

Brook/Rainbow

BROOK TROUT/RAINBOW TROUT HEADWATERS COMPETITION STUDIES

RESEARCH PROGRESS REPORT

SUBMITTED TO

TENNESSEE WILDLIFE RESOURCES AGENCY

OCTOBER 2, 1986

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INTRODUCTION

In recent years a number of studies have documented the continuing loss of native brook trout (Salvelinus fontinalis) populations in the southern Appalachians. The most detailed information on this decline consists of a series of reports on the brook trout of the Great Smoky Mountains National Park (King, 1937; Lennon, 1967; Jones, 1978; Kelly et al., 1980 and Larson and Moore, 1985) but Bivens et al. (1985) demonstrated that this continuing loss has also occurred for eastern Tennessee populations in streams located outside the Park. These authors generally agree that the initial major losses of brook trout populations in the early 1900's were largely due to habitat destruction associated with wide-spread logging and forest fires. Since that period, habitat degradation has become less of a problem, but the loss of brook trout populations has continued (Bivens et al., 1985). There is also general agreement that the continuing decline of brook trout can be largely attributed to competitive replacement by the introduced rainbow trout (Salmo gairdneri). Moore et al. (1983) provided experimental support for this hypothesis by removing rainbow trout from streams containing sympatric populations of brook and rainbow trout. This manipulation resulted in an increase in brook trout density and biomass but the increase did not completely compensate for the numbers and biomass of removed rainbows.

Current attempts to protect our declining brook trout populations emphasize efforts to exclude or remove competing rainbows from streams containing brook trout (Bivens, 1984; personal communication with Dean Elsen and Gordon Sloan, NFS fisheries biologists). Since rainbow removal is very costly (Moore et al., 1983), efforts have been concentrated on the construction of barrier dams to prevent the upstream movement of rainbows into headwater brook trout streams. This policy is based on the assumption that the competitive superiority of rainbow trout demonstrated by Moore et al. (1983) in areas of sympatric occurrence can be extended to the headwater refugia currently occupied by allopatric brook trout populations. Since a number of experimental studies have indicated that brook trout can establish dominance over similar sized rainbows (Newman, 1956; Wolfe, 1978; Cunjak and Green, 1984), this assumption is now based mainly on an hypothesized size advantage due to faster growth and greater longevity (Bivens et al., 1985; Neves et al., 1985). Whitworth and Strange (1983) provide the primary documentation for greater growth rates of rainbow trout in their study of production rates in Rocky Fork Creek in northeastern Tennessee. Unfortunately, sample size constraints forced them to utilize combined samples which tended to compare downstream rainbows with upstream brook trout over a 1.5 km study zone which spanned the transition from allopatric rainbow to allopatric brook trout populations. Also, Rocky Fork Creek is a special regulation fishing stream with minimum size limits of 6" for brook and 9" for rainbow trout (TWRA, 1983. Tennessee 1983-84

Sport Fishing Regulations). Differential harvest of the fastest growing brook trout under these conditions would tend to give the appearance that rainbows grow faster than brook trout even if there were no difference.

Another reservation concerning the hypothesized competitive superiority of rainbows in headwater streams comes from an examination the isolation characteristics of the remaining brook trout populations. Bivens et al. (1985) noted that only 33% of the remaining brook trout populations are known to be protected by barrier falls; 27% have no barriers to prevent entry of rainbows; and no data were available for the remaining 40%. The failure of rainbows to replace brook trout in streams to which they have free access could be interpreted as evidence for a shift in competitive advantage in favor of the brook trout in small headwaters.

A final reservation concerning the rainbow competition hypothesis in headwaters streams comes from examination of data presented for streams which had lost brook trout populations since the surveys by Reid Tatum in the late 1960's (Bivens, 1984). Bivens reported that 34 streams had lost their brook trout populations since Tatum's survey. Of particular interest is the data which indicates that 11 of these streams (32%) also lacked rainbow trout. This strongly suggests that factors other than rainbow competition may still contribute to loss of small headwaters populations of brook trout. In the past, the presence of rainbows in what was formerly a headwaters brook trout stream has been interpreted as evidence for competitive replacement. In view of the data

just cited from Bivens (1984), it could also be interpreted as invasion by rainbows after a competitively successful brook trout population was eliminated or seriously reduced by other factors such as flood or drought.

