SURVEY OF BROOK TROUT (*Salvelinus fontinalis*) IN STREAMS ON PRIVATE PROPERTY IN THE UPPER LITTLE TENNESSEE RIVER WATERSHED, MACON AND SWAIN COUNTIES, NORTH CAROLINA - 2014

Report to: North Carolina Wildlife Resources Commission

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TABLE OF CONTENTS

ABSTRACT

During the late summer and fall, the LTLT Stream Biomonitoring Team, assisted by community volunteers visited 31 stream sites in 12 discrete subwatersheds of the upper Little Tennessee River watershed of Macon and Swain Counties, North Carolina in search of naturally reproducing populations of brook trout (*Salvelinus fontinalis*). Our work was focused on streams on private properties and was intended to be complementary to work done by the North Carolina Wildlife Resources Commission and U.S. Forest Service on public lands, with the shared goal of assessing the health of this regionally iconic species in our watershed. We believe that we sampled very nearly every stream in the area where reproducing brook trout populations persist on private property.

Of the 31 sites sampled, with backpack electrofishers and nets, 22 in 12 subwatersheds contained wild brook trout, at population densities ranging from extremely low to robust. In 7 instances, brook trout were the only fish species present; in 4 instances blacknose dace (*Rhinichthys atratulus* was the only other fish species.

Brook trout were found to be sympatric with exotic rainbow trout (*Oncorhynchus mykiss*) and/or brown trout (*Salmo trutta*) at 9 sites. At one site we recorded brook trout with mottled sculpin (*Cottus bairdi*) for the first time in our experience in the Little Tennessee watershed. In addition to these cold water fishes, we found brook trout together with one or more of 4 species of Centrarchids. These warm water species probably represent escapees from artificial ponds or, in at least one case, beaver pond residents. In 2 instances, sympatric populations may represent "sinks" for non-reproducing brook trout, maintained by spill over from allopatric populations above barriers on National Forest Lands.

Brook trout in the upper Little Tennessee watershed are concentrated in the upper Cullasaja subwatershed, on the Highlands Plateau (18 of the total 22 sites), but we identified populations in the upper reaches of 4 other tributary watersheds (Tellico, Cowee, Tessentee and Commissioners Creeks).

While brook trout per se are of great conservation concern, there is special interest in identifying and protecting what remains of the genetically distinct so-called "southern strain" brook trout native to our area, but subject to hybridization as a consequence of repeated stocking of area streams with hatchery-reared northern strain brook trout. Accurate determination of southern vs. northern identity necessitates genetic analysis of tissue samples, which is beyond our capability. However, some observers believe that southern strain brook trout can be detected, with a moderate level of accuracy, by examination of phenotypic characteristics. We explored the possibility of using two phenotypic traits as screening tools to guide selection of sites for DNA studies.

- Eye diameter vs. head length was rejected for further consideration based on the difficulty of obtaining accurate measurements in the field and potential differences related to age and sex of fish.
- The number and patterning of red spots on the body of brook trout, however, seems to have potential as a screening tool.

One of the most significant findings was the discovery of gill lice (*Salmincola edwardsi*) on brook trout from the Big Creek and Buck Creek watersheds. This was the first report of this parasite, specific to brook trout, from the southern Appalachians, though it is well known from northern populations. Wildlife Commission biologists are following up on this potentially serious threat.

We are pleased to report that almost all landowners contacted for access permission not only

invited us onto their properties, but expressed great interest in protecting their streams and the brook trout resource. We hope to work with several of these landowners in enhancing riparian buffer zones, controlling exotic trout invasion and establishing conservation easements along brook trout streams.

INTRODUCTION

During August-October, 2014, the LTLT Stream Biomonitoring staff (Bill McLarney and Jason Meador) undertook to update and compile information on brook trout (*Salvelinus fontinalis*) populations in streams passing through private lands in the Little Tennessee River watershed of North Carolina upstream of Fontana Reservoir (Macon and Swain Counties). Two sources of baseline information on brook trout distribution were used in selection of sampling sites– a database compiled by the North Carolina Wildlife Resources Commission and McLarney's TVA/Western North Carolina Alliance 1992 study of the same watershed. These were supplemented by anecdotal reports from local residents and sites chosen on the basis of study of topographic maps.

The study was focused on private lands to take advantage of LTLT's web of landowner contacts, and to facilitate conservation follow-up. This effort is intended to be complementary to NCWRC and USFS surveys of brook trout populations on National Forest Lands. With a very few exceptions we did not visit streams where the brook trout population is found entirely on National Forest lands. As was the case in the 1992 study we did not carry out sampling in the Georgia (Rabun County) portion of the watershed. To the best of our knowledge brook trout populations in Rabun County are, with one minor exception, all located on National Forest lands.

A total of 31 sites in 12 discrete watersheds were sampled; brook trout were found at 22 sites in 11 watersheds tributary to the Little Tennessee and Cullasaja Rivers. This report concentrates mainly on these sites; streams where brook trout distribution appears to be limited to National Forest lands will be included in a summary section based on pre-existing information.

METHODS

Sampling sites were located in stream reaches on private lands thought to contain brook trout (in 12 cases corresponding exactly to sites visited in the 1992 study) or where there was thought to be a possibility of brook trout based primarily on the existence of downstream barriers. While some effort was made to locate sites close to downstream barriers, as a practical matter site location was based primarily on availability of access permission to a suitable length of stream.

All sites but two very small streams (surveyed with hand net only) were sampled using a single backpack electrofisher (most sites) or 2 electrofishing units (2 unusually wide sites) with 1-4 hand dip nets. Normal crew size was 2 individuals; 4 sites were sampled by only 1 person, and the crew was supplemented with 1-4 volunteers on 11 occasions, typically on the larger or more difficult sites.

Sampling was conducted in an upstream direction, moving slowly and attempting to capture all fish present. A minimum sample time of 20 minutes (1200 seconds) of actual electrofisher time was set, based on our previous experience that that level of effort will detect the presence of all species of fish present at a site in significant numbers. In many cases, actual electrofisher time significantly exceeded this level (up to 3088 seconds, or 7076 in the special case of lower Turtle Pond Creek), in order to include a full range of habitat types or, in streams with low brook trout populations, to insure collection of at least some adult individuals for measurements and photo documentation. In addition to the 2 sites sampled without electrofishers, lower levels of effort were made on 3 occasions – one very difficult small stream where there were obviously no fish, and 2 sites visited merely to certify presence/absence of brook trout as supplemental information.

All fish captured were identified to species, counted and examined for diseases, ectoparasites or anomalies, and returned to the water unharmed. Total length was measured for all brook trout, and also for all other trout > 100 mm TL. Brook trout measuring 100 mm or more were photographed individually and measurements of eye length and head length taken. The eye/head measurements and photography were carried out to test the hypothesis that eye size and/or number/intensity of red

spots on the body can be correlated with identification of southern or northern strain brook trout using genetics technology. Eye/head measurements were replicated and spots counted on the photos. On 6 occasions, volunteer Michelle Ruigrok of the Highlands Nature Center also took and preserved fin clip samples for genetic testing.

While 100% efficiency of capture during a single pass with electrofishers and without the employment of block nets is an unlikely outcome, we feel that we approached this result on at least 9 occasions when brook trout were present. In our opinion, multiple pass depletion, in addition to greatly increasing field time, would have unduly stressed the fish. On 13 additional occasions we counted and reported fish seen but not captured. At 5 additional sites where only brook trout were present, these individuals are included in the brook trout totals in Table 1. On other occasions they are reported as "unidentified trout", or at one site where both small trout and large blacknose dace were present, simply as "unidentified fish". At one site (Big Creek below Shortoff Rd.) we experienced unusually poor fishing efficiency due to an unfortunate coincidence. Just after we began sampling, several individuals began to dismantle a beaver dam just above Shortoff Rd., out of sight. This created high turbidity and, on a wide and relatively deep site undoubtedly contributed to under- or overcounting of fish of all species (overcounting due to flushing of warm water fish from the beaver pond); data from this site should be interpreted with this in mind.

Subsequently we mapped all brook trout watersheds to show the location of sampling sites, presumptive barriers to upstream fish movement, and property boundaries within the brook trout watersheds. One of the uses of these maps is to enable us to calculate the proportion of each brook trout watershed on private or public lands, count the numbers of individual private properties in each watershed, and identify key property owners. Individual property owners are not identified in this report, but this information will be used by LTLT in follow-up work aimed at identifying conservation partners.

RESULTS – BROOK TROUT SITES

Tables 1-2 and Figures 1-12 show results for 22 sites where we carried out a full sampling protocol and determined the presence of brook trout. Figure 1 shows these brook trout watersheds, plus others where brook trout are known to be found only on National Forest Lands, in the context of the entire 455 sq. mi. upper Little Tennessee River watershed. The discussion which follows is based on information from the private lands watersheds only, and is organized by subwatersheds in order from the farthest downstream (Tellico Creek/Sugar Cove Creek) to the uppermost (Commissioners Creek).

We found brook trout on private lands in 11 (or possibly 12, see discussion of Houston Branch) discrete watersheds, isolated from other brook trout populations. It will immediately be noted that 7 of these 11 watersheds are tributary to the Cullasaja River (the largest tributary of the Little Tennessee above Fontana Reservoir) in an area which roughly corresponds to the Highlands Plateau. Occupied brook trout habitat in 4 additional watersheds located off the Highlands Plateau, plus one on the plateau, is concentrated exclusively on National Forest Lands.

The following discussions are organized at the watershed level and attempt to summarize the condition of brook trout streams on private lands in the 11 watersheds, their relation to watershed conditions within the National Forest, problems identified and potential for conservation and restoration. LTLT Site Codes for all sites are included to facilitate access to all data from these sites in the LTLT/LTER database.
(http://coweeta.uga.edu/dbpublic/dataset_details.asp?accession=LTWA_2010_06_01)

Tellico Creek watershed - Sugar Cove Creek (SUGNF-723):

The 1992 survey identified a population of brook trout in the upper reaches of Tellico Creek on National Forest lands. Only after the project was completed did we hear rumors of brook trout in Sugar Cove Creek, tributary to Tellico Creek well downstream of the reach known to be inhabited by brook trout, thus essentially a separate population. This report was subsequently reinforced by information in the NCWRC database. Previously the only fish species known from the accessible reach of Sugar Cove Creek were rainbow trout and mottled sculpins

In 2014, a sample taken near the upper limit of private property SUGNF-723 revealed approximately equal numbers of brook trout, rainbow trout and mottled sculpins, with no large specimens of either trout. This marks the first time we have found brook trout associated with sculpins in 25 years of sampling in the upper Little Tennessee watershed.

While we were not able to make an exhaustive survey of the 6,180 ft. of Sugar Cove Creek from its mouth to the 2014 sampling site, Sugar Cove Rd. (SR 1866) closely parallels the stream and we did not observe anything suggesting a barrier. It may be that brook trout found at SUGNF-723 represent overflow from an isolated population above a barrier located 3000 ft upstream of the National Forest boundary. In this case, and considering the necessity to compete with rainbow trout and sculpins, brook trout on private lands in Sugar Cove Creek may represent a "sink", contributing nothing to the long term survival of brook trout in the upper Little Tennessee watershed and of minimal importance as a fishery resource. A dense canopy of rhododendron probably limits productivity, and many of the trout were found to be thin and in relatively poor condition.

Cowee Creek watershed – Beasley Creek (BEAGR-563):

This site, BEAGR-563 corresponds exactly to one sampled in 1992. Although the methods used in that study, which was focused exclusively on presence-absence, were much less precise than those used in the present study, our impression is of fewer but larger brook trout in this allopatric population. (Largest individual in 1992 was 69 mm. TL.)

Much of the brook trout reach on Beasley Creek is impacted by sedimentation from roads and driveways (including two fords on Goshen Rd. which bracket our sample reach) and narrow buffer zones. A reach immediately downstream of the sample site is being developed as a house lot at this time, with visible damage to buffering capacity.

Cullasaja River watershed – Ellijay Creek/Bryson Branch:

Any discussion of brook trout in the watershed of Ellijay Creek (the largest tributary to the Cullasaja River) must begin with nomenclature. All of the brook trout sites known in the Ellijay watershed are located upstream of what appears on the topo quad as the North Prong of Ellijay Creek, above its junction with Ellijay Creek. However local residents refer to the "North Prong" (which is the larger of the two) as Ellijay Creek and to the smaller branch, indicated as the mainstem on the topo map, as Little Ellijay Creek. Here we will provisionally adopt the "official" terminology from the map; all of the stream reaches discussed will be considered as tributary to the North Prong of Ellijay Creek.

The confusion does not stop there. The principal barrier to upstream movement of non-native trout is a high falls on the North Prong of Ellijay Creek located not far above the mouth of Wildcat Creek. Above this point various stream reaches are referred to by locals as Ellijay Creek, Bryson Branch, Joe Creek or Knight Creek, often interchangeably. All of our brook trout samples above this point are on the mainstem above the falls, referred to on the topo quad as Bryson Branch, and this is the term we will use.

