during the past two years (Figure 3-30). The catch rate for trout in the PLR (406-559 mm) has also declined from its peak of 29 fish/h in 2006, averaging 12 fish/h since 2009 (Figure 3-30).

The substantial (3- to 4-fold) increase in trout abundance since the late 1990s (particularly for wild browns) appears to have affected growth (Bohlin et al. 2002; Vøllestad et al. 2002; Lobon-Cervia 2007) and recruitment (Walters and Post 1993)—particularly to larger size classes—as increasing numbers of fish compete for food resources that tend to limit salmonid populations in tailwaters and unregulated streams (e.g., Filbert and Hawkins 1995; Ensign et al. 1990; Korman et al. 2017). Although mean relative weights ($W_r$) for Brown Trout in the size classes immediately below the PLR (305-405 mm) were typically >90 prior to 2007, there was a general decline through 2015 as overall abundance increased (Figure 3-31). The effect of overcrowding is particularly evident for fish in the 300-400 mm size range based on the relationship of $W_r$ and total length (Figure 3-32). Mean $W_r$ for Brown Trout in the PLR has also generally declined since 2005, reaching its lowest level in 2017 (85; Figure 3-31). This suggests that the abundance of trout in the river has affected condition and thereby limited growth and recruitment into the PLR. Korman et al. (2017) related poor condition of larger Rainbow Trout in the Glen Canyon tailwater (AZ) to low fall/winter survival rates. Yard et al. (2015) observed that the highest growth and relative condition for Rainbow Trout in Glen Canyon tailwater (AZ) occurred in areas with lower densities. Similarly, McKinney et al. (2001) reported that increased abundance of Rainbow Trout in the Lee's Ferry tailwater, AZ (resulting from higher, more stable flows) was accompanied by reduced relative condition, particularly for fish ≥305 mm. Dibble et al. (2015) also found that Brown Trout length declined when large cohorts recruited to adult size in western tailwaters. Additionally, Fox and Neal (2011) saw depressed largemouth bass *Micropterus salmoides* $W_r$ at intermediate sizes as the population—managed with a 356-508 mm PLR—became overcrowded.

### Management Recommendations

The South Holston's exceptional wild Brown Trout fishery provides the primary means for attaining the tailwater's management goal, which continues to be providing a high-quality trout fishery and the variety of angling opportunities it offers (Habera et al. 2015c). These fish have undoubtedly helped produce the high angler catch rates and satisfaction levels mentioned above. Rainbow Trout are also an important part of the fishery, which is being sustained through consistent annual stocking rates for adults and fingerlings.

The mean PLR catch rate during 2009-2014 (13 fish/h) did not achieve the corresponding management plan objective (25 fish/h; Habera et al. 2009c). Currently, density-dependent factors continue to limit Brown Trout growth, condition, and recruitment into the larger size classes (i.e., the PLR), thus there is no enhancement of population size structure relative to pre-PLR conditions. Dreves et al. (2016) used a 508-mm (20-in.) minimum size limit and 1 fish/day creel limit to improve the size structure of Brown Trout (particularly for fish ≥381 mm) in the Lake Cumberland tailwater (KY) without incurring density-dependent impacts to growth and condition. Although overall Brown

Trout CPUE there increased 3-fold over 10 years, it remained relatively low (89 fish/h) and most likely below the carrying capacity of the tailwater (Dreves et al. 2016); density-dependent responses, therefore, were not triggered. Additionally, the Cumberland Lake tailwater Brown Trout fishery is hatchery supported, thus providing essentially stable recruitment annually (as in the Norris tailwater). Ultimately, if food availability and fish growth are limited in tailwater trout fisheries (e.g., in high abundance populations), then restrictive angling regulations may be unsuccessful (Flinders and Magoulick 2017).

When overall trout abundance in the South Holston tailwater is relatively high (CPUE >200 fish/h) and the angler harvest rate for Brown Trout remains extremely low (3.5%; Black 2015), it is unlikely that RSD-16 will improve much. In fact, current trout abundance would require doubling the 2017 catch for trout ≥406 mm or 16 in. from 20 to 42 to raise RSD-16 to 10, which would still be below the pre-PLR mean of 15. Although RSD target values have not been defined for balanced Brown Trout populations (Pedicillo et al. 2010), RSD-16 for South Holston tailwater Brown Trout has reached the 15-20 range both before and after (2005-2007) establishment of the PLR regulation. Achieving and maintaining an RSD-16 of ~15 (mostly composed of Brown Trout) would more closely align with the basic management goal of providing a high-quality trout fishery (Habera et al. 2015c).

Factors that impact trout year-class strength, such as high flows, can reduce density-dependent effects on growth, condition, and recruitment. Any such events in the South Holston tailwater have had minimal effects on Brown Trout year-class strength, as cohorts produced during the past several years have been sufficient to substantially increase abundance—even with declining numbers of large spawners. Brown Trout spawning activity in the South Holston tailwater begins during early November and peaks in mid to late-December (Banks and Bettoli 2000). A somewhat earlier spawning season (mid-October through November) was observed for Brown Trout in the White River (AR) tailwater, with emergence there beginning at the end of February (Pender and Kwak 2002). Fry emergence in the South Holston tailwater has not been studied, but likely occurs in March or early April (based on spawning period). Dibble et al. (2015) observed that Brown Trout recruitment was affected most by flow velocity, and that high levels of recruitment indirectly reduce fish size. Therefore, management actions that can decrease Brown Trout recruitment when necessary, such as altering dam operations (i.e., to produce high flows) could help maintain more stable trout populations with larger adults through relaxed intraspecific competition (Dibble et al. 2015) and avoidance of boom-and-bust cycles (Korman et al. 2017). Pender and Kwak (2002) observed age-0 tailwater Brown Trout using gravel interstices as refugia from high velocities at the onset of water releases, so velocities would have to be high enough or the fish vulnerable enough for high flows to be effective. This timeframe would likely occur just after emergence (March-April) in the South Holston tailwater, although it coincides with the refill period on TVA's guide curve for South Holston Lake. Interestingly, extended marginally-high flows (20-50% above average) actually improved development of large cohorts or Rainbow Trout in the Glen Canyon tailwater (Avery et al. 2015).

Angler catch rates for Brown Trout (137,000 total, 5.6/trip in 2014; Black 2015) appear high enough that harvest could help control population size and improve growth, condition, and recruitment into the PLR, thus anglers are encouraged to harvest 229-305 mm (9-12 inch) Brown Trout. Harvesting fish below the lower boundary of a PLR is necessary to prevent overcrowding; without sufficient exploitation, stockpiling occurs and the regulation becomes ineffective (Wilde 1997; Noble and Jones 1999; Fox and Neal 2011). However, if anglers are generally satisfied with the increased Brown Trout abundance and higher associated catch rates that exist now, then they may not be concerned by the current ineffectiveness of the PLR.

A new roving creel survey was conducted on the South Holston tailwater during 2017. During this survey, anglers were asked to rate their satisfaction with the trout fishery on a scale of 1 (poor) to 5 (excellent). A majority (87%) of the 454 anglers responding rated their satisfaction as good or excellent (4 or 5), while another 10% gave a rating of 3 (o.k.). These anglers were also informed that 9-12 inch Brown Trout had become very abundant in the fishery over the past several years, that the overall angler harvest rate was low (<5%), and that PLR regulations work best when fish below the 'slot' are harvested. They were then asked if they would increase their harvest of smaller (9-12 inch) fish given that it would help improve the size structure of the Brown Trout population. Although there was not a majority position, more anglers (44%) said they would increase Brown Trout harvest than those who said they would not (40%), while 16% offered no opinion. Additional results, including estimated angling pressure, catch, and harvest rates, will be available for inclusion in the 2018 report.

Because of the presence of whirling disease *Myxobolus cerebralis* in Virginia and nearby North Carolina trout fisheries—and the popularity of the South Holston tailwater with anglers from those areas, 53 Rainbow Trout and 13 Brown Trout captured during 2017 were submitted to the U.S. Fish and Wildlife Service's Fish Health Lab in Warm Springs, GA to be screened for this pathogen. Whirling disease was confirmed in Rainbow Trout and TWRA will move forward with information and education efforts directed at preventing the spread of spores and infected fish, as well as screening of additional trout fisheries in 2018.

## South Holston Tailwater

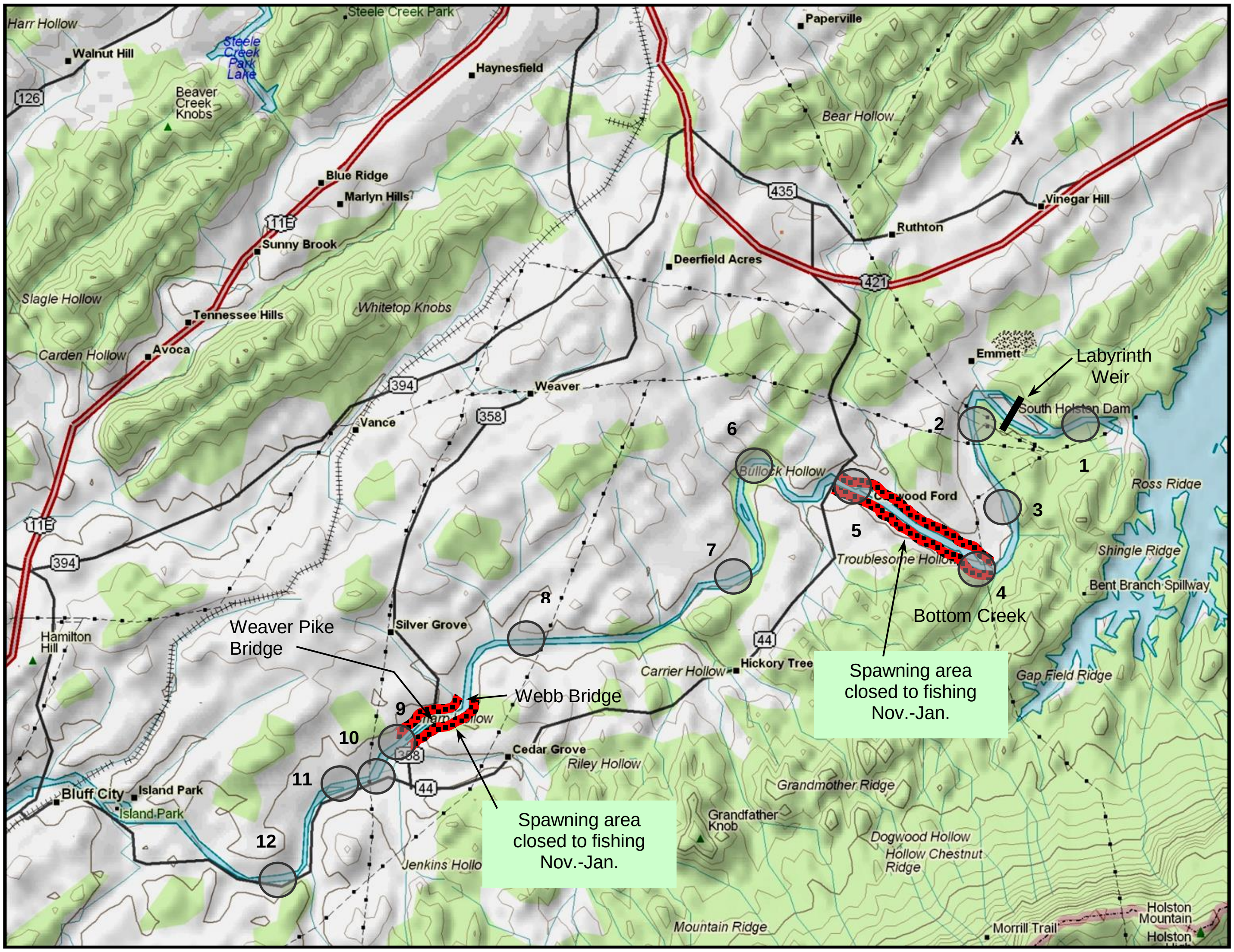



Figure 3-27. Locations of the South Holston tailwater (South Fork Holston River) monitoring stations.