In the fall of 1979 I initiated studies on self-sustaining rainbow trout populations in two headwaters streams in the Dry Creek watershed in the valley between Buffalo and Cherokee Mountains in Washington County, Tennessee. It quickly became evident that these rainbow populations exhibited growth rates and longevity very similar to that reported for brook trout in similar sized streams (Hoover, 1939; Konopacky, 1978; Robinette, 1978; Warner, 1970). Reviews of the literature initiated at this time confirmed my personal observations from field work in northern New York that brook trout dominance in headwaters streams is a widespread phenomenon and includes cases where it is the introduced species (Josephson, 1983; Vincent and Miller, 1969). In the fall of 1983 I initiated an experimental study to test the hypothesis that, although brook trout are clearly at a competitive disadvantage in large streams, their persistence in headwaters streams is due to a shift in the competitive balance which favors brook trout over rainbows.

MATERIALS AND METHODS

The Dry Creek drainage system (Fig. 1) between Buffalo and Cherokee Mountains in Washington County, Tennessee was chosen as the primary study site because (1) the only salmonid species present was a self-sustaining rainbow population, (2) it is small enough that all the major streams could be easily monitored over a series of years, (3) there is sufficient diversity in stream size that it can be expected to develop the species distribution pattern currently considered typical of stream systems containing both brook and rainbow trout, and (4) it can be reached in 15 minutes from my place of employment, East Tennessee State University. Briar Creek, a small second order tributary of Dry Creek, was selected as the primary experimental stream for the introduction of brook trout because it is on National Forest Service land and could be studied without the problems which might develop under the uncertainty of changing management plans which could occur on streams under private ownership. A 30' waterfall approximately .75 miles above its junction with Dry Creek conveniently isolates the main experimental reach from invasion by downstream rainbows. Approximately .45 miles above the waterfall a small barrier dam was constructed to restrict rainbow trout movement into the .85 mile section of stream picked for the initial introduction of brook trout. The initial research plan called for removal of rainbows from this introduction section (section #3 on Fig. 1) to ensure successful establishment of brook trout. Rainbows in sections

#2 and #4 were to be left undisturbed to test the hypothesis that brook trout in section #3 could successfully spread out and displace these rainbow populations. This conservative approach to brook trout introduction was adopted since the prevailing regional opinion among fisheries biologists was that such thinning of the rainbow population was absolutely essential for successful brook trout introduction. A more rigorous test of the brook trout's competitive ability would be whether or not they could also invade section #1 below the falls and the adjacent Ramsey Creek, another second order stream under private ownership.

Due to the initially favorable results from the Briar Creek project described later in this report, I initiated another introduction study in the spring of 1986. Devil's Fork, a tributary to Clark's Creek in Unicoi County, Tennessee was selected for a brook trout introduction without prior thinning of the resident rainbow trout population. An approximately .75 mile section isolated between two large waterfalls was utilized for this more rigorous test of the brook trout's competitive ability.

Width and maximum depth (thalweg depth) were measured at 10 pace intervals on all stream study sections. Table 1 summarizes average physical and spot chemical measurements for the streams described above. All measurements were made during periods of low summer flow.

All fish sampling or collecting for transfer was conducted by means of a back-pack electrofishing outfit. Total length (TL) was measured to the nearest mm and scales were taken from below the dorsal fin when required for aging. Age was determined by counting the number of scale annuli under a compound microscope. During surveys of the experimental areas following introduction of brook trout, all young-of-the-year (YOY) were identified with a permanent fin clip unique to each year class to establish known age individuals in the population.

Population estimates and confidence intervals were calculated by formulae 3.7 and 3.8 in Ricker (1975) for Petersen mark and recapture estimates and by the two catch removal method described by Seber and LeCren (1967).

