Detecting the Effects of Logging Activity on Fish in Caspar Creek, California: A Manipulative Approach

Study Plan

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BACKGROUND

Due to the economic and political importance of salmonid populations in the Pacific Northwest, the non-point source effects of logging will ultimately have to be linked with salmonid production and survival. Studies of the impacts of logging on fish have produced conflicting results (Bisson and Sedell 19841, and much debate has centered around the design of impact studies (Hall and Knight 1981). We see a present need to effectively evaluate logging/fishery interactions using a manipulative approach and have an excellent opportunity to do so in conjunction with the Caspar Creek Watershed Study (PSW RWU-4351). We see three areas of concern when proposing an impact study: 1) the basic approach and the subsequent ability to make strong statistical inferences about treatment effects, 2) eliminating or separating out effects due to natural variation in anadromous salmonid populations, and 3) adjusting for the nuances of changes in the fish/habitat relationship over time and space.

Two basic approaches can be used to assess treatment effects. The first and most common is the observational approach. This includes designs that observe natural systems to detect change or show difference. This design allows broad questions to be addressed but results in a wider range of alternative interpretations of the source of treatment effects. A second approach, the manipulative approach, includes designs that manipulate systems to test hypotheses. Controlled manipulation will produce stronger inference than will observations alone and will substantially reduce the number of alternative interpretations of the source of treatment effects.

One major problem in developing designs is to accommodate the complexities introduced by the life history strategies of anadromous salmonids. Salmonid abundance naturally varies with time and space, as well as with a complex set Of biological and physical habitat variables. In addition, any assessment of impacts on salmonid production, growth, and survival must take into consideration the natural variability in abundance not necessarily due to proximate watershed effects. Abundance will be dependent on a full range of physical and biological factors from both stream and ocean phases of the life cycle. Defensible methods of evaluation must separate or eliminate this natural variation so that fish production, growth, and survival from any given time will more likely be linked to watershed effects in that period. Lastly, physical changes and habitat characteristics that may be meaningful determinants of the potential or capacity of any given habitat for fish production, growth, and survival must be determined to develop a base from which change can quantifiably be measured.

OBJECTIVES

The objective of this study is to evaluate the short- and long-term instream effects attributable to logging for: **1)** fish growth, condition, and survival, 2) vertebrate community structure, 3) habitat availability and 4) habitat capacity, including changes the capacity of the stream to retain steelhead through the winter period.

DESIGN

The design of the study is partially constrained by limits of the timber harvest schedule. It appears that the timber will be sold in 1989 assuring a minimum of three years of pre-harvest calibration data. The treatment (scheduled logging) is planned only for the North Fork of Caspar Creek (above the weir pond). Thus the "treatment" is limited to the North Fork of Caspar Creek as another watershed with similar attributes for pairing is not readily available. The South Fork of Caspar Creek (above the weir pond) and the upper reach of North Fork of the South Fork of the Noyo, draining similar watershed areas, will be used as two different types of controls. One control (South Fork of Caspar Creek) will provide a control for treatment (logging) effects and the other control (called a marker stream in this study) will provide a control for manipulation effects. This in effect leaves the study with no replication of the treatment but will still allow inferences to be made on the effects of logging within the Caspar Creek watershed (assuming small year to year within site variability). By having two controls, the design does provide an <u>a priori</u> basis for constructing an expected result: if there is no treatment effect, data from the control streams should be no more similar than either control vs. the treatment stream (Newbold et al. 1980). Broader application of the results will be based on judgement comparisons of this case study with other published case studies.

The study design will include 3 replicate manipulation sites on the treatment reach (North Fork of Caspar Creek) and 3 replicate manipulation sites on the control reach (South Fork of Caspar Creek). The manipulation in this study is the introduction and monitoring of steelhead trout at the manipulation sites (see methods section). In addition, 2 replicate observational sites (for quantifying changes in unmanipulated communities) will be set up on each of the treatment, control, and marker (North Fork of the South Fork of the Noyo) reaches. In this study, a marker stream is a second type of control in which no manipulation (i.e., no introduction of fish) will take place and it will, in the analysis, provide an additional treatment/control comparison to be made.

The minimum calibration level acceptable will be three full seasons (3 summers and 3 winters, with the summer preceeding the winter) prior to the onset of logging. Between-year variability cannot be discussed with any shorter calibration period. Completion of the study will not be possible with less than 3 full seasons (or a number equal to the calibration period) following the end of logging. The preferred maximum duration of the logging period itself, should be 2 or 3 years and no more than 4 years.

Logging can change stream habitats by altering the movement of watershed products -- water, sediment, woody debris, small organic debris, terrestrial insect drop, and dissolved solids -- into channels and by reducing shade. Because we anticipate streamside vegetation will be cut only on a limited basis in this experiment, we do not expect water temperature and woody debris to be greatly affected. Previous studies in the Experimental Watershed have shown that logging affected timing but not peaks or volume of runoff. Therefore, we anticipate the greatest changes will be associated with inputs of sediment and dissolved solids.