Two sites on Bryson Branch were sampled in 1992 and found to contain allopatric populations of brook trout; both were repeated this year. One additional site (BRYER-724) located in a forested

reach just above Ellijay Rd. (SR 1001) was the object of an incomplete sample this year, undertaken to confirm the barrier function of the high falls. Eight juvenile brook trout, and no other fish, were taken in 356 seconds of electrofishing, confirming that the downstream high falls is the effective barrier.

The uppermost Bryson Branch site (BRYGM-591) is located above and below USFS road 325 off Goodenville Mine Rd. (SR 1522). As in 1992, brook trout were found to be abundant and highly colored, with a good mix of adults and juveniles. However, this reach is severely affected by run-off from the private road, which is deeply gullied and essentially impassable. This road was apparently intended to serve several undeveloped, and for the most part inaccessible, private properties, 5 of which contain 2,850 ft. of Bryson Branch, including the extreme headwaters. BRYGM-591 is separated from the lower site (BRYCD-590), located off Circle D Farms Rd., by a barrier falls, located on National Forest lands, so that the possibility of 2 distinct populations exists. The area around and immediately below the falls is recognized as a "Significant Natural Heritage Area" by the North Carolina Natural Heritage Program, based primarily on botanical considerations, but this could be useful in conservation planning for aquatic organisms as well.

In terms of abundance, size and general appearance brook trout at the 2 sites are very similar. Landowners from the lower National Forest Boundary down through BRYER-724 as far as Ellijay Rd. have taken good care of the stream. While one owner has done a modest amount of riparian clearing, aimed mainly at making foot travel possible, he has not completely eliminated shade, and he has also removed a low dam which may have impeded fish movement. This reach is moderately impacted by sediment from the upper site and also from nearby roads. One small, high-gradient, heavily sedimented tributary, (apparently corresponding to Joe Creek on the topo quad) located between BRYGM-591 and BRYCD-590 was found to have no fish.

Below Ellijay Rd., 2,200 ft. of Bryson Branch flow through an abandoned field with little or no riparian cover. This reach was not visited, but may suffer from elevated temperatures in the summer. Restoration of riparian vegetation could help recuperate a very significant length of brook trout stream.

Cullasaja River – Buck Creek subwatershed:

Buck Creek is a large Cullasaja River tributary popular as a fishing stream for brown and rainbow trout; a map of its course reveals a patchwork of private and public ownership. Above its confluence with Little Buck Creek (previously determined to not contain brook trout) it passes over a series of large falls any one of which could constitute a barrier to upstream fish movement. Our selection of a lower limit for brook trout presence on Buck Creek, corresponding to a high falls and a National Forest boundary at the downstream end of our sample site BUCBC-725 is to a considerable degree arbitrary.

Waterfalls notwithstanding, rainbow trout are present at all points on Buck Creek and its tributary, Stewart Cove, up to the uppermost National Forest Boundary, above our upper sampling sites. Both streams have high falls near this boundary, and are likely home to allopatric brook trout populations above those points.

Two sites on Buck Creek (BUCRH-599, previously visited in 1992 and BUCBC-725 and one on Stewart Cove (STECD-726) were sampled in 2014. All 3 had moderately strong trout populations, with rainbows slightly outnumbering brook trout, and accounting for the largest fish. Only one brook trout (from Stewart Cove) exceeded 150 mm. TL and exhibited full adult coloration. The situation is superficially similar to that at Sugar Cove Creek, leading to the suspicion that the upper Buck Creek watershed below 3,500-3,600 ft. may represent a "sink" for brook trout, with fishery significance mainly for rainbow trout. It is difficult to determine the lower extent of brook trout range in Buck

Creek, but sympatric brook trout occur over at least 4,550 and up to 19,000 ft. of Buck Creek, plus 1,640 ft. of Stewart Cove.

Brook trout (but not rainbow trout) at all 3 sites in the Buck Creek watershed were found to be infested with the parasitic copepod *Salmincola edwardsi*, also found in the Big Creek watershed. See further discussion below.

Cullasaja River – Crow Creek:

In 1992, acting on a tip from an angler who reported capturing a wild brook trout in the Cullasaja River Gorge near the mouth of Crow Creek we found brook trout (and no other fish) to be present in lower Crow Creek all the way down to its mouth at the Cullasaja River, at the lower end of the Cullasaja Gorge. With an altitude of about 2,200 ft. these were the only brook trout found below 2,700 ft. in the upper Little Tennessee watershed during the 1992 study. However, the lower 890 ft. of Crow Creek are located below a high falls. This fact, and the fact that we did not capture any juveniles, suggests that there may not have been a reproducing population of brook trout in lower Crow Creek in 1992. In any event, in 2014 we found rainbow trout, plus 1 brown trout and no brook trout at CROGO-600.

However, based on one sample just above Goldmine Rd. (SR 1679) on upper Crow Creek (CROGM-727) we suggest that allopatric brook trout populate the rest of the Crow Creek watershed. Heavy shade, with a strong predominance of rhododendron near the creek suggests low productivity. Although brook trout population density was moderately high, both adult brook trout taken were thin, one extremely so, suggesting undernourishment. From this point 5,200 ft. downstream to the high falls, on a mix of public and private lands, varying conditions prevail, probably resulting in better habitat in some sectors.

About 500 ft. upstream of CROGM-727 is a large pond which, while fragmenting the stream, is apparently not a source of exotic fish or critically elevated temperatures. In discussions with the owner, we were told that the pond contained fish, but he did not know what kind. We were denied access to the pond and to 1,800 ft. of blue line stream upstream, which could represent an extension of brook trout habitat on Crow Creek.

Cullasaja watershed – Brush Creek:

Brush Creek (Macon County) is tributary to the Cullasaja River just above Cullasaja Falls, and should not be confused with Brush Creek tributary to the Little Tennessee River in Swain County, which was found to have brook trout in 1992, but not in 2014. The watershed of Macon County Brush Creek above a barrier falls is almost entirely within National Forest except for a single private inholding of 60 acres containing 2 large ponds (constructed for the purpose of providing recreational fishing) and 3 short segments of Brush Creek located respectively above the upper pond, between the ponds and below the lower pond but above a barrier falls.

Before the ponds were built, the entire length of Brush Creek on the property undoubtedly contained brook trout. However, the ponds were stocked with rainbow trout, and also contribute to elevated temperatures and fertility. A sample reach below the lower pond (BRHBP-728) had a profuse growth of filamentous algae, an elevated population of heavily parasitized blacknose dace and almost no trout (we took a single small rainbow trout parr). The reach between the ponds was not considered relevant to this study, and further efforts were confined to Brush Creek above the upper pond.

There (BRHSS-601) we found a modest population of both brook and rainbow trout. No rainbow trout over 100 mm. TL were taken, suggesting that if upper Brush Creek has significance to

this species it is primarily as spawning and nursery habitat. However, brook trout were a mix of adults and juveniles, and even the juveniles were very highly colored. To what extent an unusually dense population of blacknose dace may compete for habitat with trout is unknown. We suspect that further upstream on National Forest lands Brush Creek and its tributary Rattlesnake Branch harbor an important brook trout population.

Following our visit, the landowner announced her intention to encourage guests to harvest rainbow trout from the upper pond, but to release any brook trout caught. There are also tentative plans to temporarily drain the lower pond, which may enhance water quality downstream, but is unlikely to restore lower Brush Creek to brook trout quality. We have suggested liming as a possible control for the parasite infestation observed on blacknose dace. A very small branch tributary to the lower pond and located entirely on private property was not visited; it may serve as spawning and nursery habitat for brook and/or rainbow trout resident in the lower pond.

Cullasaja River – Stephens Creek:

About 5,000 ft. of Stephens Creek (STEAP-606) above a series of ponds off Dendy Orchard Rd. (SR 1678), including all of the stream large enough to be significant as trout habitat, is in a single private ownership. Downstream of the ponds (STEGM-605), Stephens Creek is populated by brown trout and blacknose dace. While the ponds have long been stocked with rainbow, brown and brook trout, above the ponds in 1992 we found what we characterized as the "best" allopatric population of brook trout in the upper Little Tennessee watershed, based on the combination of density and average size.

In 2014 we were shocked to find a greatly reduced sympatric population together with a dominant population of small rainbow trout; presumably fish from the ponds are using the creek as spawning habitat. The watershed is entirely forested and otherwise suitable for brook trout. If we can find the means, the landowner is willing to attempt to remove rainbow trout from the stream and screen the ponds to prevent reinvasion.

Cullasaja River – Turtle Pond Creek subwatershed:

Turtle Pond Creek drops over a barrier falls into the Cullasaja River not far below Turtle Pond Rd. Although all 3 species of trout are present in the watershed, Turtle Pond Creek and its tributaries contain brook trout at all levels, and the proportion of brook trout may be increasing.

The lowermost site (TUPTP-081) located just above the bridge on Turtle Pond Rd. (1620), was not sampled as part of this project, but rather on July 26 as part of LTLT's upper Little Tennessee River Watershed Biomonitoring Project, using methods aimed at calculation of an Index of Biotic Integrity (IBI). We have previous IBI samples from 1992, 1999, 2004 and 2009. All previous samples were dominated by brown trout and blacknose dace, with small numbers of rainbow trout and brook trout – the latter exclusively as adults, perhaps moving down from upstream allopatric populations. However, in 2014 brook trout accounted for 21% of trout in the sample, and were represented by a mix of adults and juveniles.

While an increase in abundance of brook trout would appear to be a positive result, it may reflect acidification in a watershed naturally characterized by very low pH. This hypothesis is supported by the disappearance of rainbow trout from our uppermost site on Turtle Pond Creek (TUPAP-611); what was a sympatric population of brook trout in 1992, with the appearance of strong species segregation by habitat, is now apparently allopatric (along with a strong population of blacknose dace.)

Our upper and lower sites on Turtle Pond Creek are separated by 10,500 ft. of stream, including a 3,600 ft. long wetland reach which is periodically dammed by beavers. Local residents blame the beavers for the decline of what was once a renowned trout fishery. Certainly it is true that in the wetland reach the substrate is dominated by accumulated sand and very fine gravel and is not capable of providing an abundance of food or spawning habitat for trout, but acidification may also be a factor.

In all we sampled 5 sites in the Turtle Pond Creek watershed – three on the mainstem (including 2 already described) and one at the lower end of the wetland reach (TUPBN-609), plus one each on two tributaries to Turtle Pond Creek downstream of the wetland reach, Piney Knob Fork (PIKNF-610) and Bennie's Branch (BENTP-608). Of these, only the upper mainstem site approaches a high density brook trout population, and brook trout density in the wetland reach is extremely low, though characterized by relatively large fish.

Of the two tributaries, Piney Knob Fork is probably more important. Most of the watershed is in National Forest, and most of the 730 ft. of stream on private property is very well and deliberately conserved. Part of the upper watershed is located in a Society of American Foresters Protected Natural Area, which should afford some protection. However, there are issues with sedimentation from road crossings.

In retrospect our sample on Piney Knob Fork may have underestimated brook trout population density. The lower half of our sample reach was located in an atypically low gradient reach with heavy accumulation of sediment in pools; it appeared to us that brook trout density was higher in the upper half of the sample reach.

The smaller, low gradient Bennie's Branch was previously sampled in 1992. Uncharacteristically, it continues to harbor all 3 species of trout. We have noted low temperatures here during the summer months, suggesting that it may have importance as a summer refugium for brook trout from the Turtle Pond Creek mainstem.

The Turtle Pond Creek watershed is our largest brook trout watershed (5.6 sq. mi.) and, questions of sedimentation and possible acidification aside, can be said to have very good water quality overall. However, it is one of the focal points of residential development in the Highlands area and may be considered to be under severe pressure.

Although damming by beavers is largely under control, there are at least 2 large manmade ponds in the watershed which may be contributing to higher water temperatures. One is located at the very headwaters on the grounds of a retreat center located at Dillard Rd. (NC highway 106). Flow immediately below this pond during the summer is too low to maintain trout populations, and there are no major tributaries along the approximately 1.3 mi. between the dam and our site TUPAP-611 suggesting that the still mostly forested reach below Dillard Rd. may protect important sources of spring flow.

Cullasaja watershed – Big Cr. subwatershed:

Big Creek (not to be confused with another Big Creek on the Highlands Plateau which forms part of the Chattooga River watershed) is the second largest brook trout watershed (4.3 sq. mi. above the lower known limit of brook trout population at Pinky Falls), but over much of its length it is a marginal brook trout stream due to sedimentation, organic enrichment and competition with brook trout by brown trout and warm water fish species. However, two tributaries, Houston Branch and Norton Prong, support strong brook trout populations and there may be undetected patches of strong brook trout population in the middle sector of the mainstem.