Table 3-11. Location and sampling information for the 12 stations on the South Holston tailwater, 7 March 2017.

| Station | Site Code | County | Quadrangle | Coordinates | Reach Number | River Mile | Effort (s) | Output |
|---|---|---|---|---|---|---|---|---|
| 1 | 420170201 | Sullivan | Holston Valley 206 SE | 36.5236N-82.09306W | 06010102-14,0 | 49.5 | 600 | 884 V DC 120 PPS, 4-5 A |
| 2 | 420170202 | Sullivan | Holston Valley 206 SE | 36.52500N-82.11528W | 06010102-14,0 | 48 | 600 | 884 V DC 120 PPS, 4-5 A |
| 3 | 420170203 | Sullivan | Holston Valley 206 SE | 36.50972N-82.10694W | 06010102-14,0 | 46.8 | 600 | 884 V DC 120 PPS, 4-5 A |
| 4 | 420170204 | Sullivan | Holston Valley 206 SE | 36.50417N-82.11111W | 06010102-13,2 | 46.4 | 600 | 884 V DC 120 PPS, 4-5 A |
| 5 | 420170205 | Sullivan | Bristol 206 SW | 36.51250N-82.12778W | 06010102-13,2 | 45.3 | 600 | 884 V DC 120 PPS, 4-5 A |
| 6 | 420170206 | Sullivan | Bristol 206 SW | 36.51389N-82.14444W | 06010102-13,2 | 44.2 | 600 | 884 V DC 120 PPS, 4-5 A |
| 7 | 420170207 | Sullivan | Bristol 206 SW | 36.50972N-82.14861W | 06010102-13,2 | 43 | 600 | 30-40% low range 120 PPS DC, 4 A |
| 8 | 420170208 | Sullivan | Bristol 206 SW | 36.49528N-82.18056W | 06010102-13,2 | 40.6 | 600 | 30-40% low range 120 PPS DC, 4 A |
| 9 | 420170209 | Sullivan | Keenburg 207 NW | 36.48194N-82.20556W | 06010102-13,2 | 38.6 | 600 | 30-40% low range 120 PPS DC, 4 A |
| 10 | 420170210 | Sullivan | Keenburg 207 NW | 36.47917N-82.20833W | 06010102-13,2 | 38.4 | 600 | 30-40% low range 120 PPS DC, 4 A |
| 11 | 420170211 | Sullivan | Keenburg 207 NW | 36.47778N-82.21528W | 06010102-13,1 | 38 | 600 | 30-40% low range 120 PPS DC, 4 A |
| 12 | 420170212 | Sullivan | Keenburg 207 NW | 36.46556N-82.22083W | 06010102-13,1 | 37.1 | 600 | 30-40% low range 120 PPS DC, 4 A |

Table 3-12. Catch data for the12 electrofishing stations on the South Holston tailwater sampled 7 March 2017.

| Station | Species | Total Catch | Size Range (mm) | Total Weight (g) | % Abundance (number) | % Abundance (weight) |
|---|---|---|---|---|---|---|
| 1 | Rainbow | 8 | 278-480 | 4,411 | 100 | 100 |
| | Brown | 0 | -- | 0 | 0 | 0 |
| **Totals** | | **8** | | **4,411** | **100** | **100** |
| 2 | Rainbow | 10 | 250-479 | 3,698 | 14 | 21 |
| | Brown | 60 | 112-410 | 13,711 | 86 | 79 |
| **Totals** | | **70** | | **17,409** | **100** | **100** |
| 3 | Rainbow | 5 | 173-298 | 960 | 6 | 7 |
| | Brown | 72 | 110-360 | 12,755 | 94 | 93 |
| **Totals** | | **77** | | **13,715** | **100** | **100** |
| 4 | Rainbow | 4 | 329-351 | 1,431 | 7 | 9 |
| | Brown | 55 | 94-412 | 13,808 | 93 | 91 |
| **Totals** | | **59** | | **15,239** | **100** | **100** |
| 5 | Rainbow | 9 | 166-390 | 1,987 | 24 | 27 |
| | Brown | 29 | 119-565 | 5,292 | 76 | 73 |
| **Totals** | | **38** | | **7,279** | **100** | **100** |
| 6 | Rainbow | 5 | 231-335 | 1,368 | 9 | 9 |
| | Brown | 49 | 172-370 | 13,714 | 91 | 91 |
| **Totals** | | **54** | | **15,082** | **100** | **100** |
| 7 | Rainbow | 5 | 233-325 | 1,195 | 11 | 9 |
| | Brown | 41 | 141-498 | 12,500 | 89 | 91 |
| **Totals** | | **46** | | **13,695** | **100** | **100** |
| 8 | Rainbow | 11 | 214-347 | 2,166 | 27 | 16 |
| | Brown | 30 | 180-487 | 11,744 | 73 | 84 |
| **Totals** | | **41** | | **13,910** | **100** | **100** |
| 9 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 66 | 123-478 | 16,994 | 100 | 100 |
| **Totals** | | **66** | | **16,994** | **100** | **100** |
| 10 | Rainbow | 0 | -- | 0 | 0 | 0 |
| | Brown | 22 | 151-400 | 7,660 | 100 | 100 |
| **Totals** | | **22** | | **7,660** | **100** | **100** |
| 11 | Rainbow | 7 | 163-334 | 1,290 | 13 | 8 |
| | Brown | 45 | 168-536 | 14,858 | 87 | 92 |
| **Totals** | | **52** | | **16,148** | **100** | **100** |
| 12 | Rainbow | 7 | 255-417 | 2,554 | 14 | 14 |
| | Brown | 44 | 214-406 | 16,178 | 86 | 86 |
| **Totals** | | **51** | | **18,732** | **100** | **100** |
| **Total Rainbows** | | 71 | 163-480 | 21,060 | 12 | 13 |
| **Total Browns** | | 513 | 94-565 | 139,214 | 88 | 87 |
| **Overall totals** | | **584** | | **160,274** | **100** | **100** |

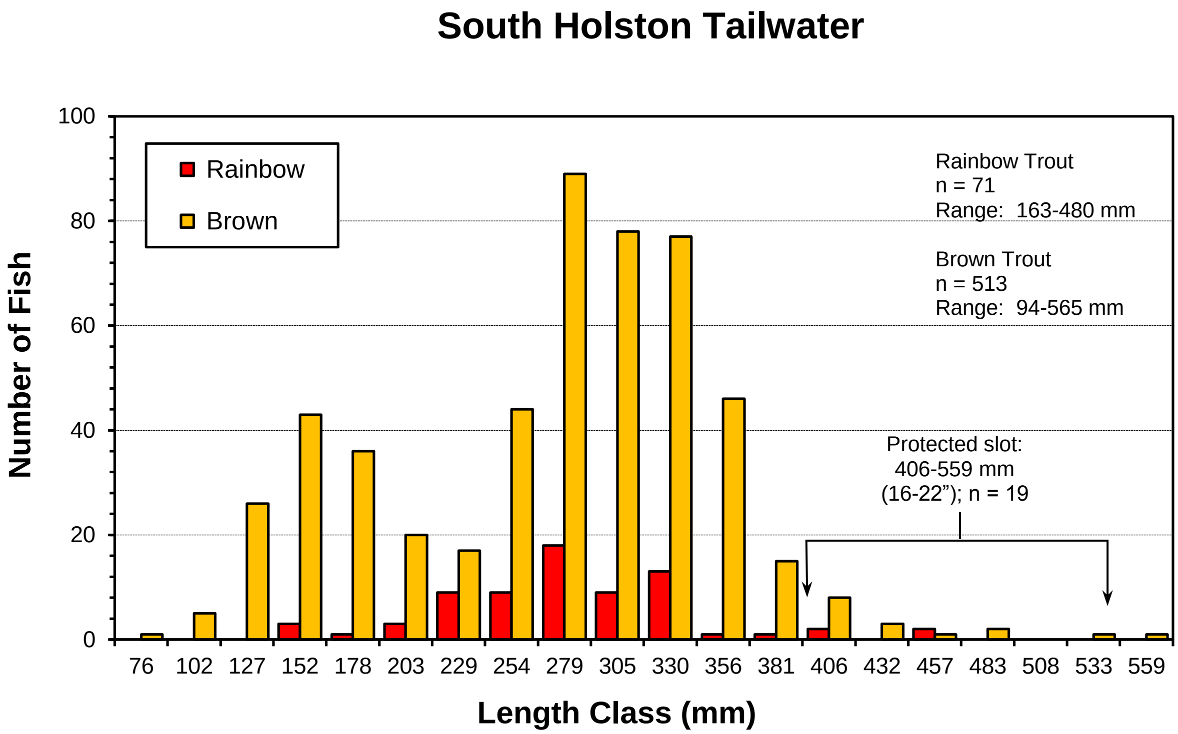



Figure 3-28. Length frequency distributions for trout from the South Holston tailwater monitoring stations in 2017.

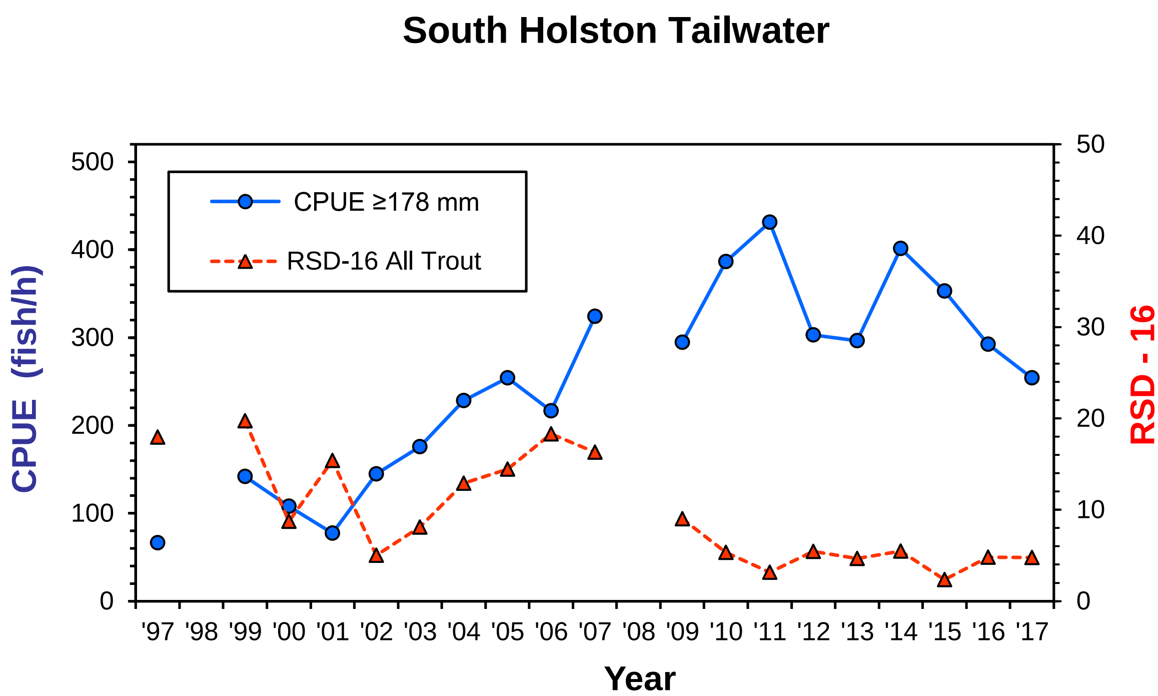
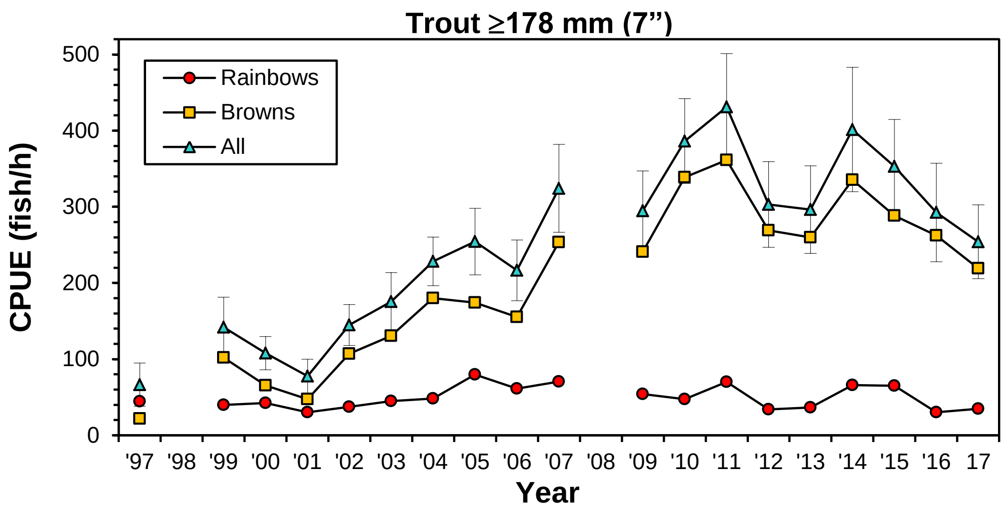
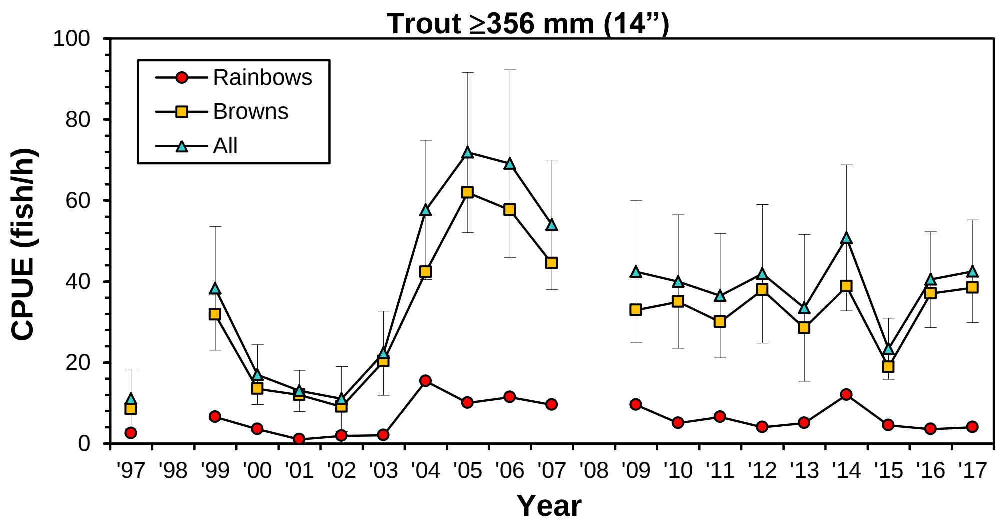