An increase in sediment inputs would probably introduce more fines (sand and silt) into the streambed possibly causing pool volumes to decrease and riffle volumes to increase (Bisson and Sedell 1984). These changes can be expected to change the volume and quality of habitat available to fishes during the summer low flow period. In addition, decreased fish production can be expected from increased short-term pulses of sediment by interfering with normal social organization, spatial positioning, feeding ability, visual ability, and by increasing stress (Berg 1982). Increased sediment inputs can also abrade periphyton and thus affect the diversity and abundance of primary producers in logged streams (Erman and Ligon 1985). These changes can be expected to occur against a background of normal changes including those caused by shifting channel structure, such as woody debris, which is abundant in these channels. In addition to monitoring change through the biological portion of the study design, changes in channel morphology, substrate sizes, cover, water temperature, discharge, suspended sediment concentration, pH, and conductivity will be monitored to follow the most probable and important changes in physical habitat.

METHODS

Basic Assessments

Before the manipulation and observation sections are established, the entire stream channel accessible to fish above the weir ponds will be surveyed to determine the availability of habitat types (Bisson 1981) to fishes. This initial survey will provide the basis for selection of the manipulation and observational sections and to institute stratified sampling. It will also provide habitat specific estimates of population levels (numbers and biomass per unit volume) and age distributions of the aquatic vertebrate species present. Of particular importance will be the abundance and age class structure of l+ or greater steelhead as these fishes would be expected to remain in the stream for 2 or 3 years (dependent on several variables including the quality and quantity of prefered habitat). Beginning in the second year of the study the number of marked steelhead (steelhead introduced into the manipulation sections will be marked with an adipose fin clip) recovered in the survey will provide an indication of the number of overwintering individuals from the introduced population.

Observational Sections

Two approximately 100-meter-long observational sections will be established independently of the manipulation sections in each of the treatment, control, and marker streams. The exact section lengths will be determined by the number and types of habitats required to obtain equal representative reaches in each of the treatment, control, and marker streams. The sections will be surveyed twice a year during the low flow period (approximately June and August) using a backpack electrofisher and the three pass habitat specific sampling method of Bisson (1982) or a habitat specific snorkel sampling scheme (G. Reeves, PNW Corvallis in progress) . The final decision on which method is to be used for the duration of the study will be made after comparisons of the methods the first year. Habitat specific population estimates for all vertebrates in each observational section will then be computed (Carle and Strub 1978).

In each reach the following physical measurements will be taken:

Channel morphology - Detailed maps of channel boundaries, woody debris, substrate classes, overhead cover, habitat types, and depth contours will be constructed with tape, compass, and rod. Areas of each of these will be measured from the maps, except for woody debris, whose volume will be measured by the method described by Swanson et al. (1984).

Pools - Residual depths and volumes of pools will be measured from these maps by subtracting the depth of water over the downstream lips of pools. Changes in pool volume with discharge will be monitored by reading water stage from staff gages in each pool.

Embeddedness and bed material size - Embeddedness and bed material size will be measured along randomly selected transects across habitat units randomly sampled in proportion to their area of the total channel. Parameters will be averaged for each transect. In this way, means and variances of substrate parameters can be computed for whole reaches as well as for individual habitat types.

Along each transect, the B-axis of each particle encountered at 0.3m intervals will be measured (the pebble count, after Wolman, 1954). Embeddedness -the relative depth (O-20%, 20-40%, 40-60%, 60-80%, and 80-100%) to which bed particles are buried by fine matrix material (Platts et al. 1983) - will be measured for each large particle grouped in size classes of 90-128mm, 128-180mm, and >180mm. Bed relief provided by each large particle will be measured from the surrounding bed to the top of the particle. Embeddedness and bed relief for each size class will be averaged for each transect.

Manipulation Sections

Three manipulation sections will be established in each of the North Fork and South Fork of Caspar Creek above the weir ponds. Each manipulation section will consist of an individual, similar pool type (Bisson 1981) bounded by a short riffle section both upstream and downstream. The pool type to be used will be determined by the availability of three replicate types available both in the North and South Forks of Caspar Creek. Pools were chosen as the habitat type for manipulation reaches because our previous research in Caspar Creek shows these habitats do not dry up and are heavily relied upon during the summer low flow period by steelhead populations.