In 2014 we sampled 3 sites on the mainstem of Big Creek. At Pinky Falls (BIGPF-615), a Highlands/Cashiers Land Trust property which protects a small patch of primary forest, located at the

head of Randall Reservoir it is a wide (up to 44 ft.) stream passing over a series of cascades with alternating wide pools, narrow runs and largely bedrock riffle areas. Here, similar to 2014, we took only 2 brook trout, along with 24 brown trout and 58 blacknose dace. This reach is probably of little or no importance in maintaining brook trout populations in the Big Creek watershed.

Our uppermost site on Big Creek (BIGHH-729) is located near the upper limit of private property on the mainstem, in the Hickory Hills Subdivision. Here one bank of the low gradient creek is occupied by a community park, with little riparian buffering. But the other side is wooded and adequately shaded. The major limiting factor would appear to be temperature; this reach is located just 2,800 ft. below a large municipal water supply reservoir which undoubtedly raises the temperature, and above any significant tributary which might mitigate this problem. On the day of sampling water temperature was 65F, as compared to 60 at Pinky Falls and 57 at Norton Prong, which joins Big Creek not far downstream of the site. Here we took 1 adult brook trout in a total sample of 56 fish, including 42 warm water centrarchids and no other trout.

Above BIGPF-615, most of the length of Big Creek is characterized by low gradient reaches interrupted by vertical or near-vertical drops, at least one of which forms an effective barrier to upstream fish movement. The substrate is primarily bedrock, often heavily sedimented. True riffles and freestone reaches are scarce. In 1992 we took a few brook trout under very difficult conditions (overhanging vegetation) at a site in this reach (BIGBA-617) located just above the mouth of Bad Branch. In 2014 we selected a more accessible intermediate site on Big Creek (BIGSO-730) located just below Shortoff Rd. (1540), below the junction of Norton Prong and just above a 12 ft. vertical barrier.

The sample here was decidedly mixed, with fair abundance of brook trout (10 individuals of all sizes, including the 2 largest individuals captured during the study), but also 33 blacknose dace and 28 warm water centrarchids, including a ca. 12 inch TL largemouth bass. As mentioned in the introduction this sample was distorted by an unfortunate coincidence. About halfway through the sample, just as we reached the deepest section, several people began dismantling a beaver dam located just above Shortoff Rd., out of our view. On one hand the resulting turbidity severely reduced visibility and with it efficiency of capture of all species. On the other, opening the dam may have released larger fish and/or an exaggerated number of warmwater species from the beaver pond. Limitations acknowledged, the presence of both small and large trout brook trout here argues for the presence of a naturally sustaining brook trout population in the middle reaches of Big Creek.

Two tributaries located primarily on private lands appear to be important contributors to brook trout numbers on the Highlands Plateau. The low gradient Norton Prong enters Big Creek between our upper and middle mainstem sampling sites. It is characterized by very cold water, but also by intense development pressure in the watershed and heavy sedimentation. Despite the presence of warm water centrarchids in the pools, an intermittently sparse riparian buffer and serious local sources of sediment our sample site on Norton Prong at Shortoff Rd. (NOPCR-731) had a strong population of highly colored brook trout of all sizes from small parr to large adults. Our observations suggest that Norton Prong is an important conservation target, both in its own right and as a supply of low temperature water to Big Creek.

Houston Branch, tributary to Big Creek between the Shortoff area and Pinky Falls, is separated from Big Creek by a bedrock area which, if not quite qualifying as a “falls” appears to serve as a barrier to upstream fish movement. Houston Branch was the only site (HOUBR-616) in the Big Creek watershed where we did not take any fish species other than brook trout, and also the only one where brook trout were not heavily infested by the parasitic copepod *Salmincola edwardsi*. (See below for further discussion of this parasite.) We found it to have a strong population of moderate size brook trout.

We note that in the near future Houston Branch may experience a range of positive and negative impacts. We have been notified that the Forest Service has received approval and funding to

drain Houston Branch Reservoir, located on public lands just above Buck Creek Rd. and 4,780 ft. above our sample site at Simon Speed Rd. The reservoir is no longer being used as a water supply by the Town of Highlands. Presumptive benefits are restoration of 900 ft. of free flowing stream as brook trout habitat, reconnection with 2,330 ft. of Houston Branch above the head of the reservoir, and restoration of bog habitat in the area presently occupied by the reservoir. Potential negative impacts are from a sudden flush of warmer water, possible temporary alteration of pH, release of sediment from the reservoir bed and invasion of lower Houston Branch by redbreast sunfish present in the reservoir.

One other blueline tributary to the middle reach of Big Creek, Bad Branch, was investigated. The site (BADBR-732) was too small to sample properly with electrofishers, but was found to contain small numbers of fingerling brook trout. The maximum length of nursery habitat in Bad Branch is not more than 800 ft., but the almost fully shaded watershed is an important source of cold water to Big Creek.

Tessentee Creek watershed – Lloyd Cove:

The 1992 brook trout survey included sites on upper Tessentee Creek and 5 of its tributaries, but no brook trout were found. For some reason it did not include Lloyd Cove, which was suggested to us this year by NCWRC. In conversations with a private landowner on upper Lloyd Cove, we were informed that he had stocked it with brook trout "from here and there" about 10-15 years ago, prior to which time it contained no fish of any kind.

This stocking has been successful; at LLCDD-733 we found an allopatric brook trout population with the highest population density per area of any site visited, and the second greatest number of brook trout per 100 ft. of stream length. While these fish were mainly small, there were a fair number of highly colored adults. Lloyd Cove was notable for occupancy of very shallow riffles by trout. The downstream limit of the brook trout population has not been determined, but examination of the topo quads suggests a very high gradient reach occupying most of the stream length from near the lower end of our sample to the mouth at Tessentee Creek (2,840 ft.).

Commissioners Creek:

In 1992, based on a sample taken at the same site as this year's (COMMR-685) below Mulberry Rd. (SR 1104), we reckoned that Commissioners Creek had an unusually high population of brook trout over a potentially long reach (up to more than 2 mi. including both private and public lands). This observation was repeated in 2014; Commissioners Creek vies with Lloyd Cove for brook trout abundance (first among 22 sites in brook trout per stream length and third in terms of brook trout per water area). These fish are highly colored and riparian conditions are generally good, suggesting Commissioners Creek as an important conservation target.

Sites with no brook trout

Our 2014 study includes visits to 9 sites where no brook trout were found. In some cases we carried out the full monitoring protocol in the hope of finding brook trout, in others we deemed lesser levels of effort to be sufficient to justify not carrying out full brook trout samples. Below they are listed in the same watershed order as for the samples where brook trout were found.

Brush Creek, Swain County:

Not to be confused with the other Brush Creek, a brook trout stream in Macon County, upper Brush Creek (BRSWC-518) was identified as having an allopatric brook trout population in 1992. At the time we suspected that the brook trout we found were results of recent stocking, and this appears to have been the case. In 2014 we found a very strong population of small rainbow trout, but no brook trout or other fish. This eliminates the only brook trout site on private lands in Swain County.

Laurel Creek:

This tributary to Ellijay Creek was identified as a possible brook trout site on the basis of presence of what may be a barrier falls (Laurel Falls). The area is accessible via a gated private road which connects Ellijay Road at the mouth of Laurel Creek with Mountain Grove Rd. (SR 1521) in the headwater area. We were not able to gain access permission over this road from either end. However, we did talk to a long time local resident who was knowledgeable about brook trout in the Ellijay watershed, and who had assisted in stocking rainbow trout in Laurel Creek. He was of the opinion that prior to stocking there were no trout in Laurel Creek above the falls. It was possible to access one of the headwater branches of Laurel Creek at Mountain Grove Rd, where a full brook trout sampling protocol was carried out (LACMG-734). No fish were found.

Falls Branch:

Falls Branch forms Katie's Falls, which drops directly into the North Prong of Ellijay Creek hard by Ellijay Rd. Above the falls are a large pond in a wooded area and 4,300 ft. of Falls Branch fed by several tributary branches flowing through semi-abandoned fields with patches of forest. Upper Falls Branch was too small to sample well with an electrofisher, but it was easy to capture fish with a hand net. At FABAP-735 we found a strong population of very small rainbow trout (maximum size < 100 mm.) and no other fish. Upper Falls Branch probably serves as spawning and nursery habitat for trout from the downstream pond.

Wildcat Creek:

It was suggested by NCWRC that we look for brook trout in Wildcat Creek (tributary to the North Prong of Ellijay Creek) and its tributary Little Salt Rock Creek on private lands, based on information in their database. We had visited both of these streams, both on private lands and on National Forest above private lands in 1992 (Sites LSRBB-586, LSRAB-587, WLCRB-588 and WLCAB-589). This effort included sampling above high vertical barriers on both creeks, where we found only rainbow trout. In the best case, the available length of Wildcat and Little Salt Rock Creeks on private lands is minimal (4,500 ft. for Wildcat Creek, 2,700 ft. for Little Salt Rock Creek). Nevertheless, bearing in mind experience at Sugar Cove Creek and Buck Creek where allopatric populations of brook trout on public lands contribute to the presence of brook trout in mixed populations of trout downstream, we undertook an abbreviated sample (560 ft., 582 seconds of electrofisher time) of Wildcat Creek along Ellijay Rd. above its confluence with the North Prong of Ellijay Creek (WLCER-736). This reach provides very good habitat in a heavily shaded reach and should retain brook trout for a while if any are displaced from upstream. The sample yielded only a very strong population of small to medium size rainbow trout and several longnose dace.

Joe Creek:

We are not sure if the name applies, but from the topo quad it appears that "Joe Creek" should apply to a small, high gradient, heavily sedimented stream tributary to Bryson Branch not far downstream of BRYCD-590. According to the landowner, it formerly contained brook trout but had been heavily impacted by road runoff. An abbreviated sample in terms of time (536 seconds of electrofisher time) but not length (360 ft.) at JOECD-737 yielded no fish.

Crow Creek:

Our sample effort on Crow Creek between its mouth at the Cullasaja River and a barrier falls is described above. This reach (CROGO-600) probably occasionally receives brook trout from upper Crow Creek, but at this time is dominated by rainbow trout.

Brush Creek (Macon County):

Based on conversations with the landowner, we expected to encounter some trout, possibly including some brook trout, in this Brush Creek below the lowermost of 2 ponds. What we found was a stream apparently unsuited for permanent occupation by trout, perhaps due to temperature and/or chemical effects from the pond system, and dominated by a heavily parasitized population of the omnivorous blacknose dace.

Sites not visited

Records of two additional private lands sites from the NCWRC database (Poplar Cove Creek in the upper Cartoogechaye Creek watershed and Skeenah Creek) are almost certainly due to identification of stocker brook trout at sites well downstream of where any stream-bred brook trout were expected. These sites were not visited.

The following additional sites on the National Forest suggested by the NCWRC database and our own work in 1992 and after were not visited:

- Rattlesnake Creek (not to be confused with the Rattlesnake Creek tributary to Brush Creek in Macon County) – presently the home of the only wild brook trout population in the Swain County portion of the Little Tennessee watershed above Fontana Reservoir
- Tellico Creek above Indian Branch.
- Pol Miller Hollow (tributary to the Left Prong of Burningtown Creek) above a high falls
- Burningtown Creek above Indian Camp Creek.
- Ball Creek and Shope Fork, tributary to Coweeta Creek on the Coweeta Hydrologic Lab property.
- Betty Creek in the Southern Nantahala Wilderness

These sites are mapped (Figure 1) in order to give a complete picture of probable habitation by brook trout in streams of the upper Little Tennessee River watershed of Macon and Swain Counties, North Carolina. Starting with the assumption that brook trout were originally native to all watersheds above 2,500 ft., the original extent of brook trout habitat in the watershed was approximately 232 sq. mi. Of this today 45 sq. mi. (19.3%) still contains wild brook trout. Of this 45 sq. mi. 9.1 sq. mi. (20% or 3.9% of the total) are located on private land. However, this measure understates the importance of private lands in protecting brook trout since many of the larger streams are concentrated on private

lands. If it were possible to derive a precise number for the number of stream miles or acreage of water inhabited by brook trout, the proportional value of private lands would be seen to be much higher.

DISEASES AND ANOMALIES

All brook trout as well as other fish were routinely examined for external symptoms of diseases, parasites and anomalies. Such conditions for brook trout are noted in Table 1. In general, pathological conditions do not seem to be of great concern in brook trout streams in the upper Little Tennessee watershed, with one potentially very significant exception.

On September 19, partway through the sample on Norton Prong (Big Creek Watershed) we observed a white substance protruding from the gills of an adult brook trout. Closer inspection determined it to be a parasite, which was subsequently identified by the North Carolina Wildlife Resources Commission as the copepod *Salmincola edwardsi*. Our routine inspection for anomalies did not include prying open the gill cover since we wished to minimize handling, so it is likely we overlooked parasitized fish from sites sampled prior to that date. The parasites were detected on this particular specimen because they were so dense as to be protruding externally. All adult brook trout subsequently examined at Norton Prong (4 of a total 9) had greater or lesser infestations of this parasite.