Figure 3-29. Comparison of mean CPUE (fish/h) for all trout ≥178 mm and RSD-16 (all trout) for the South Holston tailwater.

# South Holston Tailwater



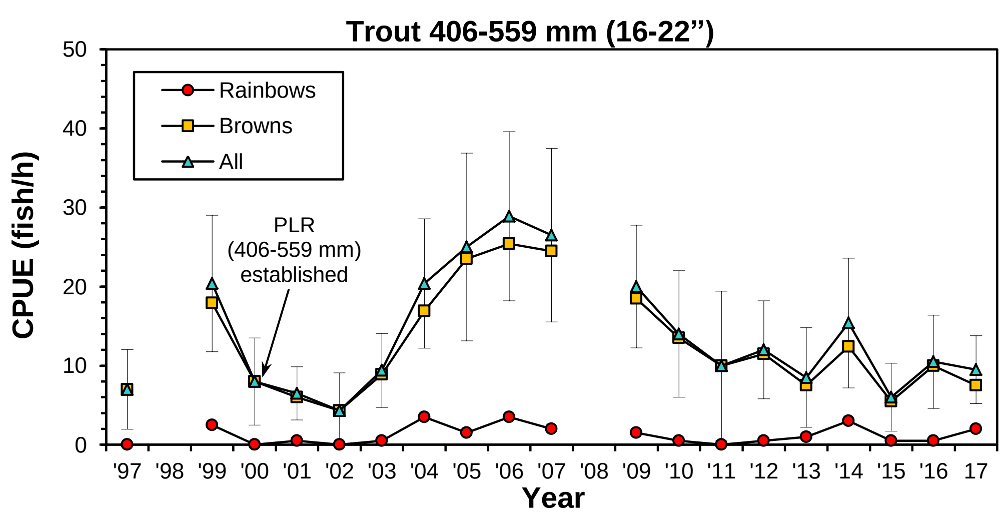




Figure 3-30. Mean trout CPUEs for the South Holston tailwater samples. Bars indicate 90% confidence intervals.

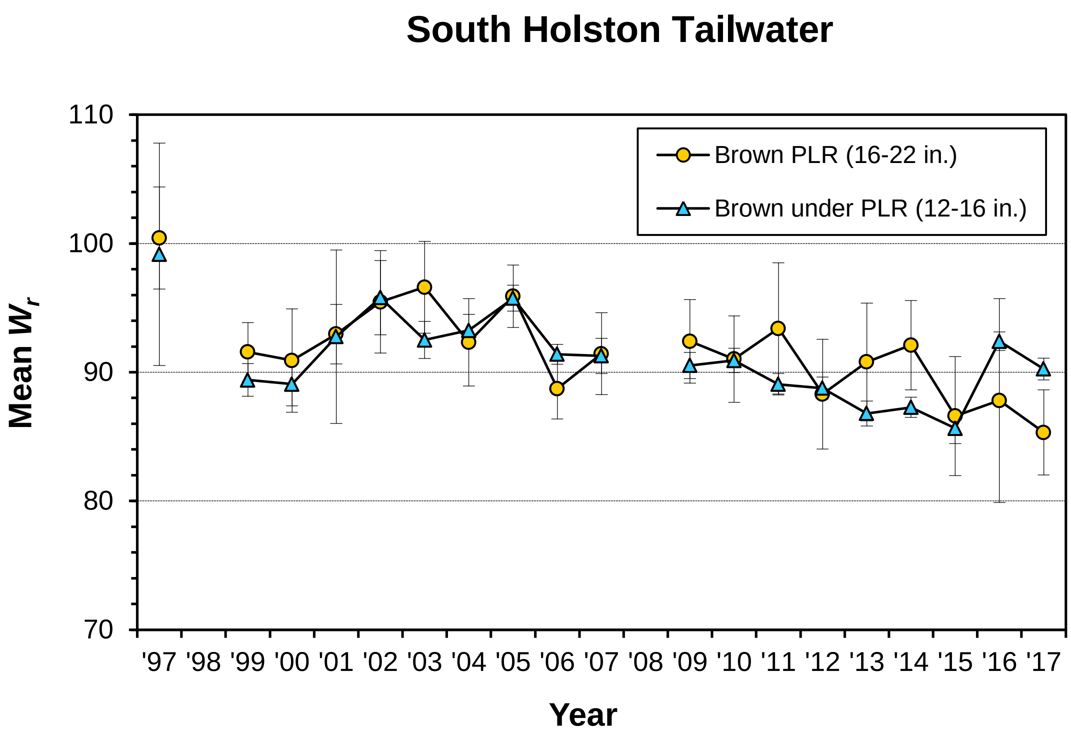



Figure 3-31. Mean relative weights ($W_r$) for brown trout from the South Holston tailwater. Bars indicate 90% confidence intervals.

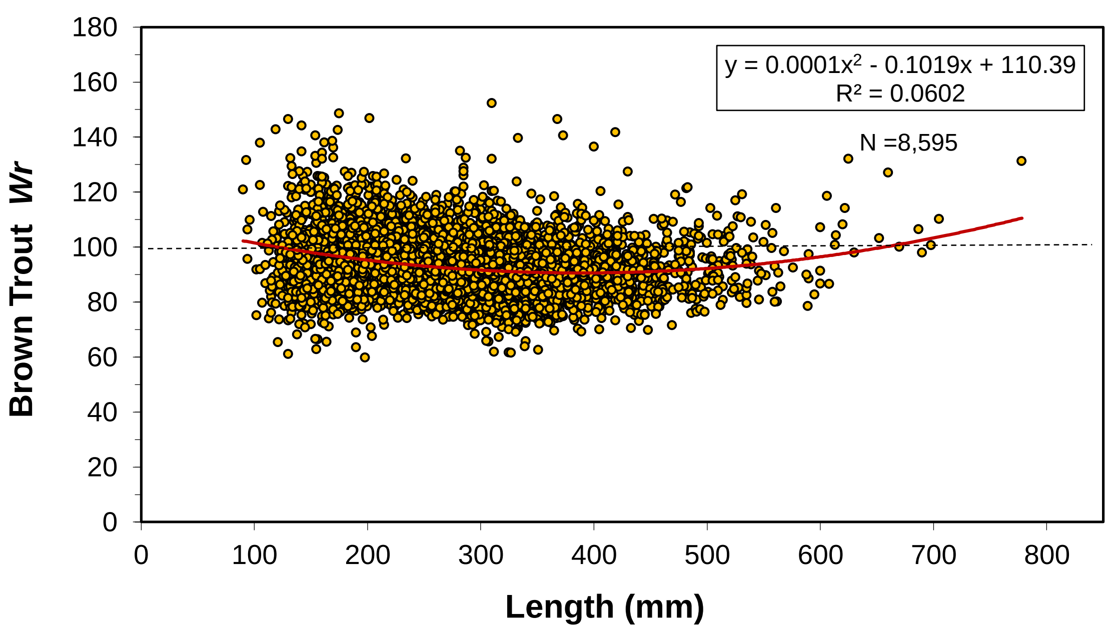



Figure 3-32. Relative weights ($W_r$) for brown trout from the South Holston Tailwater (2009-2016). Solid curved line is polynomial trend line and dashed line is optimum $W_r$ of 100.

## REFERENCES


Adams, S. B., C. A. Frissell, and B. E. Rieman. 2002. Changes in distribution of nonnative brook trout in an Idaho drainage over two decades. Transactions of the American Fisheries Society 131:561-568.

Anderson, R. O. 1976. Management of small warm water impoundments. Fisheries 1(6):561-568.

Anglin, Z. W., and G. D. Grossman. 2013. Microhabitat use by southern brook trout (Salvelinus fontinalis) in a headwater North Carolina stream. Ecology of Freshwater Fish 22:567-577.

Avery, L. A., J. Korman, and W. R. Persons. 2015. Effects of increased discharge on spawning and age-0 recruitment of Rainbow Trout in the Colorado River at Lees Ferry, Arizona. North American Journal of Fisheries Management 35:671-680.

Baird, O. E., and C. C. Krueger. 2003. Behavioral thermoregulation of brook and Rainbow Trout: comparison of summer habitat use in an Adirondack river, New York. Transactions of the American Fisheries Society 132:1194-1206.

Banks, S. M., and P. W. Bettoli. 2000. Reproductive potential of Brown Trout in Tennessee tailwaters. Fisheries Report No. 00-19. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettinger, J. M., and P. W. Bettoli. 2000. Movements and activity of Rainbow Trout and Brown Trout in the Clinch River, Tennessee, as determined by radio-telemetry. Fisheries Report No. 00-14. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W. 1999. Creel survey and population dynamics of salmonids stocked into the Watauga River below Wilbur Dam. Fisheries Report No. 99-41. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W. 2002. Clinch River creel survey results: March-October 2001. Fisheries Report No. 02-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W. 2003a. Survey of the trout fishery in the Watauga River: March-October 2002. Fisheries Report No. 03-05. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W. 2003b. Survey of the trout fishery in the South Fork of the Holston River, March-October 2002. Fisheries Report No. 03-06. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W. 2006. Clinch River creel survey results: April-October 2005. Fisheries Report No. 06-08. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W. 2007. Surveys of the trout fisheries in the Watauga River and South Fork of the Holston River: March-October 2005. Fisheries Report No. 07-07. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W., and L. A. Bohm. 1997. Clinch River trout investigations and creel survey. Fisheries Report No. 97-39. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bettoli, P. W., S. J. Owens, and M. Nemeth. 1999. Trout habitat, reproduction, survival, and growth in the South Fork of the Holston River. Fisheries Report No. 99-3. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bivens, R. D. 1979. Survey of brook trout streams on the Unaka and Nolichucky Ranger Districts, Cherokee National Forest. Internal project report, U.S. Department of Agriculture Forest Service, Cleveland, Tennessee.

Bivens, R. D. 1988. Region IV stream fishery data collection report: 1986-1987. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bivens, R. D. 1989. Region IV stream fishery data collection report: 1988. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bivens, R. D., and C. E. Williams. 1990. Region IV stream fishery data collection report: 1989. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bivens, R. D., M. T. Fagg, and C. E. Williams. 1992. Region IV trout fishery data collection report: 1991. Fisheries Report No. 93-17. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bivens, R. D., B. D. Carter, and C. E. Williams. 1996. Region IV trout fisheries report: 1995. Fisheries Report No. 96-5. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bivens, R. D., B. D. Carter, and C. E. Williams. 1998. Region IV trout fisheries report: 1997. Fisheries Report 98-3. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Black, W. P. 2014. Tennessee Statewide Creel Survey: 2013 Results. Final report, Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Black, W. P. 2015. Tennessee Statewide Creel Survey: 2014 Results. Final report, Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Black, W. P. 2017. Tennessee Statewide Creel Survey: 2016 Results. Fisheries Report 17-07. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Bohlin, T., L. F. Sundström, J. I. Johnsson, J. Höjesjö, and J. Pettersson. 2002. Density-dependent growth in Brown Trout: effects of introducing wild and hatchery fish. Journal of Animal Ecology 71:683-692.

