Trout mortality, movements, and habitat selection during winter in South Willow Creek, Montana
by William Cecil Schrader

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Few studies have assessed impacts of small hydropower development or provided information to recommend winter minimum instream flows. I examined trout populations, movements, and habitats selected during winter in three South Willow Creek study sections before small hydropower development. Streamflows were lowest during winter (November-March) both years of the study (1984-86). Overwinter decreases in rainbow trout (>75 mm) densities averaged 32% (range 18 to 45%) over both years and all sections; standing crops decreased 30,% (range 11 to 36%) . Changes in brook trout populations were less. During winter 1985-86, net distances moved by radio-tagged rainbow trout (>225 mm) ranged from 3 to 261 m. They selected high-quality pools with overhead cover, especially overhanging rock and surface turbulence, and avoided areas without cover. Selected depths were >45 cm and selected velocities were <30 cm/s; they avoided depths <15 cm and velocities >45 cm/s. Substrate selection was variable, but large substrate (>256 mm) was used for cover. Instream flows that provide maximum quantities of these selected habitats are recommended to sustain rainbow trout populations during winter.

TROUT MORTALITY, MOVEMENTS, AND HABITAT SELECTION DURING WINTER IN SOUTH WILLOW CREEK, MONTANA

by

William Cecil Schrader

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 1989

APPROVAL

of a thesis submitted by

William Cecil Schrader

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

July 24, 1989
Date

Robert G. White
Chairperson, Graduate Committee

Approved for the Major Department

24 July 1989
Date

Robert E. Moore
Head, Major Department

Approved for the College of Graduate Studies

August 11, 1989
Date

Henry L. Parsons
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Dean of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature William C. Schroder

Date July 20, 1989

ACKNOWLEDGMENTS

My sincere thanks to those who assisted in all phases of this study. Dr. Robert White directed the study and assisted in preparation of the manuscript. Drs. Ray White and Lynn Irby critically reviewed the manuscript. I also wish to thank the other members of my graduate committee, Drs. Calvin Kaya and Alfred Cunningham, for their assistance in completing this thesis. A number of Montana State University undergraduate and graduate students helped with field operations. Dr. Dalton Burkhalter provided assistance with computer programming, and Dan Gustafson helped with data analysis. Charlie Smith and Pat Dwyer provided technical advice. Special thanks are extended to Pete Gross for providing housing and help at the study site.

Lastly, I especially appreciate the encouragement and help my wife, Lynn, has given throughout my graduate school career. Her support, confidence, and patience were a continual source of inspiration.

This study was funded by the United States Fish and Wildlife Service through the Montana Cooperative Fishery Research Unit, Montana State University, Bozeman, Montana.

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF TABLES - Continued

LIST OF FIGURES

LIST OF FIGURES - Continued

LIST OF FIGURES - Continued

LIST OF FIGURES - Continued

ABSTRACT

Few studies have assessed impacts of small hydropower development or provided information to recommend winter minimum instream flows. I examined trout populations, movements, and habitats selected during winter in three South Willow Creek study sections before small hydropower development. Streamflows were lowest during winter (November-March) both years of the study (1984-86). Overwinter decreases in rainbow trout (>75 mm) densities averaged 32% (range 18 to 45%) over both years and all sections; standing crops decreased 30% (range 11 to 36%). Changes in brook trout populations were less. During winter 1985-86, net distances moved by radio-tagged rainbow trout (>225 mm) ranged from 3 to 261 m. They selected high-quality pools with overhead cover, especially overhanging rock and surface turbulence, and avoided areas without cover. Selected depths were >45 cm and selected velocities were <30 cm/s; they avoided depths <15 cm and velocities >45 cm/s. Substrate selection was variable, but large substrate (>256 mm) was used for cover. Instream flows that provide maximum quantities of these selected habitats are recommended to sustain rainbow trout populations during winter.

