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DISPERSAL OF BROOK TROUT IN REHABILITATED STREAMS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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ABSTRACT

Attempts to eradicate exotic rainbow trout (*Salmo gairdneri*) from native brook trout (*Salvelinus fontinalis*) habitats in Great Smoky Mountains National Park streams were initiated in 1976 using electrofishing techniques. During removal operations, brook trout were fin clipped (stream section coded) and placed in small holding areas at the upstream ends of 300-m sampling sections in 1977 and 1978. When sampling was completed in each section, the fish were released. Owing to concern about possible abnormal dispersal of these brook trout, their locations were determined in 1978 and 1979. Of the adult fish recaptured, 56.2 percent were recaptured in the same (home) sections; 83.3 percent either remained home or moved only one section up or downstream. Stream channel characteristics and allopatric brook trout adjacent to the study areas appeared to affect dispersal. Nonetheless, these results are consistent with the literature, suggesting that there were no apparent abnormal effects on the movements of the brook trout from the electrofishing program. Marked young-of-the-year, recaptured as I+, demonstrated limited movement. Some movement of adult brook trout between a tributary and its main stream was observed.

INTRODUCTION

Stream surveys in Great Smoky Mountains National Park (GRSM) from the 1930's to the 1970's have shown a dramatic decline in the distribution of native brook trout (King, 1937; Lennon, 1967; and Kelly et al. 1980). Many factors, such as logging, contributed to the decrease of the brook trout's range prior to the establishment of the park in 1936. Since then, displacement by exotic rainbow trout seems to be the most important reason for the continued decline of the brook trout population (King, 1937; Kelly et al. 1980). To test this hypothesis, the National Park Service (NPS) attempted to eradicate rainbow trout from portions of selected park streams and assess the response of remnant brook trout populations in terms of changes in their density and standing crop. Moore et al. (1983) recently described the standing crops of the brook trout concurrent with rainbow trout removal and reported, in general, that brook trout standing crops were increasing.

The objective of this paper is to describe the dispersal of brook trout during the rainbow trout removal project. Owing to the turbulent, steep gradient, cascade/waterfall characteristics of park streams, it was thought that handling of brook trout during the removal project might alter the limited movement typical of brook trout (McFadden, 1961) under such field conditions. Abnormal dispersal patterns could affect the recovery and distribution of rehabilitated brook trout populations.

DESCRIPTION OF STUDY AREAS

Five typical second and third order montane streams in GRSM were selected as study streams (Fig. 1). One stream, Starkey Creek, was a tributary of Sams Creek, but no physical obstruction separated the two. Channel gradient ranged from 8% to 18%, with discharge during sampling ranging from 0.2 to 2.5 m^3/second. Conductivity ranged from 7 to 20 μmhos/cm, and pH from 6.4 to 7.0 (Moore et al. 1983). Elevation at the downstream end of the study areas ranged from 701 to 1,036 m above Mean Sea Level (MSL). A description of the physical obstructions (cascades and waterfalls) on each stream is provided by Moore et al. (1981).

Dominant overstory vegetation along the slopes of stream courses included yellow birth (*Betula alleghaniensis*), sweet birch (*Betula lenta*), maple (*Acer* spp.), hemlock (*Tsuga canadensis*), yellow buckeye (*Aesculus octandra*), and tulip poplar (*Liriodendron tulipifera*). The dominant understory included rhododendron (*Rhododendron* spp.), wild hydrangea (*Hydrangea arborescens*) and sweetbells (*Leucothoe fontenosa*).

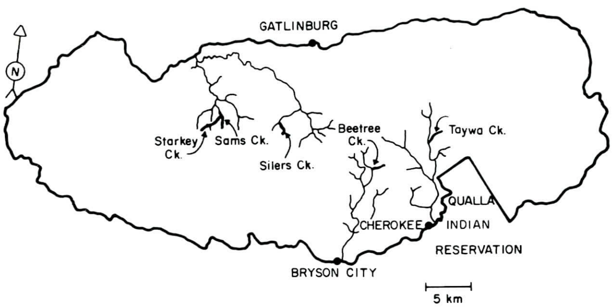

FIG. 1. *Location of study streams in Great Smoky Mountains National Park.*

MATERIALS AND METHODS

Gasoline-powered backpack electrofishing gear was used to capture trout in all study areas from 1976 to 1979 (Moore et al. 1983). Each unit consisted of a 2-cycle gasoline engine powering a 110-volt alternator, a transformer to increase voltage to approximately 700-volts alternating current, and two electrodes (one of which was the metal rim of a dip net) equipped with an operator-controlled safety switch. The unit was operated by one person to shock fish; an assistant collected the fish and placed them in a bucket of water.