Boles, H. D. 1980. Clinch River (Norris tailwater) trout fishery investigations 1971-1977. Fisheries Resources Internal Report (Interim Summary Report). U. S. Department of Interior, Fish and Wildlife Service.

Borawa, J. C. 1990. Field evaluation of domestic versus half-wild brown trout fingerling stockings. Pages 72-78 *in* J. C. Borawa, ed. Brown trout workshop: biology and management. American Fisheries Society, Southern Division, Trout Committee, Asheville, North Carolina.

Bowlby, J. N., and J. C. Roff. 1986. Trout biomass and habitat relationships in southern Ontario streams. Transactions of the American Fisheries Society 115:503-514.

Carline, R. F., and B. J. McCullough. 2003. Effects of floods on brook trout populations in the Monongahela National Forest, West Virginia. Transactions of the American Fisheries Society 132:1014-1020.

Clark, M. E., and K. A. Rose. 1997. Factors affecting competitive dominance of Rainbow Trout over brook trout in southern Appalachian streams: implications of an individual-based model. Transactions of the American Fisheries Society 126:1-20.

Clark, M. E., K. A. Rose, D. A. Levine, and W. W. Hargrove. 2001. Predicting climate change effects on Appalachian trout: combining GIS and individual-based modeling. Ecological Applications 11(1):161-178.

Cook, S. B. and T. C. Johnson. 2016. Assessment of southern Appalachian brook trout propagation as a tool for restoring Tennessee populations. Final report, Department of Biology and the Center for the Management, Protection and Utilization of Water Resources, Tennessee Technological University, Cookeville, Tennessee.

Damer, J., and P. W. Bettoli. 2008. The fate of brook trout stocked in the Watauga River below Wilbur Dam. Fisheries Report No. 08-03. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Davis, L., and T. Wagner. 2016. Scale-dependent seasonal pool habitat use by sympatric wild brook trout and Brown Trout populations. Transactions of the American Fisheries Society 145:888-902.

DeWeber, J. T., and T. Wagner. 2015. Predicting brook trout occurrence in stream reaches throughout their native range in the eastern United States. Transactions of the American Fisheries Society 144:11-24.

Dibble, K. L., C. B. Yackulic, T. A. Kennedy, and P. Budy. 2015. Flow management and fish density regulate salmonid recruitment and adult size in tailwaters across western North America. Ecological Applications 25:2168-2179.

Dodrill, M. J., C. B. Yackulic, T. A. Kennedy, and J. W. Hayes. 2016. Prey size and availability limits maximum size of Rainbow Trout in a large tailwater: insights from a drift-foraging bioenergetics model. Canadian Journal of Fisheries and Aquatic Sciences 73(5):1-14.

Dreves, D. P., J. R. Ross, and J. T. Kosa. 2016. Effect of trophy regulations and reservoir discharge on a population of stocked Brown Trout in a large, southeastern United States tailwater. Journal of the Southeastern Association of Fish and Wildlife Agencies 3:167-177.

Elliott, J. M. 2000. Pools as refugia for Brown Trout during two summer droughts: trout responses to thermal and oxygen stress. Journal of Fish Biology 56:938-948.

Ensign, W. E., R. J. Strange, and S. E. Moore. 1990. Summer food limitation reduces brook and Rainbow Trout biomass in a southern Appalachian stream. Transactions of the American Fisheries Society 119:894-901.

Filbert, R. B, and C. P. Hawkins. 1995. Variation in condition of Rainbow Trout in relation to food, temperature, and individual length in the Green River, Utah. Transactions of the American Fisheries Society 124:824-835.

Fiss, F. C., and J. W. Habera, editors. 2006. Trout management plan for Tennessee 2006-2016. Tennessee Wildlife Resources Agency, Nashville, Tennessee

Flinders, J. M., and D. D. Magoulick. 2017. Spatial and temporal consumption dynamics of trout in catch-and-release areas in Arkansas tailwaters. Transactions of the American Fisheries Society 146:432-499.

Fox, C. N., and J. W. Neal. 2011. Development of a crowded largemouth bass population in a tropical reservoir. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 65:98-104.

Habera, J. W., R. J. Strange, and R. D. Bivens. 2001a. A revised outlook for Tennessee's brook trout. Journal of the Tennessee Academy of Science 76:68-73.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2001b. Region IV trout fisheries report: 2000. Fisheries Report No. 01-03. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2003. Region IV trout fisheries report: 2002. Fisheries Report No. 03-03. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2004. Region IV trout fisheries report: 2003. Fisheries Report No. 04-04. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2006. Region IV trout fisheries report: 2005. Fisheries Report No. 06-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2008. Region IV trout fisheries report: 2007. Fisheries Report No. 08-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2009a. Region IV trout fisheries report: 2008. Fisheries Report No. 09-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, and B. D. Carter. 2009b. Management plan for the Wilbur tailwater trout fishery 2009-2014. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, and B. D. Carter. 2009c. Management plan for the South Holston tailwater trout fishery 2009-2014. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., M. A. Kulp, S. E. Moore, and T. B. Henry. 2010. Three-pass depletion sampling accuracy of two electric fields for estimating trout abundance in a low-conductivity stream with limited habitat complexity. North American Journal of Fisheries Management 30:757-766.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2011. Region IV trout fisheries report: 2010. Fisheries Report No. 11-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2012. Region IV trout fisheries report: 2011. Fisheries Report No. 12-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2014a. Region IV trout fisheries report: 2013. Fisheries Report No. 14-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, and B. D. Carter. 2014b. Management plan for the Norris Tailwater trout fishery 2014-2019. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2015a. Region IV trout fisheries report: 2014. Fisheries Report No. 15-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, and B. D. Carter. 2015b. Management plan for the Wilbur Tailwater trout fishery 2015-2020. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, and B. D. Carter. 2015c. Management plan for the South Holston Tailwater trout fishery 2015-2020. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2016. Region IV trout fisheries report: 2015. Fisheries Report No. 16-04. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2017. Region IV trout fisheries report: 2016. Fisheries Report No. 17-02. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., and B. D. Carter. 2008. Access denied: keeping the rainbows out of Left Prong. Tennessee Wildlife 31(6):21-24.

Habera, J. W. and S. E. Moore. 2005. Managing southern Appalachian brook trout: a position statement. Fisheries 30(7):10-20.

Harris, A. 2010. Trout fishing in 2006: a demographic description and economic analysis (addendum to the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation). Report 2006-6. U.S. Fish and Wildlife Service, Arlington, Virginia.

Higgins, J. M. 1978. Water quality progress in the Holston River basin. TVA Division of Environmental Planning, Chattanooga, Tennessee. TVA/EP-78/08.

Hill, D. M. 1978. Tailwater trout management. Pages 66-75 in Southeastern trout resource: ecology and management symposium proceedings. USDA Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina.

Hill, D. M., and S. R. Brown. 1980. The fishery resource of Tennessee Valley tailwaters—Cherokee. TVA Division of Water Resources, Norris, Tennessee.

Holbrook, C., and P. W. Bettoli. 2006. Spawning habitat, length at maturity, and fecundity of Brown Trout in Tennessee tailwaters. Fisheries Report No. 06-11. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Hoxmeier, R. J. H., and D. J. Dieterman. 2013. Seasonal movement, growth and survival of brook trout in sympatry with Brown Trout in Midwestern US streams. Ecology of Freshwater Fish 22:530-542.

Hoxmeier, R. J. H., and D. J. Dieterman. 2016. Long-term population demographics of native brook trout following manipulative reduction of an invader. Biological Invasions 18(10).

Hudy, M., T. M. Thieling, N. Gillespie, and E. P. Smith. 2008. Distribution, status, and land use characteristics of subwatersheds within the native range of brook trout in the eastern United States. North American Journal of Fisheries Management 28:1069-1085.

Huntsman, B. M. and J. T. Petty. 2014. Density-dependent regulation of brook trout population dynamics along a core-periphery distribution gradient in a central Appalachian watershed. PLoS One 9(3): e91673. doi:10.1371/journal.pone.0091673

Hutt, C. P., and Bettoli, P. W. 2003. Recreational specialization, preferences, and management attitudes of trout anglers utilizing Tennessee tailwaters. Fisheries Report No. 03-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Johnson, J. H., and D. S. Dropkin. 1996. Seasonal habitat use by brook trout, *Salvelinus fontinalis* (Mitchill), in a second-order stream. Fisheries Management and Ecology 3:1-11.

King, W. 1937. Notes on the distribution of native speckled and rainbow trout in the streams of Great Smoky Mountains National Park. Journal of the Tennessee Academy of Science 12:351-361.

Korman, J., M. Yard, and T. A. Kennedy. 2017. Trends in Rainbow Trout recruitment, abundance, survival, and growth during a boon-and-bust cycle in a tailwater fishery. Transactions of the American Fisheries Society 146:1043-1057.

Kriegler, F. J., G. F. McCracken, J. W. Habera, and R. J. Strange. 1995. Genetic characterization of Tennessee's brook trout populations and associated management implications. North American Journal of Fisheries Management 15:804-813.

Kulp, M. A. 1994. A comparative ecology study of two strains of brook trout in Great Smoky Mountains National Park. MS thesis, Tennessee Technological University, Cookeville, Tennessee.

Larson, G. L., S. E. Moore, and B. Carter. 1995. Ebb and flow of encroachment by nonnative Rainbow Trout in a small stream in the southern Appalachian Mountains. Transactions of the American Fisheries Society 124:613-622.

Lewis, S. L. 1969. Physical factors influencing fish populations in pools of a trout stream. Transactions of the American Fisheries Society 98:14-19.

Lobon-Cervia, J. 2007. Density-dependent growth in stream-living Brown Trout *Salmo trutta* L. Functional Ecology 21:117-124.

Lohr, S. C., and J. L. West. 1992. Microhabitat selection by Brook and Rainbow Trout in a southern Appalachian stream. Transactions of the American Fisheries Society 121:729-736.

Luecke, C., T. C. Edwards, Jr., M. W. Wengert, Jr., S. Brayton, and R. Schneidervin. 1994. Simulated changes in lake trout yield, trophies, and forage consumption under various slot limits. North American Journal of Fisheries Management 14:14-21.

Maillett, E. and R. Aiken. 2015. Trout fishing in 2011: a demographic description and economic analysis, addendum to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Report 2011-4. U.S. Fish and Wildlife Service.

Matthews, K. R., N. H. Berg, D. L. Azuma, and T. R. Lambert. 1994. Cool water formation and trout habitat use in a deep pool in the Sierra Nevada, California. Transactions of the American Fisheries Society 123:549-564.

McKinney, T., D. W. Speas, R. S. Rogers, and W. R. Persons. 2001. Rainbow Trout in a regulated river below Glen Canyon Dam, Arizona, following increased minimum flows and reduced discharge variability. North American Journal of Fisheries Management 21:216-222.

McMichael, G. A., and C. M. Kaya. 1991. Relations among stream temperature, angling success for rainbow and Brown Trout, and fishermen satisfaction. North American Journal of Fisheries Management 11:190-199.

Meerbeek, J., and P. W. Bettoli. 2005. Survival, growth, condition, and diet of stocked Brown Trout in five Tennessee tailwaters. Fisheries Report No. 05-05. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Meyer, K. A., B. High, and F. S. Elle. 2012. Effects of stocking catchable-sized hatchery Rainbow Trout on wild Rainbow Trout abundance, survival, growth, and recruitment. Transactions of the American Fisheries Society 141:224-237.

Mork, M. D. 2011. Survival and movements of large Brown Trout in a regulated river system in east Tennessee. MS thesis, Tennessee Technological University, Cookeville, Tennessee.

Myers, B. J. E., C. A. Dolloff, and A. L. Rypel. 2014. Rainbow Trout versus brook trout biomass and production under varied climate regimes in small southern Appalachian streams. Pages 127-134 *in* R. F. Carline, editor. Wild Trout IX: Looking back and moving forward. Wild Trout Symposium, Bozeman, Montana.