INTRODUCTION

Recent federal and state economic incentives have stimulated development of renewable electrical energy and have led to increased interest in small hydropower (less than 5 megawatts) production. For example, since passage of the Public Utility Regulatory Policies Act in 1978 and the National Energy Security Act in 1980, the Federal Energy Regulatory Commission (FERC) has received over 6,100 hydropower applications; less than 3,000 applications had been submitted in the preceding 60 years (O'Connor 1985). In Montana, nearly 90 applications for small hydropower were filed with FERC in 1981 and 1982 (Leathe and Enk 1985). Although most of this interest has proved to be speculative, several projects in Montana have been licensed or exempted from licensing and are now operational.

Small hydropower development in Montana and elsewhere has resource management agencies, developers, and the public concerned about potential impacts to stream fisheries. This concern led to a symposium on small hydropower and fisheries in Colorado in 1985 (Olson et al. 1985). Graham (1985) noted that the potential for adverse impacts is partly dependent on the type of project, its mode of operation, and the status of the stream fishery.

Projects of primary concern in the Rocky Mountains are high-head diversions on small, high-gradient streams inhabited by salmonids (Graham 1985). This kind of project would impound and then divert water around a section of stream (often a kilometer or more) to create hydraulic head and run electrical turbines. Although streamflows in the section would be reduced throughout the year, relatively severe dewatering could occur during winter when power demand is largest and streamflows are smallest. Salmonid abundance may decrease with winter dewatering if winter habitat is limiting or if fish are already stressed by snow and ice, low water temperatures, or other harsh conditions.

Besides reduced streamflows, other potential impacts include (Rochester et al. 1984; Graham 1985; Leathe and Enk 1985):

1. Direct mortality from turbines.
2. Barriers to migration.
3. Increased fine sediment deposition.
4. Altered flow and temperature regimes.
5. Excessive streambed scouring by ice.
6. Gas supersaturation.

These concerns are compounded by lack of information (Sale 1985). Little research has been published describing the individual or cumulative impacts of small hydropower development. This is especially true with regard to winter dewatering. Resource agencies are responsible for recommending minimum instream flows to protect stream fisheries, and they often rely on information about habitats selected by fish (e.g., Instream Flow Incremental Methodology-Bovee and Cochnauer 1977; Bovee and Milhous 1978; Bovee 1982, 1986). Yet habitat selection information for salmonids, though generally known for summer and fall (Bovee 1978; Raleigh et al. 1984), is lacking for winter (Wesche and Rechard 1980). This lack of information may be particularly significant if salmonid habitat requirements change seasonally (Campbell and Neuner 1985; Cunjak and Power 1986).

Lotic ecosystem response to modified flow regimes is complex and not well understood for any season (Sale 1985). Flow alterations can result in changes not only in physical habitat availability but also in water chemistry and temperatures, nutrient cycling, biomass and energy relationships, and fish population and community dynamics.

This study was conducted at South Willow Creek, Montana, during 1984-86. My objectives were to (1) provide baseline information on stream physical conditions and trout population parameters, especially winter mortality and movements, before small hydropower development; and (2) quantify winter habitats selected by adult rainbow trout. "Winter" is defined as that period when water temperatures were less than 4C (November through March).

STUDY AREA

The study area was in South Willow Creek, Montana (Figure 1), at and around a site where a small hydropower project began operating in 1986. Starting at a diversion dam immediately below the confluence of Potosi Creek (Figure 2), water from the mainstem is piped 700 m downstream, run through a turbine, and returned to the stream channel. Montana Department of Fish, Wildlife, and Parks (MDFWP) recommends that a minimum flow of 0.28 m^3/s remain in the bypassed channel throughout the year (Fred Nelson, MDFWP, personal communication).

South Willow Creek is a drainage of the Tobacco Root Mountains in southwestern Montana (Figure 1). The stream originates at the confluence of its north headwater fork, which flows from Granite Lake (elevation 2719 m), with its south fork, which flows from Bell Lake (2682 m). From its headwaters, South Willow Creek flows 22 km northeast, joins North Willow Creek, and forms a braided inlet to Harrison (Willow Creek) Reservoir. Willow Creek drains into the Jefferson River at the town of Willow Creek, Gallatin County, Montana.

The South Willow Creek drainage basin is about 90 km^2 and ranges in elevation from 1609 to 3228 m. Average stream