In 1977, each sampling area was divided into 300-m-long sections, except for one of 60-m in Sams Creek. There were two sympatric (both species) sections at Beetree Creek, five at Sams Creek, and three each at Silers and Taywa Creeks. Two allopatric (one species) brook trout sections were located at Starkey Creek, while single sections at Silers and Taywa Creeks were adjacent to the upstream sympatric section in each creek. Block nets, 1.2 m deep with 5 mm mesh, were placed across the stream at both ends of a section to prevent trout from escaping and to prevent the invasion of trout from outside. A third block net was placed across the stream about 50-m downstream from the upstream block net of each section to form a holding area during sampling. Three passes with the shocker were made in each section, starting with the holding area. Brook trout were fin clipped (coded by section), kept in buckets until sampling was completed for each pass, and then released into the holding area. After sampling in each section, the nets were removed and the brook trout were allowed to disperse. The upstream net however, was not removed if another section was sampled immediately upstream. In these cases, the net was not removed until that section was electrofished, usually within 24 hours. The fish were allowed to redistribute themselves because it was felt that additional handling might cause stress. Captured rainbow trout were destroyed.

Young-of-the-year (YOY), i.e., $\leq$ 90 mm total length, brook trout were given an adipose clip in all sections during each year of this study. The reasons for doing this were (1) to give this age class a known mark, and (2) this mark seemed least likely to affect their survival. Since all fish of this age class were given the same mark, the direction and extent of their movements could not be determined.

Movement data were obtained from the locations (sections) of recaptured brook trout in succeeding sample years (1978 and 1979). Recaptured fish which had moved were remarked with the mark of the section of recapture. This enabled us to follow the movements of such fish the next year.

Up to three 300-m stream sections downstream and one section upstream from the study areas were electrofished once each year to check for marked brook trout. Marks were identified to determine the number of sections the fish had moved.

Chi-square was used to test for statistical significance.

RESULTS AND DISCUSSION

During 1977 and 1978, 1,702 age I and older brook trout were captured, marked, and returned to the study areas. Of these, 422 (24.8%) were recaptured one or more times

TABLE 1. *Movement data for recaptured marked adult brook trout for four types of single stream channel situations.*

Channel Type	N[1]	No. marked	No. recaptured	No. recaptured in home section	1 section		2 sections		3 or more sections	
					up	down	up	down	up	down
Open both directions	2	767	189	87	34	31	10	6	13	8
Barrier downstream	3	226	71	32	23	0	12	0	4	0
Barrier or allopatric brook trout upstream	2	463	62	42	0	14	0	2	0	4
Barrier downstream and allopatric brook trout upstream	4	246	87	69	0	9	0	6	0	3
Total	11	1702	409	230	57	54	22	14	17	15
% of recaptured		—	—	56.2	13.9	13.2	5.4	3.4	4.2	3.7

[1]refers to the number of sections of each type

in 1978 and 1979. Two hundred and thirty (56.2%) of these individuals were recaptured in the home sections (Table 1). In fact, the vast majority (83.3%) of the brook trout which were recaptured either remained in the home section or moved only one section upstream or downstream. This study showed, therefore, that the placement of relatively large numbers of adult brook trout in small holding areas did not result in extensive emigration. These data are in agreement with the findings of other investigators of brook trout dispersal patterns (e.g., Miller, 1957; McFadden, 1961; Shetter, 1968; Bridges, 1972; Whitworth, 1980; and Helfrich and Kendall, 1982).

The lack of extensive movements by brook trout in GRSM streams was probably influenced by the steep gradient (8-18%) and cascade/waterfall nature of the study areas. Upstream movement was undoubtedly difficult and this suggests that fish moving downstream may not be able to return to the area they left. Evidence for limited movement was given additional support from a study in Rock Creek, GRSM (unpublished Park data). In the uppermost sampling area (15% gradient), 66% of the brook trout marked 8 months previously were recaptured in the same 100-m section. Miller (1957) reported similar results for cutthroat (*Salmo clarki*) in small western mountain streams. The trout remained in the same areas for up to 3 years, apparently spending their entire lives in a short reach of stream.

In sections where native brook trout could move upstream and downstream without encountering barriers or allopatric brook trout populations (at the upstream end of the home section), 46% of the fish stayed in the home section (Fig. 2). There was no significant difference ($p>.05$; $X^2=1.19$; df=1) in the number of fish recaptured in the home section and the number that had moved one or more sections away. Furthermore, significantly more ($p<.05$; $X^2=7.69$; df=1) brook trout moved one section up or down from the home section than either two or more sections (Fig. 2). Similarly, in sections with a barrier at the downstream edge of a section, but open upstream, no significant differences ($p>.05$; $X^2=1.47$; df=1) were observed in the number of fish that remained and the number that moved one section upstream. Very few marked fish were recaptured two or three sections away from the home section in these situations (Fig. 2).