Nagel, J. W. 1986. Brook trout / Rainbow Trout headwaters competition studies. Research progress report submitted to Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Nagel, J. W. 1991. Is the decline of brook trout in the southern Appalachians resulting from competitive exclusion and/or extinction due to habitat fragmentation? Journal of the Tennessee Academy of Science 66:141-143.

Nagel, J. W., and J. E. Deaton. 1989. Growth and longevity of Rainbow Trout in two headwater streams in northeastern Tennessee. Journal of the Tennessee Academy of Science 64:9-12.

Noble, R. L., and T. W. Jones. 1999. Managing fisheries with regulations. Pages 455-480 *in* C. C. Kohler and W. A. Hubert, editors. Inland fisheries management in North America, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Page, L. M., H. Espinosa-Pèrez, L. T. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrak, R. L. Mayden, and J. S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico, 7th edition. American Fisheries Society, Special Publication 34, Bethesda, Maryland.

Pedicillo, G, A. Carosi, L. Ghetti, and M. Lorenzoni. 2010. Population size structure indices and growth standards for *Salmo (trutta) trutta* Linnaeus, 1758 in central Italy. Knowledge and Management of Aquatic Ecosystems 399(02). doi:10.1051/kmae/2010030.

Pender, D. R., and T. J. Kwak. 2002. Factors influencing Brown Trout reproductive success in Ozark tailwater rivers. Transactions of the American Fisheries Society 131:698-717.

Peterson, J. T., R. F. Thurow, and J. W. Guzevich. 2004. An evaluation of multipass electrofishing for estimating the abundance of stream-dwelling salmonids. Transactions of the American Fisheries Society 113:462-475.

Pfitzer, D. W. 1962. Investigations of waters below large storage reservoirs in Tennessee. D-J-R Project F-1-R. Tennessee Game and Fish Commission, Nashville, Tennessee.

Power, M., and G. Power. 1996. Comparing minimum-size and slot limits for brook trout management. North American Journal of Fisheries Management 16:49-62.

Roddy, D., editor. 2018. Coldwater fish production—statewide hatchery report: 2017. Fisheries Report No. 18-02. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Roghair, C. N., C. A. Dolloff, and M. K. Underwood. 2002. Response of a brook trout population and instream habitat to a catastrophic flood and debris flow. Transactions of the American Fisheries Society 131:718-730.

Sánchez-Hernández, J., S. L. Shaw, F. Cobo, and M. S. Allen. 2016. Influence of a minimum-length limit regulation on wild Brown Trout: an example of recruitment and growth overfishing. North American Journal of Fisheries Management 36:1024-1035.

Schexnayder, S. M., A. Griffin, and J. M. Fly. 2014. Fishing participation and attitudes of anglers in Tennessee, 2012. Human Dimensions Research Lab, Department of Forestry, Wildlife and Fisheries. University of Tennessee, Knoxville, Tennessee.

Scott, E. M., K. D. Gardner, D. S. Baxter, and B. L. Yeager. 1996. Biological and water quality responses in tributary tailwaters to dissolved oxygen and minimum flow improvements. Tennessee Valley Authority, Water Management Services, Norris, Tennessee.

Shields, R. A. 1950. A survey of east Tennessee trout streams with recommendations for management. Internal report, Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Sotiropoulos, J. C., K. H. Nislow, and M. R. Ross. 2006. Brook trout, *Salvelinus fontinalis*, microhabitat selection and diet under low summer stream flows. Fisheries Management and Ecology 13:149-155.

Stitt, B. C., G. Burness, K. A. Burgonmaster, S. Currie, J. L. McDermid, and C. C. Wilson. 2014. Intraspecific variation in thermal tolerance and acclimation capacity in brook trout (*Salvelinus* *fontinalis*): Physiological implications for climate change. Physiological and Biochemical Zoology 87:15-29.

Strange, R. J., and J. W. Habera. 1993. Wild trout project: 1992 annual report. Publication No. R11-2216-76-001-93. University of Tennessee, Knoxville, Tennessee.

Strange, R. J., and J. W. Habera. 1994. Wild trout project: 1993 annual report. Publication No. R11-2216-18-001-94. University of Tennessee, Knoxville, Tennessee.

Strange, R. J., and J. W. Habera. 1995. Wild trout project: 1994 annual report. Publication No. R11-2217-18-001-95. University of Tennessee, Knoxville, Tennessee.

Strange, R. J., and J. W. Habera. 1996. Wild trout project: 1995 annual report. Publication No. R11-2217-93-001-96. University of Tennessee, Knoxville, Tennessee.

Strange, R. J., and J. W. Habera. 1997. Wild trout project: 1996 annual report. Publication No. R11-2217-93-001-97. University of Tennessee, Knoxville, Tennessee.

Strange, R. J., and J. W. Habera. 1998. No net loss of brook trout distribution in areas of sympatry with Rainbow Trout in Tennessee streams. Transactions of the American Fisheries Society 127:434-440.

Stranko, S. A., R. H. Hilderbrand, R. P. Morgan II, M. W. Staley, A. J. Becker, A. Roseberry-Linclon, E. S. Perry, and P. T. Jacobson. 2008. Brook trout declines with land cover and temperature changes in Maryland. North American Journal of Fisheries Management 28:1223-1232.

Swink, W. D. 1983. Survey of stocking of tailwater trout fisheries in the southern United States. Progressive Fish-Culturist 45(2):67-71.

Tarzwell, C. M. 1939. Changing the Clinch River into a trout stream. Transactions of the American Fisheries Society 68:228-233.

Tatum, R. 1968. Brook trout streams in upper east Tennessee. Internal memorandum, Tennessee Wildlife Resources Agency, Nashville, Tennessee.

TDEC (Tennessee Department of Environment and Conservation). 2013. State of Tennessee water quality standards: use classifications for surface waters, chapter 0400-40-04. Water Quality Control Board, Nashville.

TDEC (Tennessee Department of Environment and Conservation). 2015. State of Tennessee water quality standards: general water quality criteria, chapter 0400-40-03. Water Quality Control Board, Nashville.

TWRA (Tennessee Wildlife Resources Agency). 1998. Stream survey protocols. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

TWRA (Tennessee Wildlife Resources Agency). 2014. Protecting, preserving, and perpetuating Tennessee's wildlife and ecosystems: Strategic plan 2014-2020. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

TWRA (Tennessee Wildlife Resources Agency). 2017. Trout management Plan for Tennessee 2017-2027 (J. Habera, editor). Tennessee Wildlife Resources Agency, Nashville, Tennessee.

TVA (Tennessee Valley Authority). 1980. Improving reservoir releases. TVA Office of Natural Resources and Environmental Development, Knoxville, Tennessee.

Thompson, P. D., and F. J. Rahel. 1996. Evaluation of depletion-removal electrofishing of brook trout in small Rocky Mountain streams. North American Journal of Fisheries Management 16:332-339.

Trumbo, B., M. Hudy, E. P. Smith, D.-Y. Kim, B. A. Wiggins, K. H. Nislow, and C. A. Dolloff. 2010. Sensitivity and vulnerability of brook trout populations to climate change. Pages 62-68 *in* R. F. Carline and C. LoSapio, editors. Wild Trout X: Conserving wild trout. Wild Trout Symposium, Bozeman, Montana.

Verhille, C. E, K. K. English, D. E. Cocherell, A. P. Farrell, and N. A. Fangue. 2016. High thermal tolerance of a Rainbow Trout population near its southern range limit suggests local thermal adjustment. Conservation Physiology 4(1):1-12.

Vøllestad, L. A., E. M. Olsen, and T. Forseth. 2002. Growth-rate variation in Brown Trout in small neighbouring streams: evidence for density-dependence? Journal of Fish Biology 61:1513-1527.

Walters, C. J., and J. R. Post. 1993. Density-dependent growth and competitive asymmetries in size-structured fish populations: a theoretical model and recommendations for field experiments. Transaction of the American Fisheries Society 122:34-45.

Warren, D. R., A. G. Ernst, and B. P. Baldigo. 2009. Influence of spring floods on year-class strength of fall- and spring-spawning salmonids in Catskill Mountain streams. Transaction of the American Fisheries Society 138:200-210.

Waters, T. F. 1999. Long-term trout production in Valley Creek, Minnesota. Transaction of the American Fisheries Society 128:1151-1162.

Weaver, D. M., and T. J. Kwak. 2013. Assessing effects of stocked trout on nongame fish assemblages in southern Appalachian Mountain streams. Transaction of the American Fisheries Society 142:1495-1507.

Weiland, M. A., and R. S. Hayward. 1997. Cause for the decline of large Rainbow Trout in a tailwater fishery: too much putting or too much taking? Transaction of the American Fisheries Society 126:758-773.

Whitworth, W. E., and R. J. Strange. 1983. Growth and production of sympatric brook and Rainbow Trout in an Appalachian stream. Transaction of the American Fisheries Society 112:469-475.

Wilde, G. R. 1997. Largemouth bass fishery responses to length limits. Fisheries 22:14-23.

Wiley, R. W., R. A. Whaley, J. B. Satake, and M. Fowden. 1993. Assessment of stocking hatchery trout: a Wyoming perspective. North American Journal of Fisheries Management 13:160-170.

Wilkins, L. P., L. Kirkland, and A. Hulsey. 1967. The management of trout fisheries in reservoirs having a self-sustaining warm water fishery. Pages 444-452 *in* C. E. Lane, symposium chairman. Reservoir Fishery Resources Symposium, Reservoir Committee, Southern Division, American Fisheries Society, Bethesda, Maryland.

Willis, D. W., B. R. Murphy, and C. S. Guy. 1993. Stock densities: development, use, and limitations. Reviews in Fisheries Science 1(3):203-222.

Yard, M. D., J. Korman, C. J. Walters, and T. A. Kennedy. 2015. Seasonal and spatial patterns of growth of Rainbow Trout in the Colorado River in Grand Canyon, Arizona. Canadian Journal of Fisheries and Aquatic Sciences 73:125-139.

Yeager, B. L., D. M. Hill, W. M. Seawell, C. M. Alexander, and R. Wallus. 1987. Effects of aeration and minimum flow enhancement on the biota of Norris tailwater. TVA Office of Natural Resources and Environmental Development, Knoxville, Tennessee.

Yeager, B. L., T. A. McDonough, and D. A. Kenny. 1993. Growth, feeding and movement of trout in South Holston tailwater. Water Management Services, WM-94-003. Tennessee Valley Authority, Norris, Tennessee.

# APPENDIX A

Quantitative Wild Trout Stream Samples
1991-2017

Table A-1. Wild trout streams sampled quantitatively during 1991-2017.