In 8 subsequent samples we examined all adult brook trout for *Salmincola* and found it present on all individuals at samples from Big Creek below Shortoff Rd. and at all 3 sites in the Buck Creek watershed. *Salmincola* was not determined to be present at 2 of 5 samples in the Turtle Pond Creek watershed, in Brush Creek and at Houston Branch in the Big Creek watershed. We have no information on *Salmincola* at 10 additional sites sampled on or before Sept. 19; these sites are recorded as "not observed" in Table 1.

We think it is reasonable to expect that *Salmincola* is present throughout the Buck Creek watershed and over the entire length of Big Creek inhabited by brook trout, from the head of Randall Reservoir (Pinky Falls) at least up to a reservoir above the Hickory Hills subdivision. Its absence from Houston Branch reinforces the notion that the Houston Branch brook trout population is effectively separated from that of the Big Creek mainstem by a steep slickrock area near the mouth.

At the 3 sites in the Buck Creek watershed where brook trout are sympatric with rainbow trout, we found no evidence of the parasite on rainbow trout; *S. edwardsi* is generally considered to be specific to brook trout. While *S. edwardsi* is not uncommon in northern waters, so far as we can determine this is the first report of this parasite from the southern Appalachians; it may have been introduced with stocked brook trout of northern origin. We can only speculate on potential effects on brook trout populations, but they can only be negative. The North Carolina Wildlife Resources Commission has already undertaken to publicize our findings, in the hope of securing additional information from anglers and discouraging promiscuous stocking of brook trout by private individuals.

Apart from *Salmincola*, the incidence of diseases, parasites and anomalies was minimal. At no site did we report more than 2 individuals with symptoms; at 15 sites we observed no pathological conditions. The most common conditions were finrot and deformities of the jaw or fins (3 individuals each). We observed 1 lesion on the opercle and 1 fish exhibited exopthalmus. One individual from Piney Knob Fork was missing both eyes, emaciated and presumably moribund.

"SOUTHERN STRAIN" BROOK TROUT

The principal objective of our work is simply to determine the presence, and something of the condition, of remaining wild *Salvelinus fontinalis* populations in our area; the presumption is that the

continued existence of any naturally reproducing brook trout population is a good thing, whether viewed as a fishery resource or a component of aquatic biodiversity. However, the significance of our work and that carried out by government agencies increases to the degree that we are able to help determine the presence of relatively genetically pure "southern strain" brook trout populations.

In planning for this project, we considered taking and preserving fin clips for DNA analysis aimed at uncovering southern strain populations; however it was decided that this time-consuming procedure was not compatible with our goal of achieving complete coverage of possible brook trout populations on private lands in Macon and Swain Counties. Nonetheless, we are unable to avoid speculating on the genetic identity of the fish we find, and so offer a few comments which may be helpful to the Wildlife Commission is prioritizing streams for genetic sampling.

One clue is the history of the streams, to the extent that it is known. A stream like Buck Creek below the barrier falls on National Forest property, which has long been managed for recreational fishing, has likely been repeatedly "contaminated" with northern strain brook trout genes. Something similar can be surmised for Lloyd Cove which, according to the landowner at our sample site, had no fish before he stocked it with brook trout "from here and there".

There are those who claim to be able to visually distinguish northern and southern strain brook trout, not with such a degree of accuracy as to obviate the need for DNA work, but sufficiently to be able to suggest the probability of southern strain genes. This approach is complicated by the fact that we are not dealing simply with the question of southern vs. northern strain fish, but in many cases with hybrids resulting from stocking northern fish into southern strain populations. Nevertheless, we took this project as an opportunity to carry out preliminary tests on two of the hypothesized phenotypic differences between northern and southern strain brook trout – eye size (Southern fish are reputed to have larger eyes relative to the size of the head.) and patterns of red spots on the body (southern fish with more, differently distributed and/or brighter spots).

For all brook trout >100 mm. TL, we measured the diameter of the eye (length) and the length of the head (tip of upper jaw to trailing edge of opercle), and took a closeup photo (one side only). The photo was used to count red spots and observe the pattern of their distribution, and also to redo the eye/head measurements.

Eye-head measurements:

Table 3 shows the mean and median eye length:head length ratio for all brook trout >100 ml. TL, based on photographs, broken down by sample site and watershed group. Results are inconclusive, showing only minor, non-significant differences. In our view, the results are compromised by:

- Small sample size (as few as 1-3 individuals from some sample sites)
- Inconsistencies when measurements from the field are compared with those based on photos. It is not simply the case that one method is more accurate than the other, but that meristics from live fish can never match the accuracy which can be obtained with museum specimens. In the field we were handicapped by wiggly fish and a desire to not subject the fish to excessive handling. Use of photos removes those objections, but problems arise comparing fish with their mouths open when photographed with others with closed mouths, flaring of the opercles, etc.
- Probable differences in dimensions related to size, age and possibly sex. We especially note that some of the smaller individuals have what can only be characterized as juvenile faces, with short upper jaws; they look like parr.

We conclude that eye size is not a promising avenue for relating phenotype to genotype in brook trout. Perhaps with a very large sample of more or less uniformly sized preserved fish differences would be detectable, but this is not a likely scenario.

Red spots

The number (and to a lesser extent the patterning) of red spots on the body does appear to show promise for preliminary sorting of brook trout according to the probability of southern vs. northern genotype. While small sample size and the existence of varying degrees of hybridization are still concerns, Table 4 and Figure 13 suggest significant differences in the number of red spots on fish from different populations. Note that among the 4 watersheds where the mean number of red spots on one side was >20 are the (presumably) isolated Houston Branch and Commissioners Creek (considered a top candidate for southern strain based on preliminary testing). The lowest mean numbers of red spots (10-12) were reported for Buck Creek and Lloyd Cove, watersheds where, as discussed above, the probability of past stocking with northern strain trout is high. We also note, somewhat more subjectively, that in the watersheds where red spots are more abundant, the pattern of distribution is highly irregular, whereas for fish with smaller numbers of spots, the spots tend to be arrayed in tidy rows, columns and diagonals.

It is probable that in many cases spots are undercounted, related to the quality of the photos. Glare is the principal problem, but some photos are too dark and in many cases the pectoral fin is positioned so as to possibly obscure spots. Nevertheless, we offer the frequency, and possibly patterning of red spots as a useful factor in prioritizing brook trout populations for genetic analysis.

PROBLEMS, OPPORTUNITIES AND CONSERVATION ACTIONS

Some of the follow-up activities to this project (sampling on National Forest lands, the *Salmincola* problem, large scale genetic testing) are clearly in the domain of the Wildlife Commission, but there are a number of areas where LTLT can and should be involved in problem solving and conservation activities.

Landowner contacts:

LTLT's effectiveness in this project thus far stems to a great degree from our established, and growing, web of landowner contacts. It is pleasing to us to note that, almost without exception, the landowners with whom we came into contact in the course of the work reported here were sympathetic to what we are trying to do. All of them have expressed a desire to protect and enhance the streams and watersheds and – to the extent that they are aware of it – the brook trout resource on their properties.

Over the next year we will be compiling lists of private landowners in all of the watersheds where we worked. Some watersheds (most notably Big Creek, with 709 mostly small property owners) are essentially suburban. In these instances we will be selective, not attempting to directly contact small landowners located at some distance from blue line streams. In other cases (Stephens Creek, Sugar Cove Creek) there are only 1-2 private landowners in the watershed. In all cases, we will break down the landowner lists into 3 categories – 1) landowners along stream reaches known or suspected to contain brook trout populations, 2) landowners along smaller blue line streams in brook trout watersheds, 3) those who apparently do not have flowing streams on their property.

Beginning with group no. 1 (and especially those landowners we already know or met during the study) we will undertake individualized communication – and where necessary, education – about

the results and goals of our project, the importance of brook trout in the Southern Appalachians and, especially, opportunities to collaborate in conserving brook trout and their small stream habitat, as follows:

- Recognition as friends of the brook trout and the high altitude stream environment.
- Participation as volunteers in future monitoring events (undertaken by 2 landowners in the recently completed round)
- Opportunities to donate conservation easements along brook trout streams.
- The opportunity to become members of LTLT and donate to the perpetuation of our long-term work on behalf of the upper Little Tennessee watershed.
- Participation in solving problems as described below.

Riparian buffer zones:

Protection and restoration of riparian vegetative buffers fits neatly under LTLT's "Shade Your Stream" initiative, which emphasizes tree planting and minimally invasive stream restoration methods. We stand ready to receive easements on properties including intact riparian buffers along brook trout streams, but also to help establish adequate buffers along currently unshaded stream reaches. We will emphasize the importance of linking headwater buffers to downstream reaches, ultimately protecting more than just brook trout habitat.

Sedimentation:

A number of the streams discussed in this report carry sediment loads well in excess of natural levels. In high altitude areas, probably the most significant source of sediment is roads, public and private. We hope to assist landowners in controlling sedimentation originating with erosion of their access roads and driveways (as well as such other sources as may exist). We will also draw attention to those cases where the problem may originate with the DOT or Forest Service and channel pressure on public agencies for resolution of erosion and sedimentation problems originating off private lands.

Ponds:

We identify ponds and reservoirs as negative contributors to the health of at least 10 of the 22 brook trout sites described here. Among the problems caused by ponds – of which the public is generally unaware – are fragmentation of stream reaches, sources of rainbow trout and other exotic species which compete with brook trout and their role as solar water heaters. We have already identified 3 situations where landowners (including the Forest Service in one case) are willing to work with us to correct problems originating with impoundments, and will make a special effort to contact impoundment owners in brook trout watersheds.

CONCLUSION

As Figure 1 shows, in the upper Little Tennessee Watershed we have lost over 80% of our original brook trout populations, and much of what remains is genetically compromised through hybridization with or replacement by stocked fish of northern origin. Our goal moving forward is to participate indirectly, through providing information to the Wildlife Resources Commission, the US Forest Service and other organizations (for example Trout Unlimited), and directly as a local conservation organization in defining, preserving and expanding remaining brook trout habitat in our

area, while protecting the integrity of the native “southern strain” as an essential component of regional biodiversity. We see education on the brook trout issue as a building block in our Citizen Science program and anticipate that increased awareness of this particular issue will have the effect of benefitting downstream, non-brook trout stream reaches, and ultimately the entire upper Little Tennessee watershed.

ACKNOWLEDGEMENTS

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Further encouragement, as well as a space for our first meeting was provided by Damon Hearne of Trout Unlimited.

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Kelder Monar of LTLT prepared the maps.

Thanks also to the numerous landowners who granted us access permission and in most cases encouraged and inquired about our work.

APPENDIX

Table 1. Fish

Site	Sugar Cove Cr.	Beasley Cr.	Bryson Br.	Bryson Br.	Buck Cr.	Stewart Cove	Buck Cr.	Crow Cr.	Brush Cr.	Stephens Cr.	Turtle Pond Cr.	Bennies Br.	Piney Knob Fork	Turtle Pond Cr.	Turtle Pond Cr.	Big Cr.	Houston Br.	Big Cr.	Norton Prong	Big Cr.	Lloyd Cove	Commissioners Cr.
Location	USFS boundary	@ Goshen Rd.	Circle D farms	off Goodenville Mine Rd.	below Buck Cr. Rd.	above mouth	above Stewart Cove	above Goldmine Rd.	above ponds	above ponds	above Turtle Pond Rd.	above Turtle Pond Rd.	above mouth	lower end of wetland	above wetland	@ Pinky Falls	Simon Speed Rd.	below Shortoff Rd.	below Shortoff Rd. @ Crisp St.	Hickory Hills subdivision	1 mi. above Tessentee Cr.	below Mulberry Rd.
<u>Brook Trout</u>																						
Adults (>100mm TL)	4	2	9	7	2	2	2	3	3	2	3	1	4	3	7	1	15	3[α]	9	1	11	16
Juveniles	8	8	21	25	10	14	9	16	3	1	7	4	7	1	6	1	12	7[α]	15		37	33
Total	12	10	30	32	12	16	11	19	6	3	10	5	11	4	13	2	27	10[α]	24	1	48	49
Mean Length (mm)	81.3	96.9	101.0	92.2	89.8	83.7	81.4	74.6	103.5*	121.0*	xxx	101.4‡	94.8	157.0*	118.2	105.5*	115.8	138.9	110.7	158.0*	82.4	95.1
Median Length (mm)	64.5	86.0	81.0	76.5	84.0	76.0	92.0	70.5	90.0*	141.0*	xxx	90.0‡	86.5	158.0*	89.0	105.5*	104.0	113.5	81.0	158.0*	65.0	75.0
Largest Individual (mm)	138	153	230	192	152	172	103	157	195	142	167	212	148	243	247	135	198	280	236	158	172	210
<u>Abundance</u>																						
Brook Trout / 100 LF	4.12	3.06	9.90	7.66	4.74	5.93	3.31	7.31	3.09	0.77	2.28	2.06	3.89	1.49	5.00	0.74	9.09	2.69[α]	9.60	0.33	16.72	19.35
Brook Trout / 100 ft^2	0.37	0.51	1.32	1.55	0.27	0.46	0.17	0.81	0.17	0.08	0.10	0.22	0.22	0.08	0.31	0.02	0.79	0.11[α]	1.42	0.03	2.79	1.40
Salmincola	/	/	/	/	Yes	Yes	Yes	/	No	/	/	/	No	No	/	/	No	Yes	Yes	/	/	/
Other Anomalies	None	None	None	∞(healed)	None	ç (fin), ◊	None	None	None	None	∞	None	[xx]	None	None	None	∞	ç (jaw), ϕ	ç (jaw)	None	None	None
<u>Other Fish</u>		None	None	None				None									None				None	None
Unidentified trout	2				3	3	5			3	1	3‡										
Rainbow trout	14				15	14	14		7	21	11	1										
Brown trout											26	4				24						
Blacknose dace									189		34	3	13	29	70	58		33[α]	36	9		
Redbreast sunfish																		24[α]	8	24		
Green sunfish																1				18		
Bluegill																			1			
Largemouth bass																		4[α]		4		
Mottled sculpin	12																					
Total Fish	40	10	30	32	30	33	30	19	212	27	82	16	24	33	83	85	27	71[α]	69	56	48	49