Two situations existed in which brook trout only moved downstream. The first was when either an allopatric brook trout population or a barrier existed immediately upstream from the home section. In these cases significantly ($p<.05$; $X^2=7.81$; df=1) more fish were recaptured in the home section than were recaptured one or more sections downstream (Fig. 2). Few fish were recaptured more than one section away from the home section. The second situation occurred when a section was bounded by an allopatric brook trout population upstream and a physical barrier downstream. These sections had significantly ($p<.05$; $X^2=46.15$; df=1) more fish recaptured in the original section than one section downstream. In fact, sections in this category had the highest percent of fish recaptured in the home section (Fig. 2). Few fish were recaptured more than one section away from the home section.

These data suggest that an allopatric brook trout population adjacent to the upstream end of a study area may serve as a biological barrier and have much the same effect

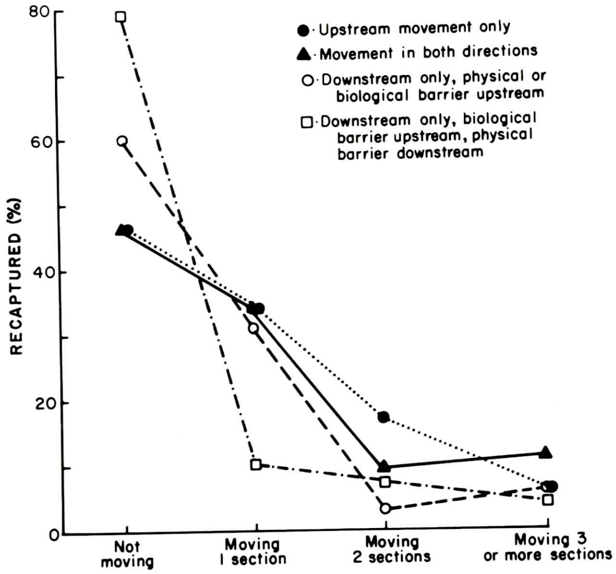

FIG. 2. *Percentage of brook trout not moving from the home section and those moving one or more sections for each of the four types of single stream channel situations. Biological barriers refer to allopatric brook trout populations upstream from the study areas.*

on dispersal as an upstream physical barrier since no marked fish were found in these areas. We believe a major reason is that brook trout attempting to disperse upstream would encounter resident brook trout and competition for space and food would most likely be intense (Newman, 1956; Kalleberg, 1958; Hartman, 1965; and Wolfe, 1978). Resident fish, even if smaller in size, probably had an advantage over wandering fish in agonistic encounters and would most likely drive the intruders downstream (Jenkins, 1969; Dill, 1978).

The highest number of recaptured adipose fin clipped brook trout usually occurred in the sections where the largest number were originally marked (data not shown). Only in one section were more marked brook trout recaptured than originally marked, indicating some movement of these young fish, but the extent and direction of their movement could not be ascertained.

Some brook trout did move considerable distances during this study (i.e., three or more sections) from their home sections. Some of the longer downstream movements occurred when brook trout passed downstream over barriers. Such movements are important because these fish can aid in the repopulation of areas devoid of rainbow trout and brook trout (Gerking, 1959). In addition, nine adult brook trout moved from Sams Creek to Starkey Creek (the tributary), and four reversed this pattern. Such movements by brook trout, though limited, are important for gene exchange between tributary populations (Ray Simon, personal communication).

The lack of extensive movements by brook trout in this study indicates that the repopulation of rehabilitated stream sections now either void or with limited brook populations may take a long time. Additional monitoring will be required to determine possible downstream immigration of YOY (Hunt, 1965; Phinney, 1975) and effects of floods on the distribution of brook trout (Elwood and Waters, 1969), but our results suggest that if park managers want to repopulate rehabilitated areas quickly, it will probably be necessary to transplant brook trout downstream into these areas. Since exotic rainbow trout were not eradicated, although their populaton densities were drastically reduced (Moore et al., 1983), such transplanting may be an attractive management strategy to retard and perhaps eliminate the repopulation of rainbow trout in these study areas.

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THE ADAMS, TENNESSEE MAGNETIC ANOMALY

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ABSTRACT

The standard geophysical techniques of horizontal magnetic gradient analysis and second derivative mapping were applied to a prominent elliptical magnetic anomaly in northeastern Montgomery County near Adams, Tennessee. The positive magnetic anomaly, labeled the Adams Magnetic High, appears to be a roughly rectangular rock body measuring 9.5 km by 6.5 km. Magnetic susceptibility