| Stream | Watershed | County | Location | Year | Primary species[1] | Total samples |
|---|---|---|---|---|---|---|
| Gee Creek | Hiwassee | Polk | CNF | 1993 | RBT | 1 |
| Rymer Camp Branch | Hiwassee | Polk | CNF | 1994 | RBT | 1 |
| Sulphur Springs Branch | Hiwassee | Polk | CNF | 1992 | RBT | 1 |
| East Fork Wolf Creek | Hiwassee | Polk | CNF | 1995 | RBT | 1 |
| Big Creek | Ocoee | Polk | CNF | 1996 | RBT | 1 |
| Goforth Creek | Ocoee | Polk | CNF | 1993 | RBT | 1 |
| Rough Creek | Ocoee | Polk | CNF | 1995 | RBT | 1 |
| Tellico River[2] | L. Tennessee | Monroe | CNF | 1993,95-02, 06, 11, 14 | RBT/BNT | 32 |
| Bald River[3] | Tellico | Monroe | CNF | 1991-00, 05, 07, 10, 13 | RBT/BNT/BKT | 39 |
| Kirkland Creek | Tellico | Monroe | CNF | 1991 | RBT | 1 |
| Henderson Branch | Tellico | Monroe | CNF | 1996 | RBT/BNT/BKT | 2 |
| Brookshire Creek | Tellico | Monroe | CNF | 1996 | BKT | 3 |
| North River[2] | Tellico | Monroe | CNF | 1991-14 | RBT/BNT | 72 |
| Laurel Branch | Tellico | Monroe | CNF | 1997 | RBT/BNT | 1 |
| Sugar Cove Creek | Tellico | Monroe | CNF | 1995-96 | RBT/BKT | 3 |
| Meadow Branch | Tellico | Monroe | CNF | 1991,95, 04 | BKT | 6 |
| Sycamore Creek | Tellico | Monroe | CNF | 1994-95,97-98 | RBT/BKT | 6 |
| Rough Ridge Creek | Tellico | Monroe | CNF | 1995 | RBT/BKT | 2 |
| Citico Creek | L. Tennessee | Monroe | CNF | 1996 | RBT/BNT | 1 |
| Doublecamp Creek | L. Tennessee | Monroe | CNF | 1992 | RBT/BNT | 2 |
| S. Fork Citico Creek | L. Tennessee | Monroe | CNF | 2004 | RBT | 1 |
| N. Fork Citico Creek | L. Tennessee | Monroe | CNF | 2003 | RBT | 1 |
| Parson Branch | L. Tennessee | Blount | Private | 1993 | RBT | 1 |
| Slickrock Creek | L. Tennessee | Monroe | CNF | 2007 | BNT | 2 |
| Little Slickrock Creek | L. Tennessee | Monroe | CNF | 2007 | BNT | 1 |
| Dunn Creek | French Broad | Sevier | Private | 1993 | RBT | 1 |
| Indian Camp Creek | French Broad | Cocke | Private | 2007 | RBT | 1 |
| Sinking Creek | French Broad | Cocke | Private | 1999 | RBT | 1 |
| Tobes Creek | French Broad | Cocke | Private | 2006 | RBT | 1 |
| Gulf Fork Big Creek | French Broad | Cocke | Private | 1993, 04, 08 | RBT/BNT | 3 |
| Deep Gap Creek | French Broad | Cocke | State Forest | 2005 | RBT | 1 |
| Laurel Creek | French Broad | Cocke | State Forest | 2013 | RBT | 1 |
| M. Prong Gulf Creek | French Broad | Cocke | Private | 1991 | BKT | 1 |
| Brown Gap Creek | French Broad | Cocke | Private | 1991 | BKT | 1 |
| Trail Fork Big Creek | French Broad | Cocke | CNF | 1996, 2001 | RBT | 2 |
| Dry Fork | French Broad | Cocke | CNF | 1994 | BKT/RBT | 2 |
| Wolf Creek | French Broad | Cocke | CNF | 1993 | RBT | 2 |
| Paint Creek[2] | French Broad | Greene | CNF | 92, 94, 95, 02-04, 08, 11, 14, 17 | BNT/RBT | 17 |
| Sawmill Branch | French Broad | Greene | CNF | 1999 | BKT/BNT | 1 |
| Little Paint Creek | French Broad | Greene | CNF | 1993 | BKT | 1 |

Table A-1 (cont.). Wild trout streams sampled quantitatively during 1991-2017.

| Stream | Watershed | County | Location | Year | Primary species[1] | Total samples |
|---|---|---|---|---|---|---|
| Camp Creek | Nolichucky | Greene | Private | 2004 | RBT | 1 |
| Jennings Creek | Nolichucky | Greene | CNF | 1992, 14 | RBT | 2 |
| Round Knob Branch | Nolichucky | Greene | CNF | 1996 | BKT | 1 |
| Dry Creek | Nolichucky | Greene | CNF | 1992 | RBT | 1 |
| Davis Creek | Nolichucky | Greene | CNF | 1992, 2003 | RBT/BKT | 2 |
| W. Fork Dry Creek | Nolichucky | Greene | CNF | 1992 | BKT | 1 |
| Horse Creek | Nolichucky | Greene | CNF | 1994 | RBT | 1 |
| Squibb Creek | Nolichucky | Greene | CNF | 1991, 2003 | RBT/BKT | 2 |
| Sarvis Cove Creek | Nolichucky | Greene | CNF | 1991, 2003 | RBT/BKT | 2 |
| Cassi Creek | Nolichucky | Greene | CNF | 2003 | RBT | 1 |
| Painter Creek | Nolichucky | Washington | Private | 1993 | RBT | 1 |
| Clark Creek | Nolichucky | Unicoi | CNF | 1991 | RBT | 1 |
| Sill Branch | Nolichucky | Unicoi | CNF | 1994 | RBT | 1 |
| Devil Fork | Nolichucky | Unicoi | CNF | 1999 | RBT | 1 |
| Longarm Branch | Nolichucky | Unicoi | CNF | 1997 | RBT | 1 |
| Dry Creek | Nolichucky | Washington | CNF | 1997 | RBT | 1 |
| Ramsey Creek | Nolichucky | Washington | Private | 1996 | RBT | 1 |
| Briar Creek[2] | Nolichucky | Washington | CNF | 1992,95-17 | RBT/BKT | 24 |
| Straight Creek | Nolichucky | Washington | CNF | 2003 | BKT | 1 |
| Broad Shoal Creek | Nolichucky | Unicoi | CNF | 1991 | RBT | 1 |
| N. Indian Creek | Nolichucky | Unicoi | CNF | 1994-95, 03 | RBT/BNT | 3 |
| Rock Creek | Nolichucky | Unicoi | CNF | 1991 | RBT/BKT | 1 |
| R. Prong Rock Creek | Nolichucky | Unicoi | CNF | 1998 | RBT | 1 |
| Red Fork | Nolichucky | Unicoi | CNF | 1998 | RBT | 1 |
| Clear Fork | Nolichucky | Unicoi | CNF | 1993 | BKT | 1 |
| South Indian Creek | Nolichucky | Unicoi | Private | 2009 | RBT | 1 |
| Mill Creek | Nolichucky | Unicoi | CNF | 1996 | RBT | 1 |
| Granny Lewis Creek | Nolichucky | Unicoi | CNF | 1991 | RBT | 2 |
| Higgins Creek (Lower) | Nolichucky | Unicoi | Private | 1992,95 | BKT/RBT | 2 |
| Spivey Creek | Nolichucky | Unicoi | Private | 2007 | RBT | 1 |
| Coffee Ridge | Nolichucky | Unicoi | Private | 2011 | RBT | 1 |
| Big Bald Creek | Nolichucky | Unicoi | Private | 1996 | RBT | 1 |
| Tumbling Creek | Nolichucky | Unicoi | Private | 1995 | RBT | 1 |
| Little Bald Creek | Nolichucky | Unicoi | Private | 2007 | RBT | 1 |
| Big Branch | Nolichucky | Unicoi | Private | 1996 | RBT | 1 |
| Rocky Fork[2] | Nolichucky | Unicoi/Greene | Private | 1991-17 | RBT/BKT | 53 |
| Rice Creek | Nolichucky | Unicoi | Private | 1995 | RBT | 1 |
| Higgins Creek (Upper) | Nolichucky | Unicoi | Private | 2006 | RBT | 1 |
| Sams Creek | Nolichucky | Unicoi | Private | 2002 | RBT | 1 |
| Jones Branch | Nolichucky | Unicoi | CNF | 1991 | BKT | 1 |

Table A-1 (cont.). Wild trout streams sampled quantitatively during 1991-2017.

| Stream | Watershed | County | Location | Year | Primary species[1] | Total samples |
|---|---|---|---|---|---|---|
| Sinking Creek | Watauga | Washington | Private | 2007 | RBT/BNT | 1 |
| Buffalo Creek | Watauga | Unicoi/Carter | Private | 1998, 02 | RBT | 2 |
| Doe River[2] | Watauga | Carter | Private | 1995-99, 02-04, 09, 12, 15 | RBT/BKT/BNT | 14 |
| Laurel Fork[2] | Watauga | Carter | CNF | 1991-01, 03, 06, 09, 12, 15 | BNT | 32 |
| Little Laurel Fork | Watauga | Carter | CNF | 1994 | BKT | 1 |
| Leonard Branch | Watauga | Carter | CNF | 2011 | BKT/BNT | 1 |
| Wagner Branch | Watauga | Carter | CNF | 1993 | BKT/BNT | 1 |
| Cook Branch | Watauga | Carter | CNF | 2008 | BNT | 1 |
| Camp 15 Branch | Watauga | Carter | CNF | 2011 | BKT/BNT | 1 |
| Camp 10 Branch | Watauga | Carter | CNF | 1995 | BKT | 1 |
| Little Doe River | Watauga | Carter | Private | 2010 | RBT/BNT | 1 |
| Simerly Creek | Watauga | Carter | Private | 1994, 2010 | RBT/BNT | 2 |
| Sally Cove Creek | Watauga | Carter | Private | 1995 | RBT | 1 |
| Clarke Creek | Watauga | Carter | Private | 1992 | BKT | 1 |
| McKinney Branch | Watauga | Carter | Private | 2010 | RBT/BNT | 1 |
| Tiger Creek | Watauga | Carter | CNF | 1991, 99 | RBT/BKT | 2 |
| Roberts Hollow | Watauga | Carter | Private | 2014 | RBT/BKT | 1 |
| Bill Creek | Watauga | Carter | CNF | 1991 | BKT | 1 |
| Roaring Creek | Watauga | Carter | Private | 2011 | RBT | 1 |
| George Creek | Watauga | Carter | CNF | 1991 | BKT | 1 |
| Buck Creek | Watauga | Carter | CNF/Private | 1997 | RBT | 2 |
| Shell Creek | Watauga | Carter | Private | 2004 | RBT | 1 |
| L. Pr. Hampton Creek[2] | Watauga | Carter | State | 1994-17 | RBT/BKT | 66 |
| Heaton Creek | Watauga | Carter | Private | 2000 | RBT | 1 |
| Toms Branch | Watauga | Carter | Private/CNF | 1991, 09 | BKT | 2 |
| Five Poplar Branch | Watauga | Carter | Private | 2000 | RBT | 1 |
| Middle Branch | Watauga | Carter | Private | 1991 | BKT | 1 |
| R. Pr. Middle Branch[2] | Watauga | Carter | CNF | 1994, 97-17 | BKT | 21 |
| Panther Branch | Watauga | Carter | CNF | 1996 | BKT | 1 |
| Cove Creek | Watauga | Carter | Private | 1991, 12 | BKT/RBT | 2 |
| Little Cove Creek | Watauga | Carter | Private | 2008 | RBT/BKT | 1 |
| Stony Creek | Watauga | Carter | CNF | 1992, 95, 04-06, 10, 13, 16 | RBT/BKT/BNT | 9 |
| Little Stony Creek | Watauga | Carter | CNF | 1992 | BKT | 1 |
| Furnace Branch | Watauga | Carter | CNF | 2003 | BKT | 1 |
| Mill Creek | Watauga | Carter | Private | 1994 | BKT | 1 |
| North Fork Stony Creek | Watauga | Carter | CNF | 1991 | BKT | 1 |
| Lindy Camp Branch | Watauga | Carter | CNF | 2008 | BKT | 1 |
| Little Stony Creek[4] | Watauga | Carter | CNF | 1993, 2014 | RBT/BKT | 2 |
| Roan Creek | Watauga | Johnson | Private | 1997 | RBT/BKT | 2 |
| Doe Creek[2] | Watauga | Johnson | Private | 1993-17 | RBT | 26 |

Table A-1 (cont.). Wild trout streams sampled quantitatively during 1991-2017.