*<10 individuals
‡ possible large blacknose dace
[α] All fish counts probably low
/ Not Observed
∞ finrot
ç deformity
[xx] blind & emaciated
◊ lesion on opercle
ϕ exophthalmus

Table 2. Site info

Site	Sugar Cove Cr.	Beasley Cr.	Bryson Br.	Bryson Br.	Buck Cr.	Stewart Cove	Buck Cr.	Crow Cr.	Brush Cr.	Stephens Cr.	Turtle Pond Cr.	Bennies Br.	Piney Knob Fork	Turtle Pond Cr.	Turtle Pond Cr.	Big Cr.	Houston Br.	Big Cr.	Norton Prong	Big Cr.	Lloyd Cove	Commissioners Cr.
Location	USFS boundary	@ Goshen Rd.	Circle D farms	off Goodenville Mine Rd.	below Buck Cr. Rd.	above mouth	above Stewart Cove	above Goldmine Rd.	above ponds	above ponds	above Turtle Pond Rd.	above Turtle Pond Rd.	above mouth	lower end of wetland	above wetland	@ Pinky Falls	Simon Speed Rd.	below Short off Rd.	below Short off Rd.	Hickory Hills	1 mi. above Tessentee Cr.	below Mulberry Rd.
Latitude (dd.ddd°)																						
Longitude (dd.ddd°)																						
Watershed	Tellico	Cowee	Cullasaja/Ellijay		Cullasaja/Buck			Cullasaja	Cullasaja /Brush	Cullasaja	Cullasaja/Turtle Pond					Cullasaja/Big					Tessentee	Commissioners
Site Code	SUGNF-723	BEAGR-563	BRYCD-590	BRYGM-591	BUCBC-725	STECD-726	BUCRH-599	CROGM-727	BRHBP-728	STEAP-606	TUPTP-081	BENTP-608	PIKNF-610	TUPBN-609	TUPAP-611	BIGPF-615	HOUBR-616	BIGSO-730	NOPCR-731	BIGHH-729	LLCDD-733	COMMR-685
Date (2014)	8/20	8/20	8/29	8/29	9/26	9/26	9/27	9/6	10/11	9/6	7/26	9/12	10/6	10/6	9/12	9/19	9/26	9/27	9/19	9/19	9/4	9/4
Watershed Area @ Site (mi^2)	1.2	1.6	0.8	0.5	4.2	1.0	4.1	0.8	2.2	0.5	5.6	0.8	1.3	1.2	0.6	4.3	0.8	2.9	0.7	1.7	0.6	0.8
Sample Length (ft)	291	327	303	418	253	270	332	260	194	388	438	243	283	269	280	269	297	372	250	304	287	269
Altitude (ft)	2800	2400	3020	3480	3500	3600	3540	2980	3460	3160	3340	3340	3400	3360	3400	3780	3800	3760	3900	3940	2300	2700
Width (ft)	10-12	5-7	7-8	6-8	15-20	10-16	13-26	7-11	16-20	9-11	19-28	9-10	15-21	15-21	15	19-44	9-14	18-32	7-15	8-11	5-7	10-16
Max Depth (ft)	2.0	0.8	1.1	1.0	2.7	1.2	4.5	1.0	2.2	1.6	2.7	2.3	2.1	2.8	1.9	4.4	1.3	3.0	2.9	1.8	1.6	3.3
Gradient	High	Med.	Med.	Med.	Med.	Med/Hi	Med.	Low	Med.	Med.	Low	Low	Low-Med.	Low	Low-Med.	High	Low	Low	Low	Low	Low/Med	Med.
Dominant Land Use (L/R)	Forest	Lawn	Forest/ field	Forest	Forest/ Road	Forest	Forest/ Field	Forest	Forest	Forest	Road/ Forest	Forest	Forest/ Resid.	Resid.	Road/ Forest	Forest	Forest	Resid/ Road	Resid	Resid/ Lawn	Field	Road/ Forest
Riparian Width (L/R)	50/Full	10/10	Full/5	Full	Full/30	Full	Full/30	Full	Full	Full	30/Full	Full	Full	Full	10/Full	100/ Full	40/>50	50/25	0/10	30/0	100	20/Full
Quality Riparian Quality	Excel.	Good	Excel/ Fair	Excel.	Good/ Fair	Excel.	Excel/ Fair	Good/ Excel.	Excel.	Excel.	Good/ Excel.	Excel.	Good	Good	Poor/ Excel.	Excel	Good/ Excel	Excel/ Good	Poor	Good/ Poor	Excel.	Good
Water Temp (F)	61	62	60	60	59	55	56	65	56	58	59	58	46	48	60	60	56	60	57	65	60	62

Table 3. Eye diameter/head length ratio for brook trout in the upper Little Tennessee Watershed, Macon County, NC, 2014.

Subwatershed	no. fish	mean ratio (eye /head length)
Turtle Pond Creek	12	0.211
Commissioners Creek	16	0.214
Bryson Branch	15	0.222
Lloyd Cove	11	0.228
North Macon County*	7	0.229
Buck Creek	6	0.236
Cullasaja West**	4	0.249
Big Creek less Houston Branch	18	0.251
Houston Branch	14	0.254
Brush Creek	3	0.256

*Sugar Cove and Beasley Creeks
** Crow and Stephens Creek

Table 4. Number of red spots (one side) per fish - brook trout from Little Tennessee watershed Macon County, NC – 2014.

		No. Red Spots	
Subwatershed	**no. fish**	**Mean**	**Range**
Lloyd Cove	11	10.8	7-17
Buck Creek	6	11.3	3-23
Cullasaja West**	4	12.0	4-20
North Macon County*	7	12.9	7-17
Big Creek less Houston Branch	18	18.2	8-43
Bryson Branch	15	19.2	13-32
Commissioners Creek	16	21.7	9-44
Turtle Pond Creek	12	22.2	10-34
Brush Creek	3	22.3	17-28
Houston Branch	14	26.4	15-44

*Sugar Cove and Beasley Creeks
** Crow and Stephens Creek

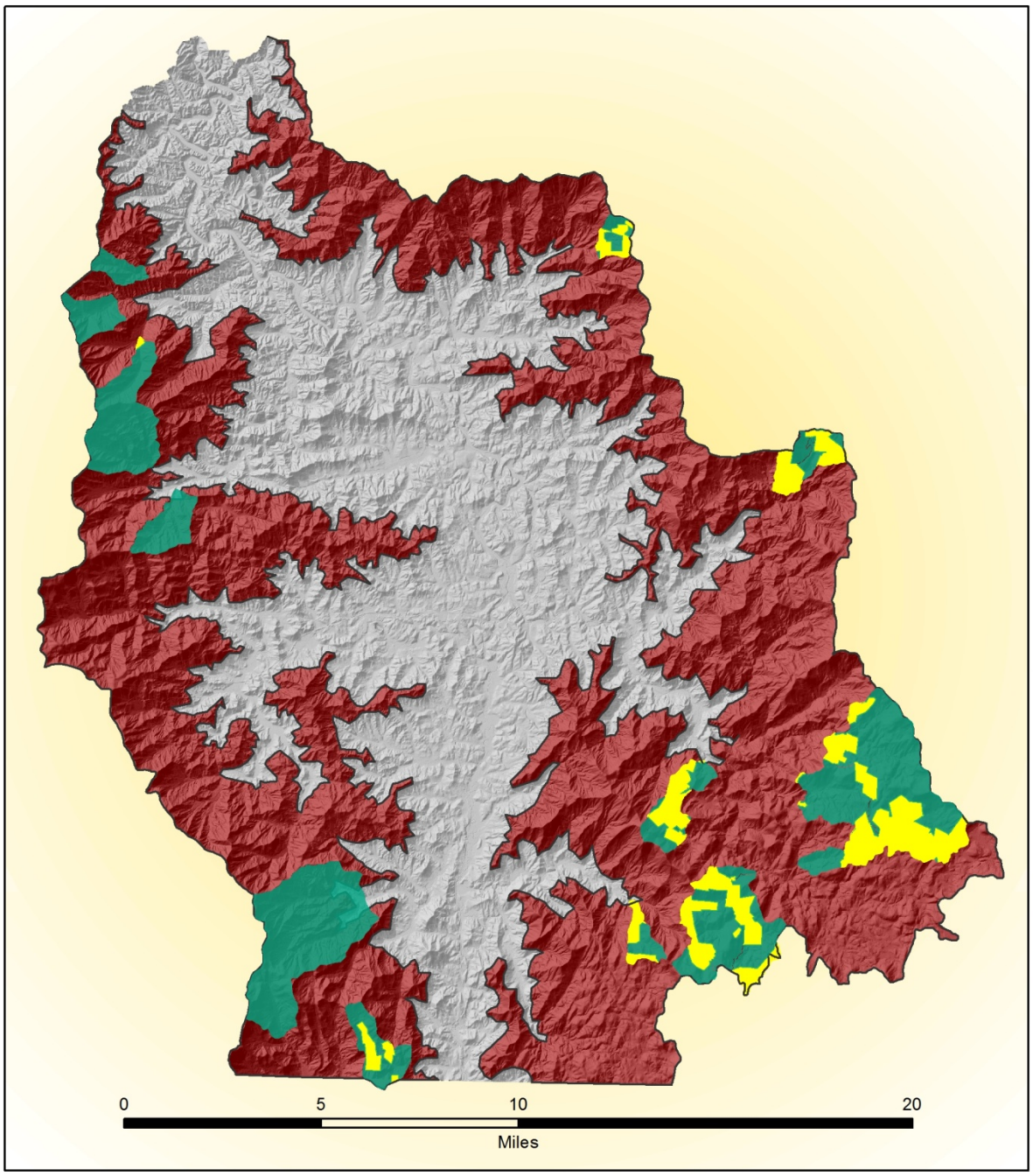

0
5
10
20
Miles
N
W
E
S
Brook Trout Range in the Upper Little Tennessee River Watershed in North Carolina
Legend
Present Range (USFS)
Present Range (Private)
Inferred Historical Range

Figure 1.

