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Influence of Stream Gradient on Standing Stock of Brook Trout in the Snowy Range, Wyoming

Abstract

Gradient and other instream habitat variables were assessed for their influence on brook trout (*Salvelinus fontinalis*) abundance in small streams where brook trout were the only fish species present. Brook trout occurred throughout the gradient-range studied (0.4-9.2 percent), but increased gradient had a negative influence on abundance. Gradient, width to depth ratio, mean depth, and mean width accounted for 68.8 percent of the variation in brook trout abundance among the 24 study reaches.

Introduction

Stream gradient is believed to have a negative influence on the abundance of brook trout (*Salvelinus fontinalis*) in small Rocky Mountain streams. The relation between gradient and abundance has been evaluated, but only for brook trout in the presence of other salmonids. Brook trout have been observed to be most abundant in low gradient stream reaches and cutthroat trout (*Salmo clarki*) in high gradient reaches (Bachmann 1958, MacPhee 1966, Griffith 1972). Gibson (1978) made a similar observation in streams containing brook trout and Atlantic salmon (*S. salar*): brook trout were most abundant in pools and salmon in areas with higher water velocity. Observations on resource partitioning have been made in streams where rainbow trout (*S. gairdneri*) and brown trout (*S. trutta*) occurred with brook trout (Nyman 1970, Cunjak and Green 1983).

The hypothesis that brook trout biomass is related to stream gradient in small Rocky Mountain streams was tested in the Snowy Range of Wyoming, where only brook trout occur in many streams. Because confounding influences of possible competition with other fish species did not occur, we were able to test whether the relation was due simply to habitat selection by brook trout.

Study Area and Methods

We evaluated 24 reaches in 13 streams in 1984; all reaches were at an elevation of 2,800 to 3,200 m and there were no nearby beaver ponds. The streams were in coniferous forest or subalpine habitats. Gradients in the reaches studied ranged from 0.4 to 9.2 percent. All streams had flow patterns typical of those in streams of the Rocky Mountain Region: flows were low from late fall until spring (May to July), when peak runoff occurs due to snowmelt.

Study reaches were 65-85 m long. Gradient of each stream reach was measured with a transit level and rod or a clinometer. Within each reach, we measured width, depth, and substrate along transects at 5-m intervals, using the procedures of Platts *et al.* (1983). We used a portable direct current electrofishing unit, isolated the upper and lower limits of each reach with block nets, and performed three consecutive electrofishing passes in each reach. Brook trout abundance in each reach was estimated by the method described by Zippin (1958).

Relations between independent variables and brook trout abundance were analyzed by one-way analysis of variance, the Newman-Keuls test, and stepwise-multiple regression (Nie *et al.* 1975).

Results

The 24 stream reaches were segregated into three gradient classes for analysis (Figure 1): low (0.4-1.8 percent, n = 8), moderate (2.0-5.0 percent, n = 10), and high (6.8-9.2 percent, n = 6). Standing stock differed significantly among the three gradient classes (ANOVA, F = 4.43, P = 0.025, df = 23). The average standing stock of brook trout was 40.5 kg/km (SD = 24.7) in low gradient, 24.7 kg/km (SD = 12.9) in moderate gradient, and 14.1 kg/km (SD = 5.2) in high gradient. Paired comparisons of the mean standing