| Stream | Watershed | County | Location | Year | Primary species[1] | Total samples |
|---|---|---|---|---|---|---|
| Campbell Creek | Watauga | Johnson | Private | 1993 | RBT | 1 |
| Slabtown Branch | Watauga | Johnson | Private | 1995 | RBT | 1 |
| Vaught Creek | Watauga | Johnson | Private | 2005 | RBT | 1 |
| Furnace Creek | Watauga | Johnson | Private | 1992 | BKT | 1 |
| Goose Creek | Watauga | Johnson | Private | 2006 | RBT/BNT | 1 |
| Forge Creek | Watauga | Johnson | Private | 1993 | RBT/BKT | 2 |
| Roaring Creek | Watauga | Johnson | Private | 2001 | RBT | 1 |
| Bulldog Creek | Watauga | Johnson | Private | 2009 | RBT | 1 |
| Big Dry Run | Watauga | Johnson | Private | 1994 | RBT | 1 |
| Heaton Branch | Watauga | Carter | Private | 1994 | RBT | 1 |
| Little Laurel Branch | Watauga | Carter | CNF | 1992 | BKT | 1 |
| Trivett Branch | Watauga | Carter | Private | 1996 | BNT | 1 |
| Big Creek | S. F. Holston | Sullivan | CNF | 1994 | RBT | 1 |
| Fishdam Creek | S. F. Holston | Sullivan | CNF | 1991, 2005 | RBT | 2 |
| Sharps Creek | S. F. Holston | Sullivan | CNF | 2012 | RBT | 1 |
| Little Jacob Creek | S. F. Holston | Sullivan | CNF | 1991, 2000 | RBT | 2 |
| Rockhouse Run | S. F. Holston | Sullivan | CNF | 1993 | BKT | 1 |
| Laurel Creek[2] | S. F. Holston | Johnson | CNF | 1993-94, 01-02, 04, 07, 10, 13, 16 | RBT/BNT | 9 |
| Beaverdam Creek[2] | S. F. Holston | Johnson | CNF | 1991-17 | RBT/BNT | 54 |
| Tank Hollow | S. F. Holston | Johnson | CNF | 2003 | BKT | 1 |
| Chalk Branch | S. F. Holston | Johnson | CNF | 1994 | BKT | 1 |
| Maple Branch | S. F. Holston | Johnson | CNF | 1994 | BKT | 1 |
| Fagall Branch | S. F. Holston | Johnson | CNF | 1995 | BKT | 1 |
| Birch Branch[2] | S. F. Holston | Johnson | CNF/Private | 1991,95-16 | BKT/RBT | 23 |
| Marshall Branch | S. F. Holston | Johnson | CNF | 1999 | BKT | 1 |
| Heaberlin Branch | S. F. Holston | Johnson | CNF | 1993 | BKT | 1 |
| Johnson Blevins Br. | S. F. Holston | Johnson | Private | 1991 | BKT | 1 |
| Jim Wright Branch | S. F. Holston | Johnson | Private | 1991 | BKT | 1 |
| E. Fk. Beaverdam Ck. | S. F. Holston | Johnson | CNF | 1992 | BKT | 1 |
| Valley Creek | S. F. Holston | Johnson | CNF | 1993 | BKT | 1 |
| Owens Branch | S. F. Holston | Johnson | CNF | 1995 | RBT/BNT | 1 |
| Lyons Branch | S. F. Holston | Johnson | CNF | 1992 | RBT | 1 |
| Gentry Creek[2] | S. F. Holston | Johnson | CNF | 1992,96-16 | RBT/BKT | 23 |
| Grindstone Branch | S. F. Holston | Johnson | CNF | 1996 | BKT | 1 |
| Kate Branch | S. F. Holston | Johnson | CNF | 2000 | BKT | 1 |
| Atchison Branch | S. F. Holston | Johnson | Private | 2006 | RBT | 1 |

[1]RBT = Rainbow Trout; BNT = Brown Trout; BKT = Brook Trout.

[2]Monitoring stream. TWRA Region III began monitoring streams in the Tellico and Little Tennessee watersheds in 2014.

[3]Includes a site sampled in the allopatric Brook Trout zone in 1992; monitoring Site 2 was discontinued in 2010.

[4]Watauga Lake tributary.

# APPENDIX B

Qualitative Stream Surveys
1991-2017

Table B-1. Streams sampled qualitatively during 1991-2017 to determine the presence of wild trout.

| Stream | Watershed | County | Location | Coordinates | Survey date | Wild trout present[1] |
|---|---|---|---|---|---|---|
| Smith Creek | Hiwassee | Polk | CNF | 35.15135, -84.42420 | Nov-99 | RBT |
| Coker Creek | Hiwassee | Monroe | Private | 35.26978, -84.26283 | Jul-96 | None |
| Wolf Creek | Hiwassee | Polk | CNF | 35.16522, -84.38135 | May-99 | RBT/BNT |
| Wildcat Creek | Tellico | Monroe | CNF | 35.29894, -84.25793 | Jul-96 | None |
| Natty Creek | Tellico | Monroe | CNF | 35.31705, -84.22875 | Jul-96 | None |
| Tobe Creek | Tellico | Monroe | CNF | 35.29990, -84.22923 | Jul-96 | None |
| Laurel Branch | French Broad | Sevier | Private | 35.77184, -83.39841 | Jul-15 | None |
| Wilhite Creek | French Broad | Sevier | Private | 35.87333, -83.32037 | Jul-15 | None |
| Lin Creek | French Broad | Sevier | Private | 35.86744, -83.32864 | Jul-15 | None |
| Mill Creek | French Broad | Sevier | Private | 35.73479, -83.57456 | Jul-15 | RBT |
| Indian Camp Creek (lower) | French Broad | Cocke | Private | 35.77938, -83.26361 | Jun-06 | RBT |
| Indian Camp Creek (lower) | French Broad | Cocke | Private | 35.77622, -83.26537 | Jun-06 | RBT, BKT |
| Indian Camp Creek (lower) | French Broad | Cocke | Private | 37.77337, -83.26657 | Jun-06 | RBT, BKT |
| Greenbrier Creek | French Broad | Cocke | Private | 35.78278, -83.24322 | Jun-06 | RBT |
| Groundhog Creek | French Broad | Cocke | Private | 35.78918, -83.18387 | Jul-15 | RBT |
| Robinson Creek | French Broad | Cocke | Private | 35.79097, -83.19433 | Jul-15 | RBT |
| John Creek | French Broad | Cocke | Private | 35.86611, -83.03250 | Jun-01 | None |
| Baker Branch | French Broad | Cocke | Private | 35.86306, -83.03083 | Jun-01 | None |
| Tom Creek | French Broad | Cocke | Private | 35.85306, -83.01806 | Jun-01 | RBT[3] |
| Gulf Fork Big Creek | French Broad | Cocke | Private | 35.82385, -83.09162 | May-07 | RBT/BNT |
| Gulf Fork Big Creek | French Broad | Cocke | Private | 35.83037, -83.05730 | May-07 | RBT/BNT |
| Gulf Fork Big Creek | French Broad | Cocke | Private | 35.82064, -83.04665 | May-07 | RBT/BNT |
| Gulf Fork Big Creek | French Broad | Cocke | Private | 35.81805, -83.04191 | May-07 | RBT/BNT |
| Laurel Fork (upper) | French Broad | Cocke | CNF | 35.88146, -83.06236 | Jun-14 | None |
| Laurel Fork (lower) | French Broad | Cocke | Private | 35.89220, -83.06274 | Jun-14 | None |
| Grassy Fork | French Broad | Cocke | Private | 35.81585, -83.08673 | Jun-03 | RBT[4] |
| Deep Gap Creek | French Broad | Cocke | State | 35.79321, -83.02074 | Oct-06 | BKT |
| Brush Creek | French Broad | Cocke | CNF | 35.95817, -82.93442 | Jun-15 | None |
| Paint Creek | French Broad | Greene | Private | 36.00702, -82.77679 | Jun-15 | RBT/BNT |
| Paint Creek | French Broad | Greene | CNF | 36.02082, -82.74602 | Jun-15 | RBT |
| Cove Creek | Nolichucky | Greene | Private | 35.97882, -82.86960 | Jun-15 | None |
| Back Creek | Nolichucky | Greene | Private | 36.01896, -82.80796 | Jun-08 | None |
| Camp Creek | Nolichucky | Greene | Private | 36.07811, -82.76464 | Jul-03 | RBT |
| Bumpus Cove Creek | Nolichucky | Unicoi | Private | 36.16941, -82.47134 | Jul-07 | RBT |
| Bumpus Cove Creek | Nolichucky | Washington | Private | 36.15227, -82.49503 | Jul-07 | RBT/BNT |
| Broad Shoal Creek | Nolichucky | Unicoi | CNF | 36.15229, -82.44492 | Jun-08 | RBT |
| Dry Creek | Nolichucky | Unicoi | Private | 36.17448, -82.35113 | Jun-10 | None (dry) |
| Dick Creek | Nolichucky | Unicoi | CNF | 36.17326, -82.31647 | May-11 | No fish |
| Rocky Branch | Nolichucky | Unicoi | Private | 36.17589, -82.29530 | Jun-10 | None |
| Simerly Creek | Nolichucky | Unicoi | Private | 36.18453, -82.25218 | Jun-10 | None[2] |

Table B-1 (cont.). Streams sampled qualitatively during 1991-2017 to determine the presence of wild trout.

| Stream | Watershed | County | Location | Coordinates | Survey date | Wild trout present[1] |
|---|---|---|---|---|---|---|
| Birchlog Creek | Nolichucky | Unicoi | Private | 36.15263, -82.24237 | Jun-10 | None |
| South Indian Creek (upper) | Nolichucky | Unicoi | Private | 36.03568, -82.55163 | Jun-05 | RBT |
| South Indian Creek (middle) | Nolichucky | Unicoi | Private | 36.05937, -82.52198 | Jun-05 | RBT[4] |
| South Indian Creek (lower) | Nolichucky | Unicoi | Private | 36.12065, -82.44834 | Jul-08 | RBT[4] |
| Spivey Creek (lower) | Nolichucky | Unicoi | Private | 36.06566, -82.50199 | Jun-06 | RBT |
| Spivey Creek (middle) | Nolichucky | Unicoi | Private | 36.05169, -82.50063 | Jun-06 | RBT |
| Spivey Creek (middle) | Nolichucky | Unicoi | Private | 36.03955, -82.48652 | Jun-06 | RBT |
| Spivey Creek (upper) | Nolichucky | Unicoi | Private | 36.04042, -82.47109 | Jun-06 | RBT |
| Murray Branch | Nolichucky | Unicoi | Private | 36.04610, -82.51080 | May-11 | RBT[4] |
| Murray Branch | Nolichucky | Unicoi | Private | 36.04348, -82.51683 | May-11 | None |
| Slip Creek | Nolichucky | Unicoi | Private | 36.02103, -82.50891 | Jun-06 | RBT[4] |
| Little Bald Creek | Nolichucky | Unicoi | Private | 36.03993, -82.46505 | Jun-06 | RBT |
| Pete Creek | Nolichucky | Unicoi | CNF | 36.01286, -82.58934 | Jun-05 | None[2] |
| E. Fork Higgins Creek | Nolichucky | Unicoi | CNF | 35.99601, -82.53006 | Jun-05 | None[2] |
| Long Branch | Nolichucky | Unicoi | CNF | 36.08811, -82.42917 | Jun-08 | BKT |
| Sinking Creek (upper) | Watauga | Carter | Private | 36.25559, -82.36470 | Jun-06 | RBT, BKT, BNT |
| Sinking Creek (upper) | Watauga | Carter | Private | 36.25192, -82.36493 | Jun-06 | RBT, BKT, BNT |
| Sinking Creek (middle) | Watauga | Carter | Private | 36.26143, -82.36430 | Jun-06 | RBT, BKT |
| Sinking Creek (lower) | Watauga | Carter | Private | 36.27966, -82.36838 | Jun-06 | RBT |
| Basil Hollow | Watauga | Washington | Private | 36.25134, -82.36456 | May-07 | RBT |
| Dry Creek | Watauga | Carter | Private | 36.25910, -82.28150 | Jun-09 | BNT[4] |
| Honeycomb Creek | Watauga | Carter | Private | 36.24304, -82.26767 | Jun-09 | RBT[4] |
| Gap Creek | Watauga | Carter | CNF | 36.26756, -82.23016 | Jun-09 | None |
| Upper Gap Creek | Watauga | Carter | Private | 36.25850, -82.23574 | Jun-09 | None[2] |
| Little Doe River | Watauga | Carter | Private | 36.24629, -82.19464 | Jun-09 | RBT/BNT |
| Little Doe River | Watauga | Carter | Private | 36.22870, -82.18899 | Jun-09 | RBT/BNT |
| Simerly Creek (lower) | Watauga | Carter | Private | 36.22769, -82.18925 | Jun-09 | RBT/BNT |
| Big Flats Branch | Watauga | Carter | Private | 36.24634, -82.14575 | Aug-06 | RBT |
| Firescald Branch | Watauga | Carter | CNF | 36.24920, -82.08700 | Nov-15 | BKT |
| Doll Branch | Watauga | Carter | Private | 36.15115, -82.02994 | Jun-04 | RBT |
| Morgan Branch | Watauga | Carter | Private | 36.17449, -82.02072 | Jun-08 | RBT[4] |
| Bear Branch | Watauga | Carter | CNF | 36.18106, -82.01066 | Jun-08 | RBT[4] |
| State Line Branch | Watauga | Carter | Private | 36.16797, -82.00265 | Jun-08 | RBT[4] |
| Hampton Creek (upper) | Watauga | Carter | Private | 36.14939, -82.05561 | Jun-08 | RBT[4] |
| Sugar Hollow Creek | Watauga | Carter | Private | 36.15694, -82.07053 | Jun-08 | RBT[4] |
| Bearwallow Hollow | Watauga | Carter | State | 36.15899, -82.10180 | Jul-14 | None |
| Nidifer Branch | Watauga | Carter | Private | 36.39768, -82.09988 | May-95 | None[2] |
| Hinkle Branch | Watauga | Carter | Private | 36.40950, -82.09707 | May-95 | None[2] |
| Peters Branch | Watauga | Carter | Private | 36.40696, -82.07738 | Jun-11 | None (nearly dry) |
| Horselog Branch | Watauga | Carter | Private | 36.40822, -82.06854 | Jun-11 | None (nearly dry) |
| Laurel Branch | Watauga | Carter | Private | 36.41660, -82.07871 | May-95 | None[2] |
| Grindstaff Branch | Watauga | Carter | Private | 36.41442, -82.05386 | Jun-11 | None |