Brook trout used for introduction were all from native stocks found in local streams. Introductions in Briar Creek were made in the fall of 1983 and again in the spring of 1984. A total of 114 brook trout of mixed ages were included in this series of introductions and included specimens from East Fork Beaverdam Creek (Johnson County), George Creek (Carter County) and Tiger Creek (Carter County). In the spring of 1986, 42 adult and 31 YOY brook trout from Tiger Creek were transferred to Devil Fork.

RESULTS

Rainbow trout population structure. Figures 2-4 summarize information available on the age structure and size distribution of rainbow trout in the Dry Creek watershed. All of these samples were taken in the late summer or early fall of the years indicated. The most extensive series of data is that for section #2 on Briar Creek (Fig. 2). These are especially noteworthy for the complete absence of the 0+ age category. A very heavy flood in early May, 1984 apparently resulted in the almost total failure of the 1984 year class in the small headwaters streams in this watershed. This is also evident in the very low occurrence of 0+ individuals in Fig. 2 for other Briar Creek sections and in the complete absence of 0+ individuals in the corresponding Ramsey Creek sample (Fig. 3). The relatively wide and low gradient main stream, Dry Creek, did not suffer this year class failure. In this area the high flow spread over the banks and flooded the adjacent farm lands instead of scouring the normal stream channel. The general impression derived from inspection of these figures is that rainbow populations in the small headwaters streams of this watershed exhibit slow growth and rarely survive beyond their third year of life (age 2+).

Rainbow trout removal. Removal of rainbow trout from the .85 mile length of section #3 was carried out from the fall of 1983 to June of 1986. During this period a total of 598 rainbows were removed from this section. By June of 1986 the introduced brook trout had successfully spawned twice so I terminated the rainbow removal phase of this study.

Briar Creek brook trout introductions. Rainbow trout removal sampling during 1984 revealed that the brook trout introduced in the fall of 1983 did not successfully spawn. Either these fish did not have time to adjust to their new location or they had spawned prior to transfer. In June of 1986 the presence of brook trout fingerlings indicated a successful spawning in ? the fall of 1984 and a series of regular inventory samples was begun. Results of this sampling are summarized in Table 2. During this period, I was still involved in developing a sampling schedule and procedure which would minimize the potentially adverse effects of electrofishing on the populations but provide an adequate record of the progress (or lack thereof) of the introduced brook trout. Some sampling periods consisted of two-pass mark and recapture samples designed to yield quantitative information on population densities but analysis of the results suggested that I might - how? be getting sampling mortalities which were unacceptable in view of the small populations involved. This prompted me to decide on a single yearly pass through each of the study

sections in late June or early July when both rainbow and brook trout YOY had grown enough to be sampled by electrofishing. This sampling schedule will be followed in future years.

In interpreting the data in Table 2, attention should focus mainly on the relative percentage figures given in parentheses following the actual number of fish sampled. Actual number sampled gives some indication of the reliability of the calculated percentages. The data for Section #3 indicate that by June of 1985 the rainbow removal program had effectively established brook trout as the dominate species in this section. The Section #2 data reveals downstream invasion by brook trout and successful spawning in this zone containing an undisturbed rainbow population. Most of the brook trout were found in the 250 m stretch just below the barrier dam. Samples from Section #1 in 1986 indicate very limited passage of brook trout over the falls. The data from Section #4 are extremely encouraging. Although no brook trout were sampled in this reach in the fall of 1985, obviously some brook trout were either present and missed or moved in prior to spawning. The June, 1986 sample revealed that brook trout fingerlings dominated this section containing an undisturbed rainbow population. During the sampling of this section most of the rainbow YOY were taken in the lower 100 m. Above this the fingerling population consisted almost entirely of brook trout with an occasional rainbow fingerling that was obviously stunted compared to those in the first 100 m.