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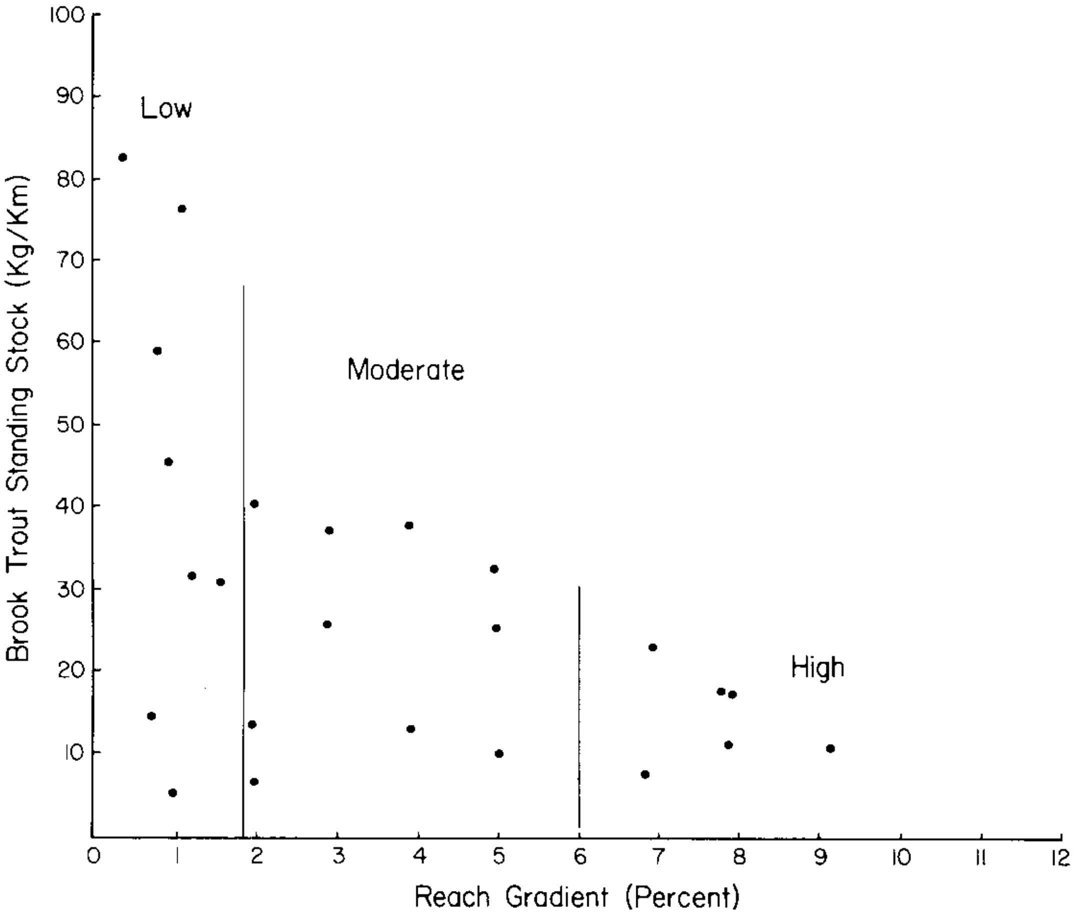

Figure 1. Relation between stream gradient and brook trout standing stock for 24 stream reaches in the Snowy Range, Wyoming, 1984.

stock between gradient classes, based on the Newman-Keuls test, yielded significant differences ($\underline{P} \leq 0.10$) among all three gradient classes.

The amount of variation in standing stock within each gradient classes declined with increasing gradient. The coefficients of variation for reaches at different gradients were 61.1 percent (low gradient), 52.2 percent (moderate), and 36.6 percent (high).

Stepwise multiple regression analysis indicated that stream gradient accounted for 25.5 percent of the variation in standing stock among the 24 study reaches. In addition to gradient, the width to depth ratio, mean depth, and mean width over a stream reach cumulatively accounted for 68.8 percent of the variation in brook trout standing stock among the 24 study reaches. The multiple regression equation for this relationship was

$$S = -9.88 - 3.43G + 1246.8W/D + 12.28D - 321.5W \ (\underline{P} = 0.0001),$$

where S = kilograms of trout per kilometer of stream; G = gradient over the stream reach; W/D = width to depth ratio; D = mean depth (m); and W = mean width (m). This equation indicated that instream habitat variables accounted for variation in brook trout standing stock within the range of gradients (0.4-9.2 percent) analyzed.

Discussion

The results of this study confirmed that gradient influences the standing stock of brook trout, even in the absence of other fish species. Although brook trout occurred throughout the gradient range studied, they were about three times more abundant in low gradient than in high gradient reaches. As gradient increased, variation in standing stock decreased, an indication that other habitat variables had a stronger influence on standing stock at low than at high gradients. Gradient appeared to limit the upper level of standing stock of brook trout in streams of the Snowy Range of Wyoming.

High stream gradient appears to have a similar negative influence on brown trout and rainbow trout. Kennedy and Strange (1982) found brown trout to be limited to areas of low gradient, and Hermansen and Krog (1984) found brown trout density in small lowland streams to be negatively correlated with gradient. Such a situation may lead to competition between brook trout and brown trout in streams where both species occur (Cunjak and Green 1983). In low-gradient habitat, brook trout have been shown to dominate rainbow trout, thus providing a species advantage for brook trout when preferred habitat is limited (Cunjak and Green 1984).

Some salmonids, such as cutthroat trout (Bachmann 1958, MacPhee 1966, Griffith 1972) and Atlantic salmon (Gibson 1978), appear to select for high gradient reaches and to segregate themselves from brook trout when the species live in the same stream. This partitioning of space probably reduces competition between brook trout and these salmonids.

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