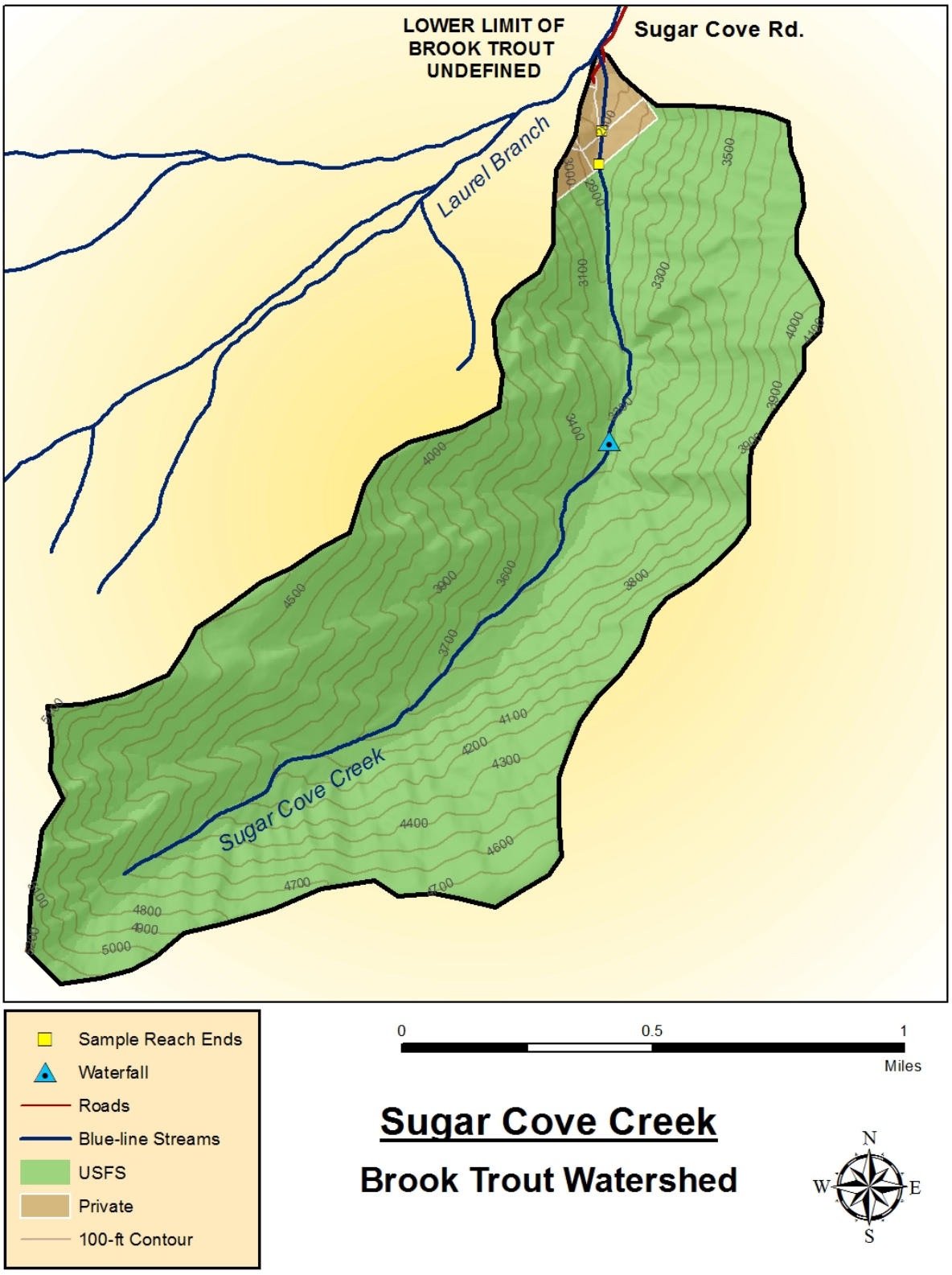

LOWER LIMIT OF
BROOK TROUT
UNDEFINED
Sugar Cove Rd.
Laurel Branch
Sugar Cove Creek
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
0.5
1
Miles
Sugar Cove Creek
Brook Trout Watershed
N
W
E
S

Figure 2.

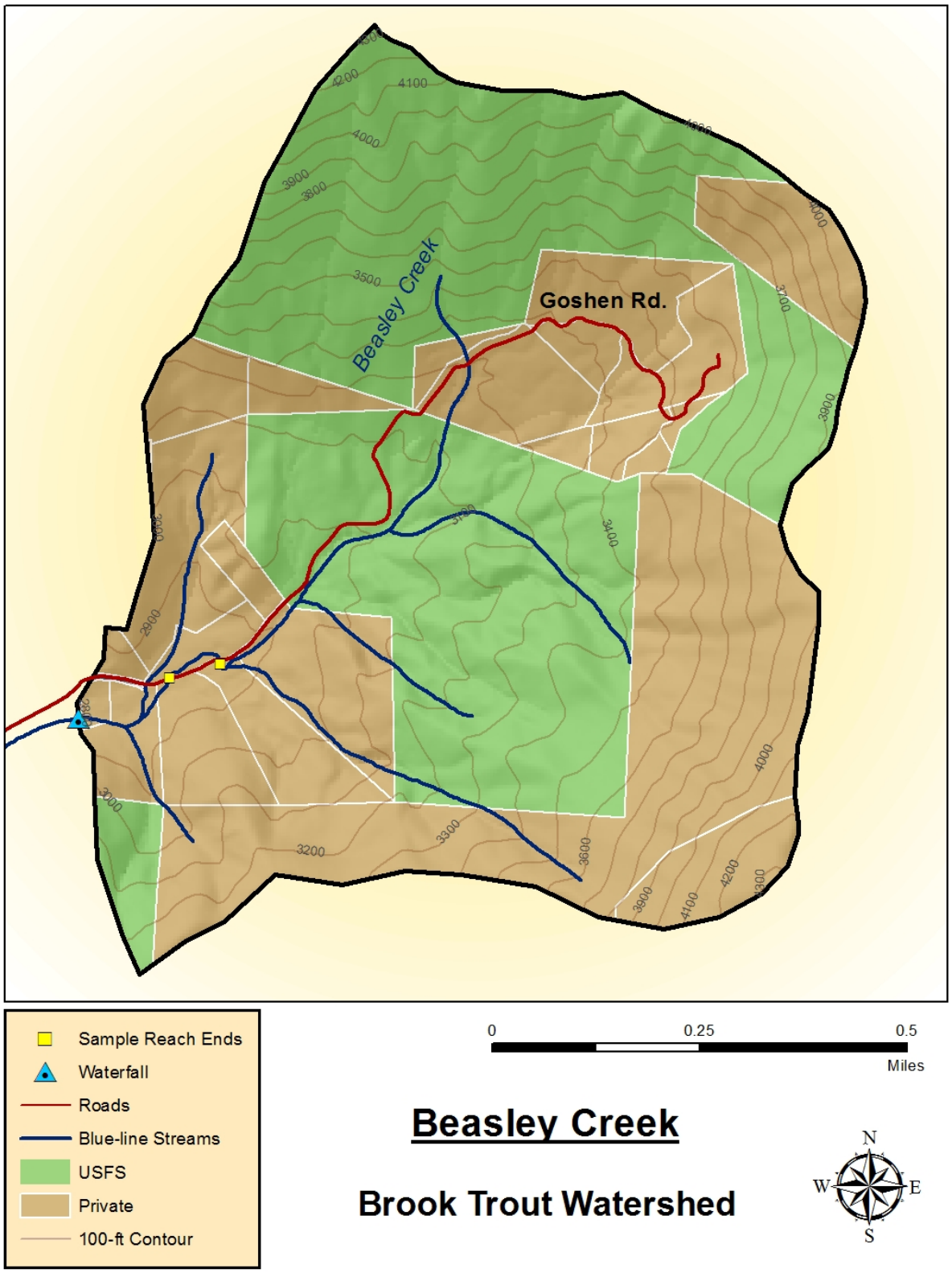

Beasley Creek
Goshen Rd.
4200
4100
4000
3900
3800
3500
3700
3400
3300
3200
3000
2900
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
0.25
0.5
Miles
Beasley Creek
Brook Trout Watershed
N
W
E
S

Figure 3.

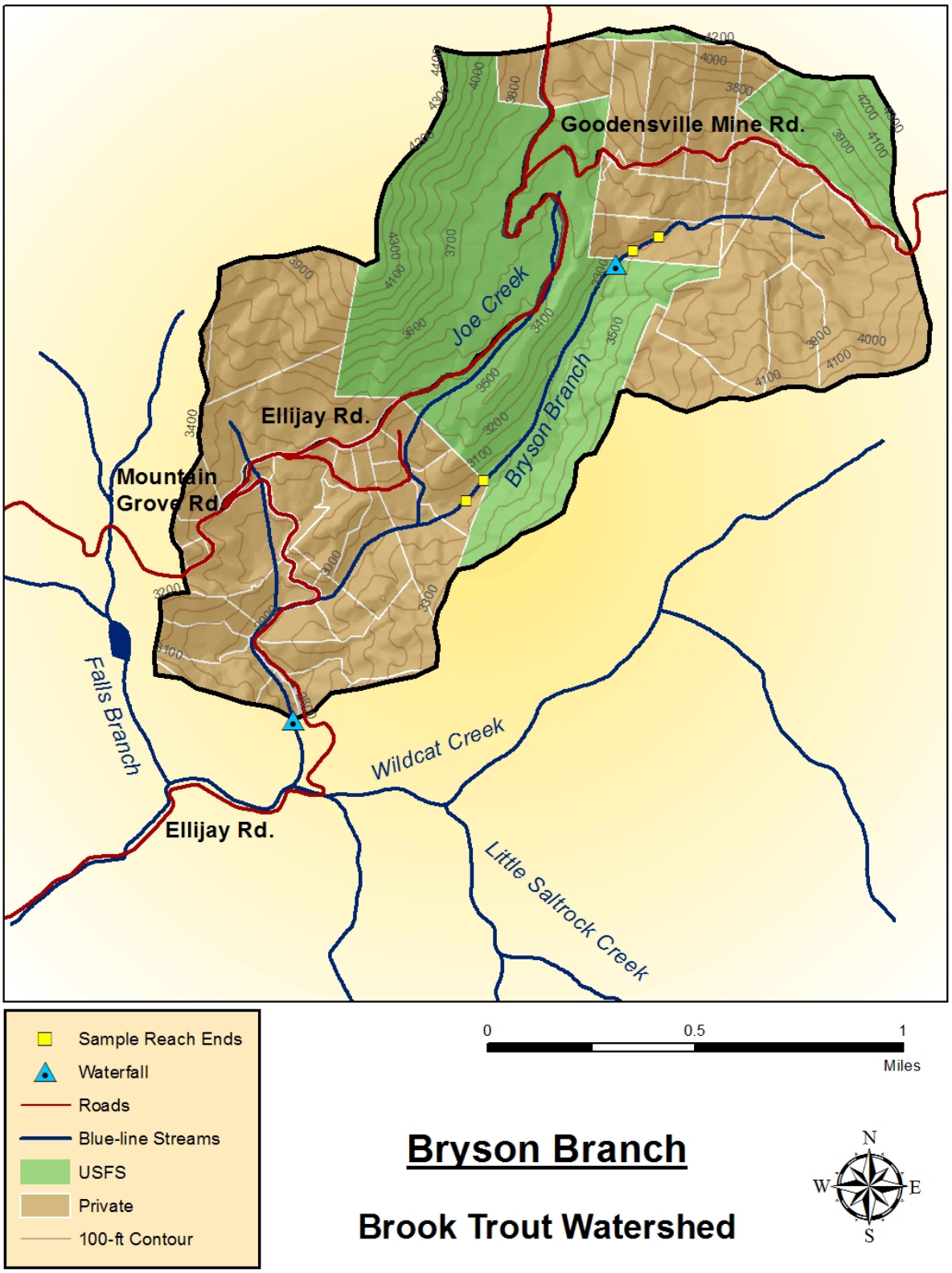

Goodensville Mine Rd.
Joe Creek
Bryson Branch
Ellijay Rd.
Mountain Grove Rd.
Falls Branch
Wildcat Creek
Ellijay Rd.
Little Saltrock Creek
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
0.5
1
Miles
Bryson Branch
Brook Trout Watershed
N
W
E
S

Figure 4.