- Not odd
found in all
situations I know
8-

- Downstream
movement by
YOY

Devil Fork brook trout introduction. In April, 1986 I conducted mark and recapture sampling of the rainbow trout population in the first 520 m of stream above the lower falls to get population estimates for fish 100 mm or larger. Population estimates and 95% confidence intervals were 117 (+or- 27) and 97 (+or- 11) for Petersen mark and recapture and Seber and LeCren two-pass removal methods respectively. Calculation of the T4 value described in Seber and LeCren (1967) indicated a significant difference between these two estimates; capture probabilities were .42 for marked fish in the Petersen method and .71 for the removal method. I have gotten results like this rather often in the past (unpublished data) and strongly suspect mortality of marked fish to be the major cause of these discrepancies. In May, 1986 I distributed 42 adult and 31 YOY brook trout from Tiger Creek over this same section of Devil Fork. In this case no rainbow trout were or will be removed from the introduction zone. This stream will be sampled in late June or early July in subsequent years to follow the fate of this introduction.

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TABLE 1. Physical and chemical measurements of study streams

Stream	Width (m)	Depth (cm)	pH	Cond. (mmhos)
Devil Fork	2.47	20.02	--	--
Dry Creek	3.18	24.01	7.9	120
Ramsey Creek	2.59	15.46	6.9	28
Briar Creek #1	2.18	13.89	7.6	54
Briar Creek #2	3.32	11.33	7.1	30
Briar Creek #3	2.56	19.51	--	--
Briar Creek #4	1.73	12.91	6.6	26

TABLE 2. Number of trout actually caught and measured,
Briar Creek, 1985 - 1986

Section#	Date	RT YOY	RT Adult	ST YOY	ST Adult
1	March '86	--	62 (98)	--	1 (02)
1	June '86	ABUNDANT	144 (--)	4 (--)	3 (--)
2	Sept '85	35 (53)	11 (17)	18 (27)	2 (03)
2	March '86	--	8 (89)	--	1 (11)
2	May '86	4 (04)	71 (70)	9 (09)	17 (17)
2	July '86	90 (52)	41 (24)	35 (20)	8 (04)
3	June '85	12 (20)	13 (21)	15 (25)	21 (34)
3	Sept '85	123 (57)	24 (11)	56 (26)	14 (06)
3	March '86	--	11 (32)	3 (09)	20 (59)
3	June '86	9 (06)	25 (17)	73 (51)	38 (26)
4	Oct '85	24 (52)	22 (48)	0 (00)	0 (00)
4	March '86	--	20 (95)	--	1 (05)
4	June '86	31 (28)	16 (15)	63 (57)	0 (00)

Numbers in parentheses represent percent of total trout
sampled on that date. RT = rainbow trout, ST = brook trout