Table B-1 (cont.). Streams sampled qualitatively during 1991-2017 to determine the presence of wild trout.

| Stream | Watershed | County | Location | Coordinates | Survey date | Wild trout present¹ |
|---|---|---|---|---|---|---|
| Stover Branch | Watauga | Carter | Private | 36.42096, -82.05016 | Jun-11 | RBT[4] |
| Right Fork Mill Creek | Watauga | Carter | CNF | 36.43993, -82.07787 | Jun-15 | BKT |
| Hurley Branch | Watauga | Carter | Private | 36.43600, -82.04804 | Jun-11 | RBT/BNT |
| Hurley Branch | Watauga | Carter | Private | 36.43150, -82.03231 | Jun-11 | RBT |
| Richardson Branch | Watauga | Carter | Private | 36.45740, -82.01002 | Jun-11 | None (dry) |
| Bowen Branch | Watauga | Carter | Private | 36.46105, -82.00719 | Jun-11 | None (dry) |
| Upper Hinkle Branch | Watauga | Carter | Private | 36.46905, -82.00466 | Jul-07 | None |
| Big Spur Branch | Watauga | Carter | CNF | 36.46786, -81.97704 | Jun-15 | BKT |
| Lindy Camp Branch | Watauga | Carter | CNF | 36.47081, -81.96968 | Jul-07 | BKT |
| Baker Ridge Branch | Watauga | Carter | CNF | 36.48095, -81.97507 | Jun-15 | BKT |
| Water Hollow Branch | Watauga | Carter | CNF | 36.47822, -81.97452 | Jun-15 | BKT |
| Sink Branch | Watauga | Johnson | Private | 36.36305, -81.99222 | Jun-09 | None[2] |
| Doe Creek | Watauga | Johnson | Private | 36.45667, -81.87556 | Oct-01 | None |
| Doe Creek | Watauga | Johnson | Private | 36.44889, -81.89889 | Oct-01 | RBT[4] |
| Doe Creek | Watauga | Johnson | Private | 36.44194, -81.90806 | Oct-01 | RBT[4] |
| Dugger Branch | Watauga | Johnson | Private | 36.39397, -81.96911 | Jun-95 | None[2] |
| Campbell Hollow | Watauga | Johnson | Private | 36.40306, -81.96558 | Jun-95 | None[2] |
| Campbell Creek | Watauga | Johnson | CNF | 36.45734, -81.95157 | Sep-14 | Barrier—no fish above |
| Spruce Branch | Watauga | Johnson | Private | 36.45630, -81.88100 | Jun-15 | RBT |
| Stout Branch | Watauga | Johnson | Private | 36.47544, -81.87173 | Jun-15 | None |
| Shaw Branch | Watauga | Johnson | Private | 36.48240, -81.85836 | Jun-15 | None[2] |
| Little Dry Run | Watauga | Johnson | Private | 36.35489, -81.93736 | Jun-09 | None[2] |
| Avery Branch | Watauga | Johnson | Private | 36.36972, -81.87307 | Jun-09 | None[2] |
| Stout Branch | Watauga | Johnson | Private | 36.36716, -81.83291 | Jun-08 | RBT[4] |
| Slimp Branch | Watauga | Johnson | Private | 36.38751, -81.84609 | Jun-08 | None |
| Lunt Branch | Watauga | Johnson | Private | 36.40488, -81.85349 | Jun-08 | None (dry) |
| Big Sandy Creek | Watauga | Johnson | Private | 36.39884, -81.80691 | Jun-08 | None (dry) |
| Furnace Creek | Watauga | Johnson | Private | 36.48419, -81.79864 | Jun-06 | RBT |
| East Fork (Furnace Creek) | Watauga | Johnson | Private | 36.36681, -81.80068 | Jun-94, Jun-15 | None |
| Cabbage Creek | Watauga | Johnson | Private | 36.40792, -81.80150 | Jun-08 | None (dry) |
| Stout Branch | Watauga | Johnson | Private | 36.42797, -81.74439 | Jul-97 | None |
| E.H. Phillippi Branch | Watauga | Johnson | Private | 36.49089, -81.84778 | Jun-15 | None[2] |
| Patrick Branch | Watauga | Johnson | Private | 36.50505, -81.82793 | Jun-15 | None[2] |
| Thomas Branch | Watauga | Johnson | Private | 36.51315, -81.83235 | Jun-15 | None[2] |
| Fenner Branch | Watauga | Johnson | Private | 36.51606, -81.83144 | Jun-15 | None[2] |
| Gentry Branch | Watauga | Johnson | Private | 36.51816, -81.82568 | Jun-15 | None[2] |
| Hall Branch | Watauga | Johnson | Private | 36.51850, -81.81934 | Jun-15 | None[2] |
| Stone Branch | Watauga | Johnson | Private | 36.52243, -81.81736 | Jun-15 | None[2] |
| Fall Branch | Watauga | Johnson | Private | 36.42452, -81.74489 | Jun-99 | RBT |
| Woodward Branch | Watauga | Johnson | Private | 36.47442, -81.72249 | Jun-10 | RBT[4] |
| Drake Branch | Watauga | Johnson | Private | 36.36566, -81.74845 | Jun-09 | RBT[4] |
| Egger Branch | Watauga | Johnson | Private | 36.36543, -81.76789 | Jun-15 | RBT[4] |
| Buttermilk Branch | Watauga | Johnson | Private | 36.35035, -81.75234 | Jun-15 | RBT[4] |

Table B-1 (cont.). Streams sampled qualitatively during 1991-2017 to determine the presence of wild trout.

| Stream | Watershed | County | Location | Coordinates | Survey date | Wild trout present¹ |
|---|---|---|---|---|---|---|
| W. Fork Buttermilk Br. | Watauga | Johnson | Private | 36.34703, -81.75228 | Jun-15 | None |
| Jenkins Creek | Watauga | Johnson | Private | 36.35215, -81.73884 | Jun-10 | RBT[4] |
| 'Poplar Ridge' Branch[5] | Watauga | Johnson | Private | 36.36566, -81.74845 | Jun-15 | RBT |
| Black Branch | Watauga | Carter | Private | 36.28758, -82.01163 | Jul-07 | RBT/BNT[4] |
| Row Branch | Watauga | Carter | Private | 36.28869, -82.01325 | Jul-07 | RBT[4] |
| Jones Branch | Watauga | Carter | Private/CNF | 36.20195, -81.98815 | Jul-02 | None |
| Baker Branch | Watauga | Johnson | Private | 36.34010, -81.92116 | May-96 | None[2] |
| Morgan Branch | Watauga | Johnson | Private | 36.32769, -81.90590 | Jun-09 | None |
| Dye Leaf Branch | Watauga | Johnson | Private | 36.33538, -81.89473 | Jun-09 | None |
| Little Creek | S. Fork Holston | Sullivan | CNF | 36.47529, -82.08702 | Jul-15 | BNT (1) |
| Roaring Creek | S. Fork Holston | Sullivan | CNF | 36.48538, -82.08930 | Jul-15 | None |
| Josiah Creek | S. Fork Holston | Sullivan | CNF | 36.49992, -82.04397 | Jul-15 | None[2] |
| Sulphur Springs Branch | S. Fork Holston | Sullivan | CNF | 36.52238, -82.02516 | Jun-05 | RBT |
| Sharps Creek | S. Fork Holston | Sullivan | Private | 36.54608, -82.01824 | Jun-11 | RBT[4] |
| Sharps Creek | S. Fork Holston | Sullivan | Private | 32.53868, -81.99159 | Jun-11 | RBT |
| Cave Spring Branch | S. Fork Holston | Sullivan | Private | 36.59283, -81.98427 | Jun-11 | None |
| Laurel Creek | S. Fork Holston | Johnson | CNF | 36.52622, -81.80172 | Jun-04 | None |
| Beaverdam Creek | S. Fork Holston | Johnson | Private | 36.53244, -81.92330 | May-03, Jun-05 | RBT/BNT |
| Beaverdam Creek | S. Fork Holston | Johnson | Private | 36.52050, -81.93219 | May-03, Jun-05 | RBT/BNT |
| Beaverdam Creek | S. Fork Holston | Johnson | Private | 36.51664, -81.93763 | May-03, Jun-05 | RBT/BNT |
| Reservoir Branch | S. Fork Holston | Johnson | Private | 36.60295, -81.81103 | May-96 | None[2] |
| Reservoir Branch | S. Fork Holston | Johnson | Private | 36.60264, -81.81086 | Oct-15 | RBT/BNT |
| Reservoir Branch | S. Fork Holston | Johnson | Private | 36.59858, -81.80787 | Oct-15 | None |
| Stillhouse Branch | S. Fork Holston | Johnson | CNF | 36.58489, -81.83032 | Jun-04 | RBT/BNT |
| Haunted Hollow | S. Fork Holston | Johnson | CNF | 36.57662, -81.85151 | Jun-04 | None |
| Dan Wiley Branch | S. Fork Holston | Johnson | CNF | 36.56981, -81.85512 | Oct-15 | None |
| Dark Hollow | S. Fork Holston | Johnson | CNF | 36.57683, -81.85896 | Jun-04 | None |
| Flat Springs Branch | S. Fork Holston | Johnson | Private | 36.54886, -81.88531 | Aug-05 | RBT/BNT |
| Grindstone Branch | S. Fork Holston | Johnson | Private | 36.53513, -81.88837 | Jun-15 | None[2] |
| David Blevins Branch | S. Fork Holston | Johnson | Private | 36.53357, -81.89964 | Jun-06 | None |
| McQueen Branch | S. Fork Holston | Johnson | Private | 36.54262, -81.90921 | Jun-06 | RBT[4] |
| Green Mountain Branch | S. Fork Holston | Johnson | Private | 36.50915, -81.91061 | Jun-06 | RBT |
| Buck Ridge Branch | S. Fork Holston | Johnson | Private | 36.49639, -81.96272 | Jul-04 | RBT/BNT |
| W. Fork Beaverdam Creek | S. Fork Holston | Johnson | Private | 36.49064, -81.94230 | Jun-06 | BKT |
| M. Fork Beaverdam Creek | S. Fork Holston | Johnson | Private | 36.49661, -81.93719 | Jun-06 | RBT, BKT, BNT |
| Seng Cove Branch | S. Fork Holston | Johnson | Private | 36.59219, -81.72168 | Jun-10 | None |
| Cave Spring Branch | S. Fork Holston | Johnson | Private | 36.59002, -81.72465 | Jun-10 | RBT[4] |
| Shingletown Branch | S. Fork Holston | Johnson | Private | 36.54533, -81.77751 | Jun-04 | None[2] |
| Drystone Branch | S. Fork Holston | Johnson | Private | 36.52833, -81.77521 | May-96 | None[2] |
| Flatwood Branch | S. Fork Holston | Johnson | Private | 36.52680, -81.80280 | Jun-04 | None[2] |
| Corum Branch | S. Fork Holston | Johnson | Private | 36.52636, -81.81085 | Jun-15 | None[2] |
| Richardson Branch | S. Fork Holston | Johnson | CNF | 36.61033, -81.67962 | Jun-93 | None |
| Richardson Branch | S. Fork Holston | Johnson | CNF | 36.61046, -81.68022 | Jun-15 | BKT |

Table B-1 (cont.). Streams sampled qualitatively during 1991-2017 to determine the presence of wild trout.

| Stream | Watershed | County | Location | Coordinates | Survey date | Wild trout present[1] |
|---|---|---|---|---|---|---|
| Whetstone Branch | S. Fork Holston | Johnson | CNF | 36.60731, -81.68474 | Jun-15 | BKT |

[1]RBT = Rainbow Trout; BNT = Brown Trout; BKT = Brook Trout.

[2]Visually inspected and judged too small (<1 m wide) or without appropriate habitat to support wild trout.

[3]Trout present, but origin questionable; could be the result of fingerling stocking by private individuals.

[4]Low abundance.

[5]Unnamed tributary to Roan Creek on Zionville quadrangle map.