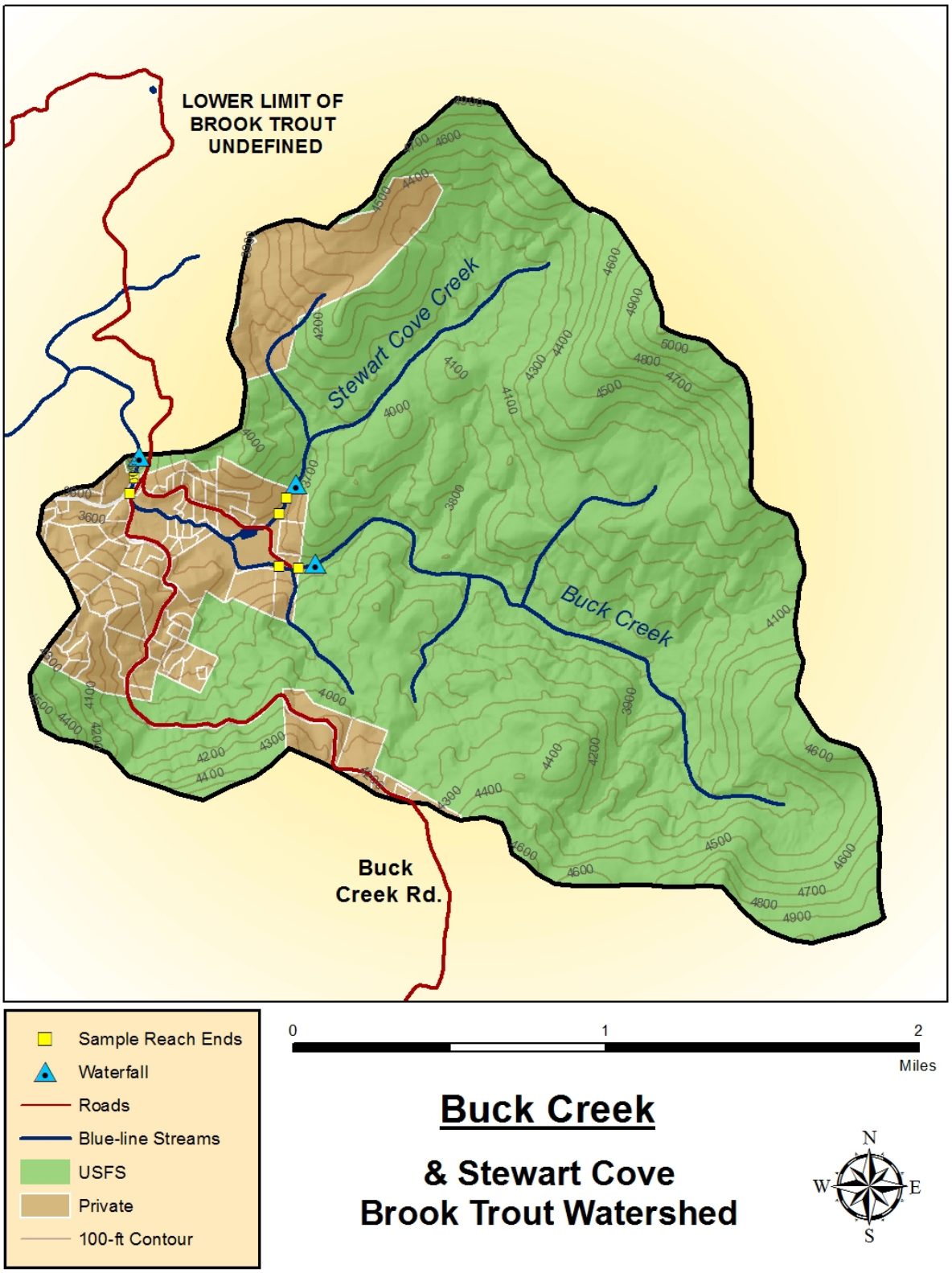

LOWER LIMIT OF
BROOK TROUT
UNDEFINED
Stewart Cove Creek
Buck Creek
Buck
Creek Rd.
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
1
2
Miles
Buck Creek
& Stewart Cove
Brook Trout Watershed
N
W
E
S

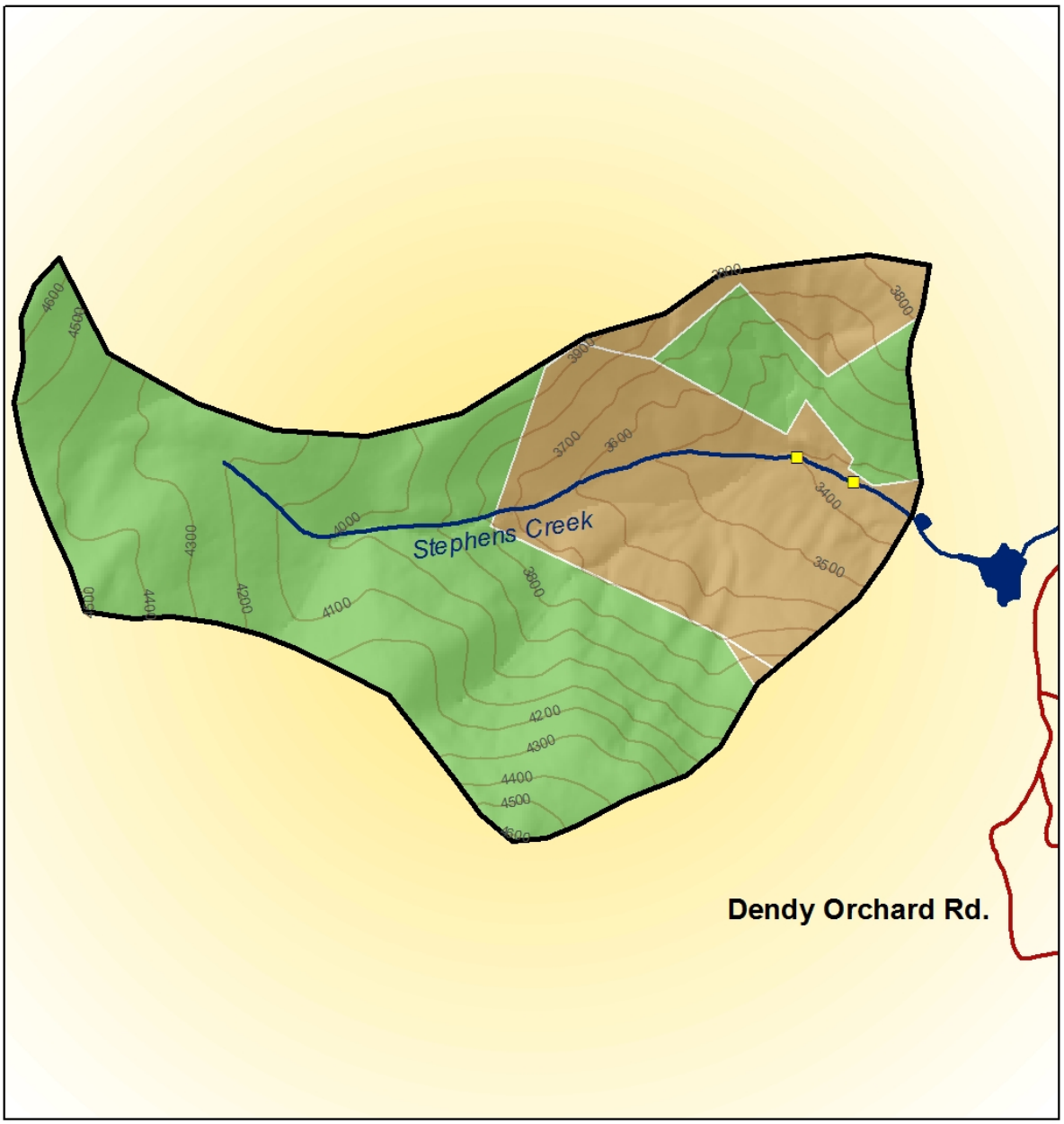
Figure 5.

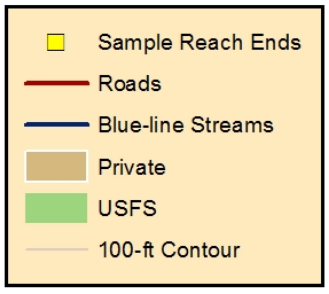

Gold Mine Rd.
Crow Creek
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
0.5
1
Miles
Crow Creek
Brook Trout Watershed
N
W
E
S

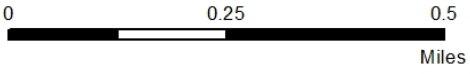
Figure 6.


Buck
Creek Rd.
Brush Creek
Rattlesnake Branch
Flat Mountain Rd.
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
0.5
1
Miles
Brush Creek
Brook Trout Watershed
N
W
E
S

Figure 7.







Stephens Creek

Brook Trout Watershed

Figure 8.

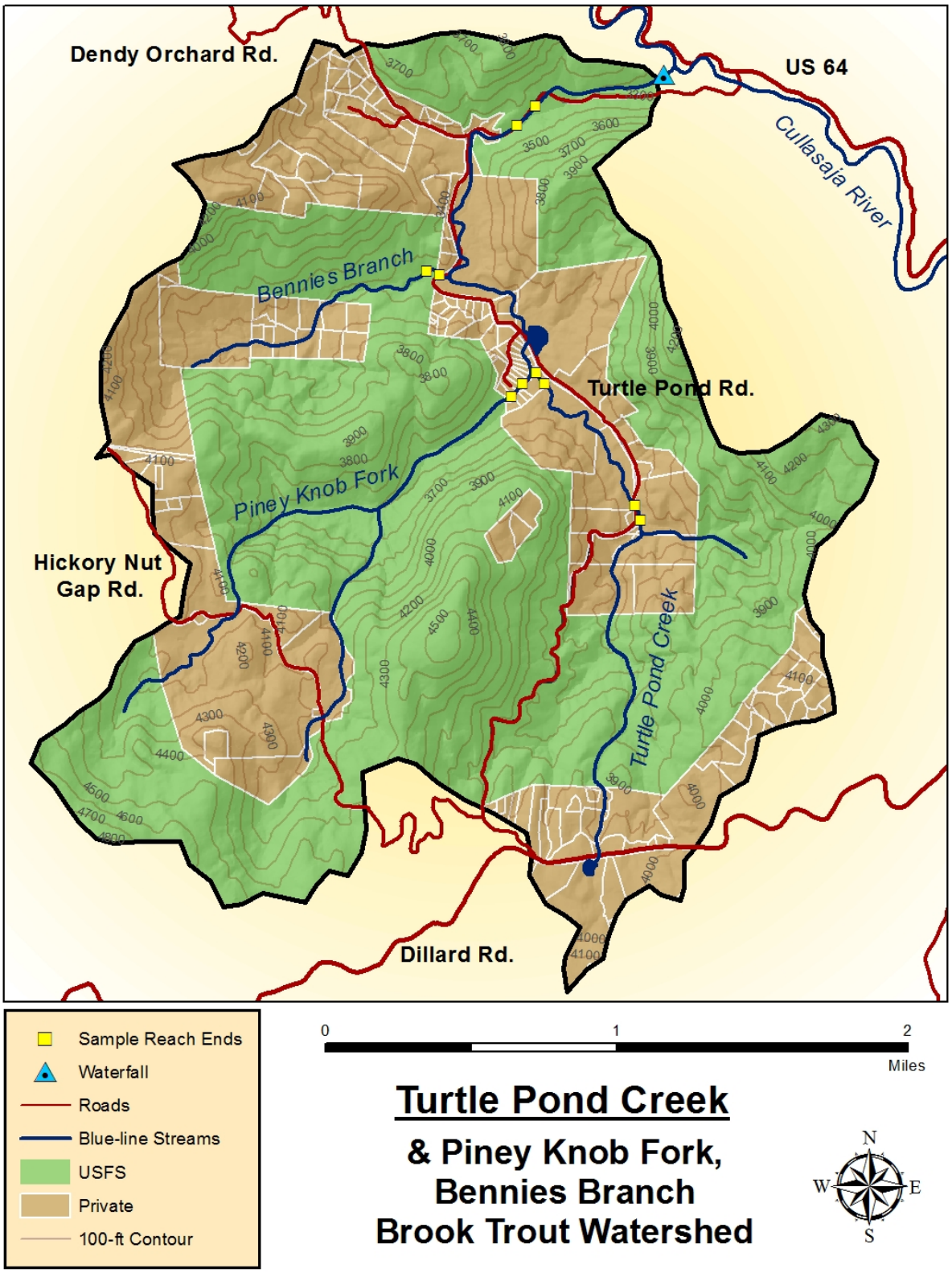

Dendy Orchard Rd.
US 64
Cullasaja River
Bennies Branch
Turtle Pond Rd.
Piney Knob Fork
Hickory Nut Gap Rd.
Turtle Pond Creek
Dillard Rd.
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
1
2
Miles
Turtle Pond Creek
& Piney Knob Fork,
Bennies Branch
Brook Trout Watershed
N
W
E
S

Figure 9.