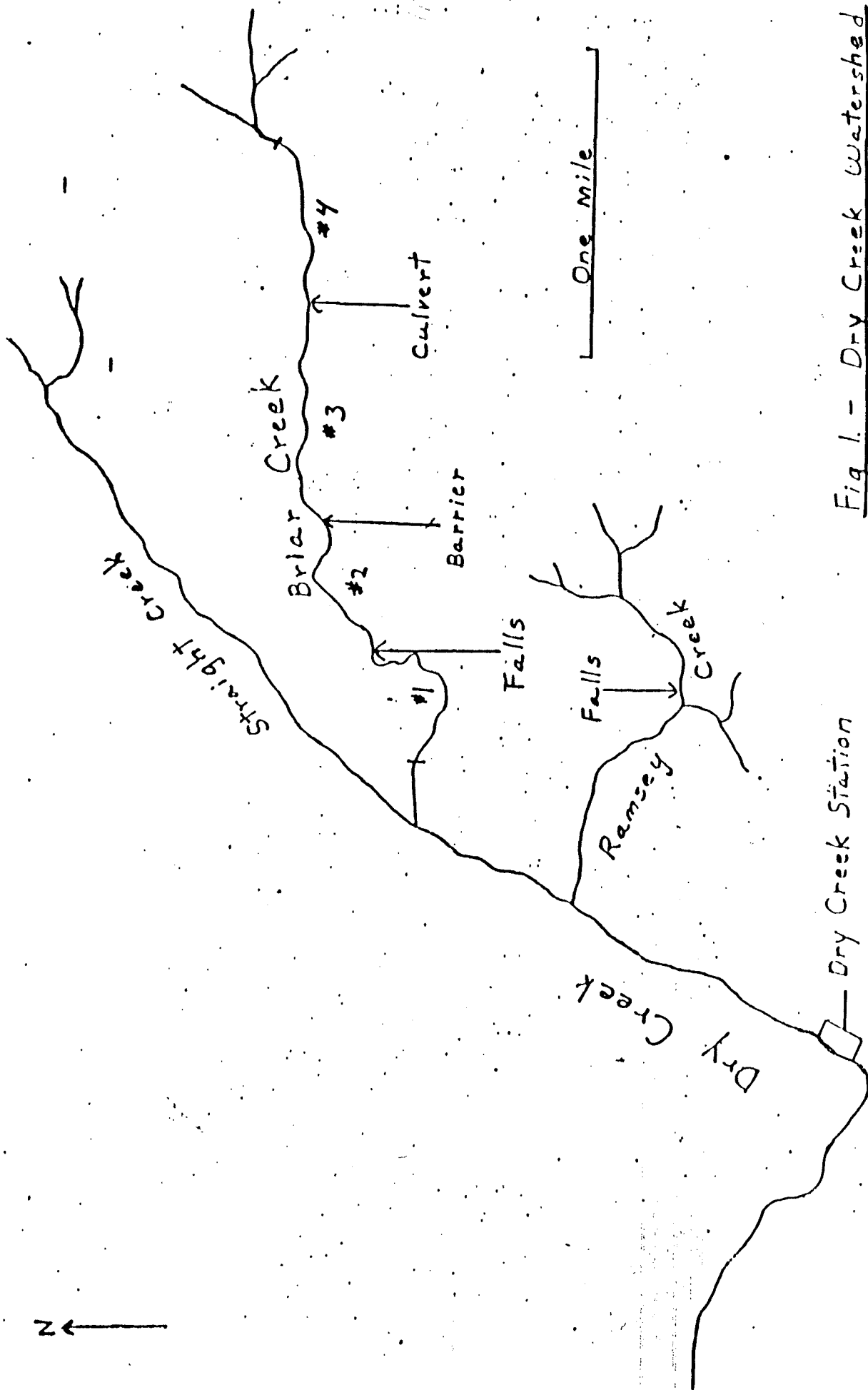


Fig 1. - Dry Creek Watershed

FIGURE 2. Length/frequency distribution by age class of rainbow trout in Briar Creek Section #2.

TL	1979	1980	1981	1983	1984
40					
50		0			
60	0000	00	0	0000	
70	000000		000	0000000000	
80	0000		000		
90	000				
100	00000000000				
110	00000000000000	11	1		
120	0000	1	111	11	1111
130	1	11	1	1	1111
140	1	111		111111	11
150	1	11	111	111	1
160	1		1	111111111111	2
170	1	1	22	1111111	
180		12		112	
190	111	1		1	2
200				122	
210	22				
220			2		2
230		2		2	2
240	2				
250					
260					
270					

FIGURE 3. Length/frequency distribution by age class of rainbow trout in Briar Creek Sections #1 and #4, 1984.

TL	Section #1	Section #4
40		
50		
60		
70	0000	
80		0
90	0	1
100		1
110	1	1111
120	1111	11111111
130	11111	111
140	1111111111	2
150	1111111	
160	111112	2
170	22	222
180	1	222
190		23
200	2	
210	2	
220	2222	
230	22	
240		
250		
260		
270	3	
280		

FIGURE 4. Length/frequency distribution by age class of rainbow trout in Ramsey Creek and Dry Creek.

TL	RC-79	RC-84	DC-79	DC-84
40				
50				
60	0000			
70	00000>>>31			
80	00000>>>29			
90	00000>>>15			
100	0		000	00000000000000
110			000000000000	00000000
120			00000>>>16	0000000
130	1111	11	0000	000000
140	11111	11111	1	00
150	111111111111	1111		1
160	111111111	11111111111	1	1111
170	11111	1112	1	11
180	11	12	1	11
190	1112	12222		111
200	1111			11
210	12	23		
220		222	1	
230		222		
240		23	1	
250	2	223	11	
260		3	1	
270				
280		3		
290				