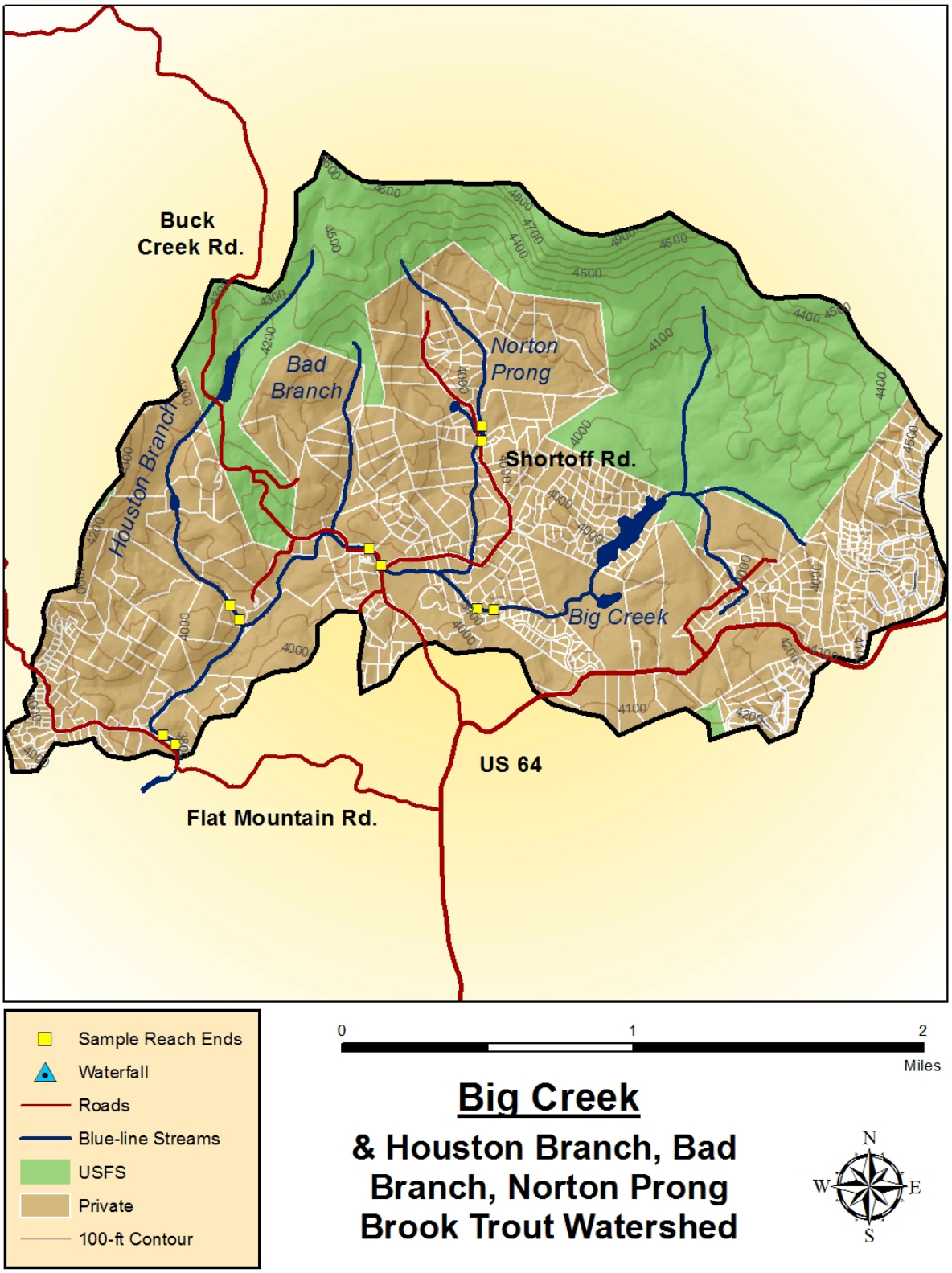

Buck Creek Rd.
Bad Branch
Norton Prong
Houston Branch
Shortoff Rd.
Big Creek
US 64
Flat Mountain Rd.
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
1
2
Miles
Big Creek
& Houston Branch, Bad Branch, Norton Prong Brook Trout Watershed
N
W
E
S

Figure 10.

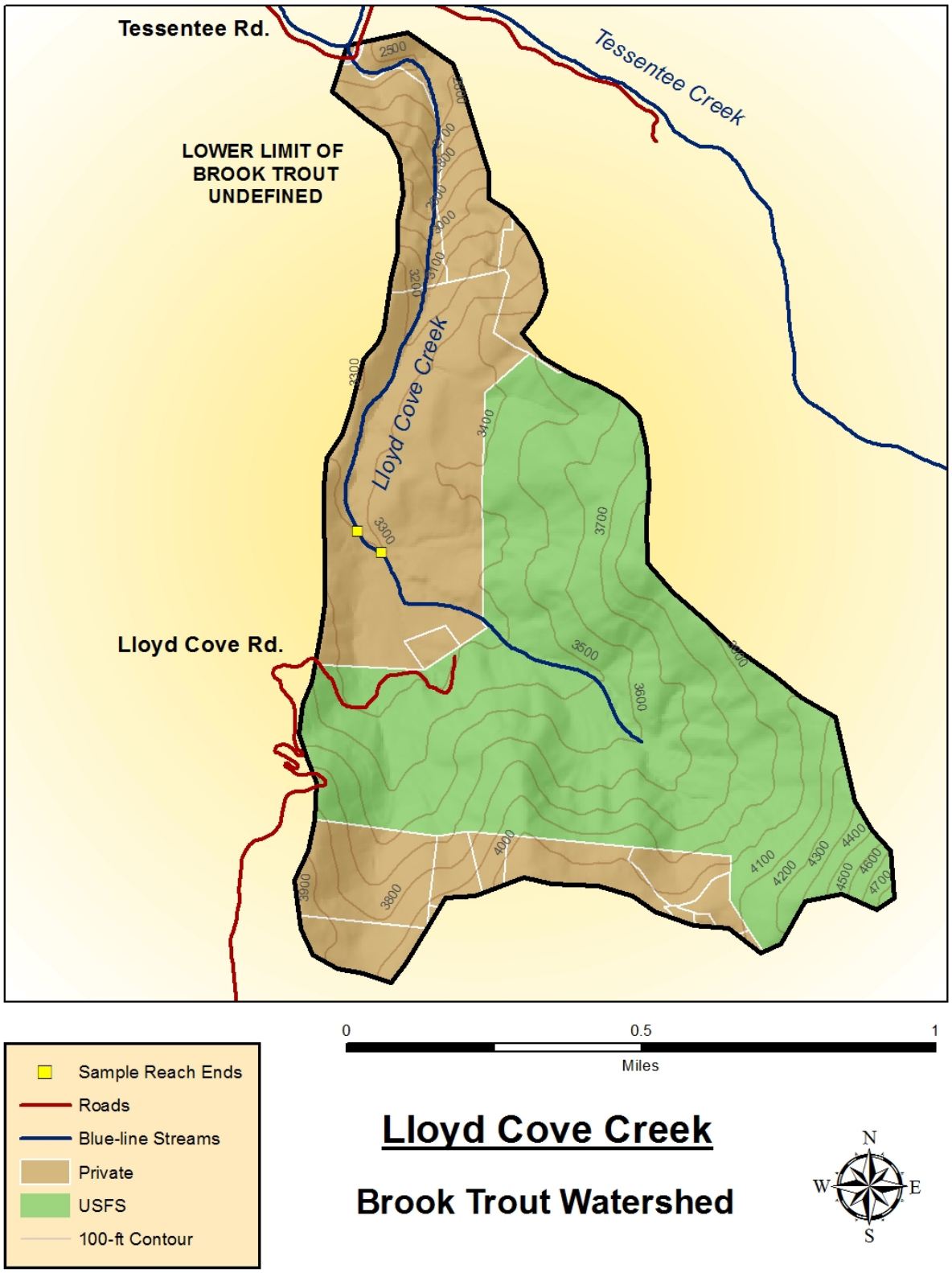

Tessentee Rd.
Tessentee Creek
LOWER LIMIT OF
BROOK TROUT
UNDEFINED
Lloyd Cove Creek
Lloyd Cove Rd.
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
4100
4200
4300
4400
4500
4600
4700
Sample Reach Ends
Roads
Blue-line Streams
Private
USFS
100-ft Contour
0
0.5
1
Miles
Lloyd Cove Creek
Brook Trout Watershed
N
W
E
S

Figure 11.

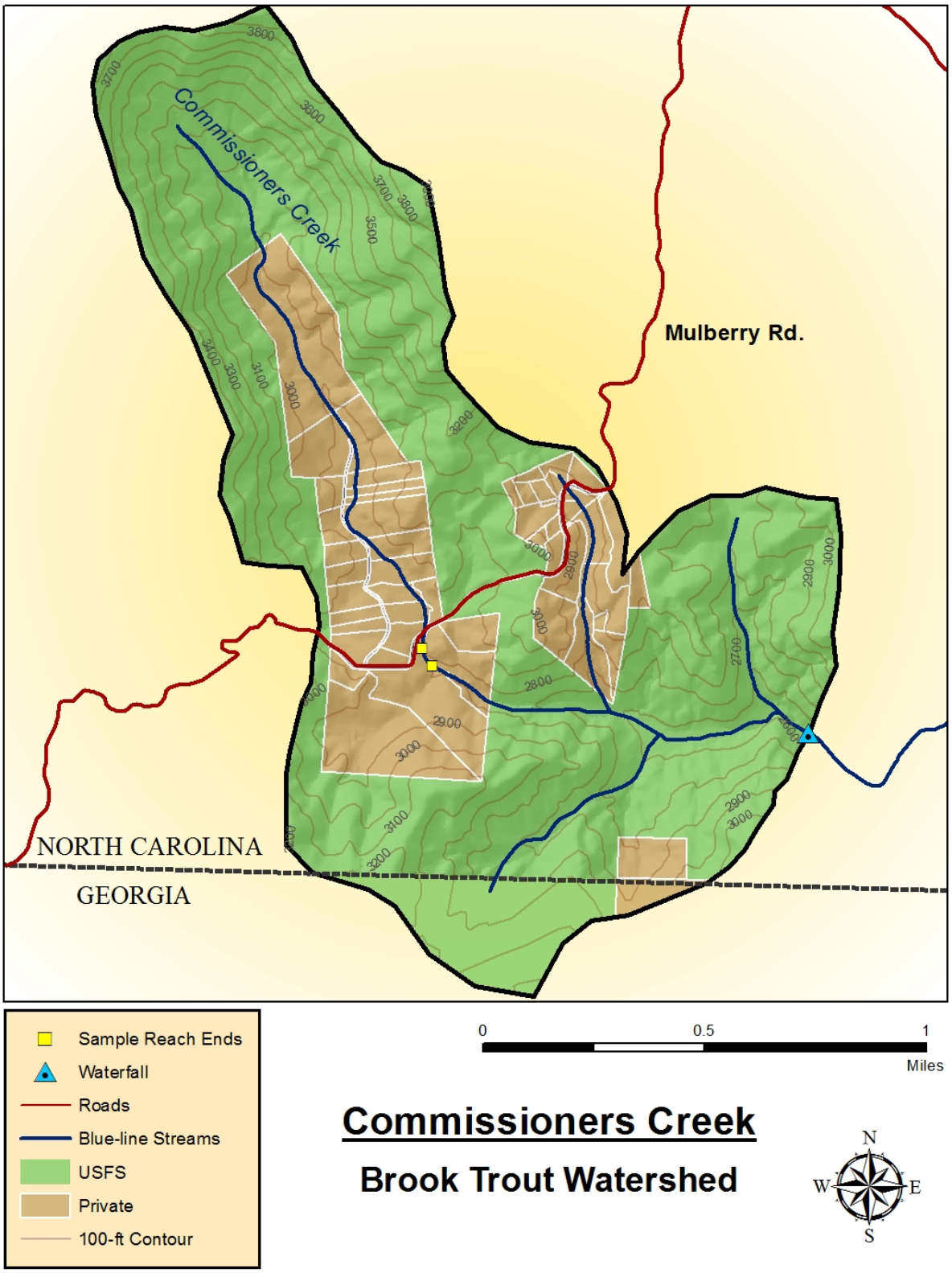

Commissioners Creek
Mulberry Rd.
NORTH CAROLINA
GEORGIA
Sample Reach Ends
Waterfall
Roads
Blue-line Streams
USFS
Private
100-ft Contour
0
0.5
1
Miles
Commissioners Creek
Brook Trout Watershed
N
W
E
S

Figure 12.

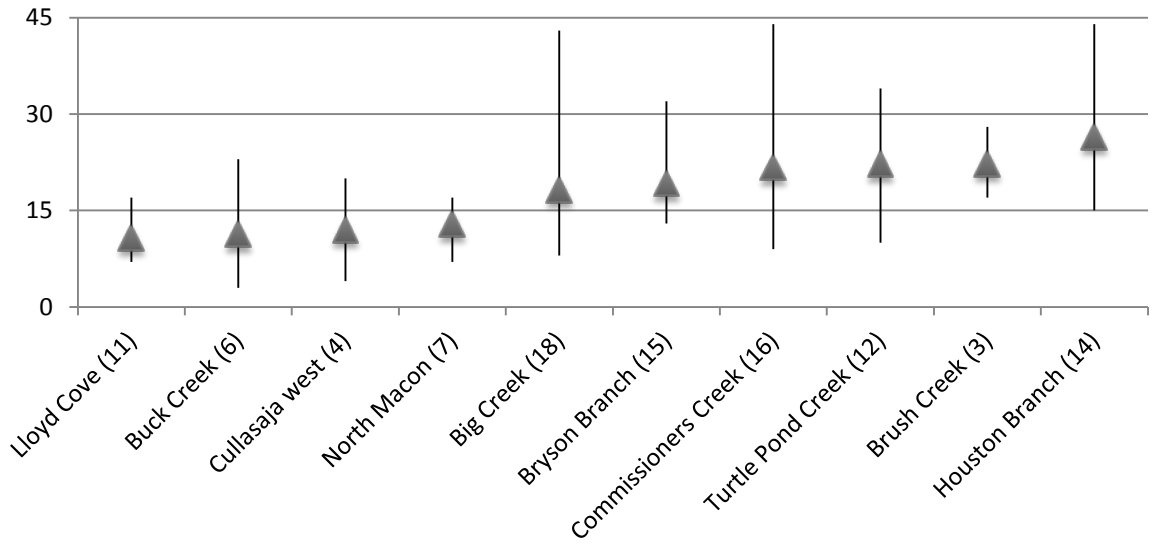


Figure 13. Minimum, maximum, and mean (triangle) red spots on one side of brook trout from Little Tennessee watershed Macon County, NC – 2014. Parentheses indicate sample size at each site.