Fish, mid-riffle, on both the upstream and downstream sides, two-way fish traps (Erman and Leidy 1975) will be placed to monitor fish moving in and out of the reach. Traps will be positioned such that the entire stream flows through the trap. Wire wings will be used if necessary. The sections will be established in June after peak flows have subsided. Traps will be set in place and all resident vertebrates occupying that section will be captured, weighed, measured, counted, and removed to another section of stream. Young of the year steelhead trout captured from below the North and South Fork Caspar confluence will then be weighed, measured, marked by an adipose fin clip, and then placed into the sections. Young-of-year steelhead were chosen because of the two salmonids in the stream they are more likely to choose to remain stream residents for a period of years if the habitat is suitable. Ideally a resident fish might be a better indicator of stream condition, but there are none present. The density of fish to be introduced into each section will be initially 4/m^3 of habitat volume at time of introduction. The idea is to "flood" the habitat, so this density is subject to change once we get "in" the creeks and get started. Fishes introduced in each successive year will be held constant at the first year density. This rate of "flooding" will insure that natural variations in fish density due to off-site effects are eliminated. Fish movement in and out of the reach will be monitored on a daily basis in July and August. All vertebrates will be counted, measured, and checked for marks, before being released in the direction they were heading. Only steelhead will be allowed to enter and stay (if they choose) in the reach, all other vertebrates will be measured, counted, and then returned to the stream in the direction they were heading but bypassing the manipulation section . In early September, at or near the annual low-flow discharge, all of the steelhead remaining in the section will be weighed, measured, and the number of marked versus unmarked fish determined. The traps will then be removed from the stream for the winter.

<u>Physical parameters.</u> Channel features will be measured from maps like those of the observational reaches. Substrate parameters will also be measured similarly, but transects will have to be more closely spaced. Measurements will be taken before fish are introduced each summer to avoid affecting their migration.

DATA ANALYSIS

Habitat Availability. Exploratory analysis of the availability of habitats and their frequency and sequence will be used in assessing vertebrate abundance and habitat relationships for the three streams. Changes in the abundance and distribution of available habitats will be quantified and compared annually.

Observational Sections. ANOVA will be run to test hypotheses

- Ho: Growth rate is the same before, during, and after logging.
- Ho: Condition factor is the same before, during and after logging-
- Ho: Overwinter retention of marked fish is the same before, during and after logging.
- Ho: Vertebrate community structure is the same before, during and after logging.
- Ho: Habitat specific salmonid abundance and biomass is the same before, during and after logging.
- Ho: Differences in the above response variables before, during and after logging will be the same for treatment and controls.

Experimental Sections. ANOVA will be run to test hypotheses:

- Ho: Growth rate is the same before, during and after logging.
- Ho: Condition factor is the same before, during and after logging.
- Ho: Habitat capacity is the same before, during and after logging.
- Ho: Seasonal emigration of young of year fish is the same before, during and after logging.
- Ho: Differences in the above response variables before, during and after logging will be the same for treatment and control.

Pool depth. Frequency distributions will be constructed for residual pool depth and compared with ANOVA. The percent area of the channel in pools (residual depth greater than zero) and frequencies of depths over critical minimum values preferred by fish will also be compared.

Substrate parameters. Frequency distributions will be constructed for embeddedness, substrate relief, and grain size. Means and standard deviations will be computed in order to perform analysis of covariance of the same reaches over time and between treated and control reaches. The frequency of critical values of parameters determined by measurements of fish preference will also be compared by ANOVA.

Water quality parameters Suspended sediment concentration, conductivity, and pH will be compared over time by testing for significant differences in parameters of relations with discharge.

SAFETY

The general safety procedures outlined in the Redwood Sciences Laboratory Safety Plan will be followed at all times. All personnel will be briefed annually in basic first aid and safety.

Access to research areas are through dangerous, wet, forested habitats with steep embankments, many downed logs, unsure footing, and tangled brush. Safety procedures include the use of proper clothing and footwear, safe driving practices, and prompt reporting of accidents. In addition, the use of extreme caution while working in streams will be emphasized. The stream substrate is slippery, currents may be swift, and pool depths may excede the height of the provided wading gear. The water is cold and hypothermia is a possibility. Work in or near water must always be done in teams and never while alone.

Extra safety precautions will be taken while electrofishing. Electrofishers have a high-voltage output and the chance of receiving an electrical shock **is** multiplied when dealing with electrical currents in or near water more than any other place. Special safety articles must be worn when using the electrofisher. These include non-leaking, dry, wading boots and non-leaking rubber electricians gloves. Only persons completing an electofishing techniques and safety session given by the RWU will conduct electrofishing surveys.

Special care will be taken in the North Fork watershed during the logging operation. Personnel will coordinated with the Department of Forestry and Timber Operator before beginning work in the stream. Hardhats will be worn by all persons.

PERSONNEL

Lynn M. Decker, Fishery Biologist, and Thomas E. Lisle, Hydrologist, (Principal Investigators) -supervise data collection and analysis; train field personnel; select experimental and observational areas; prepare reports and publications.

Field Technicians (2, GS-4/5) -gather and collate data.

YEARLY SCHEDULE

Months are given below for approximations; actual timing will be based on the hydrograph. Year-to-year sample times will be kept consistent with the final first-year time table.

May	-Assess Habitat Availability
	-Select Experimental and Observational Sections
	-Assess population of 1+ Steelhead
June	-Place fish traps and begin monitoring experimental sections
	-Survey observational sections
August	-Survey observational sections
Sept.	-Assess fish numbers and condition in experimental sections,
	-Remove traps for winter

EXPECTED PUBLICATIONS

Habitat availability and habitat capacity for salmonids before and after logging, in Caspar Creek, California.

Changes in fish growth and condition before and after logging, in Caspar Creek, California.

Changes in vertebrate community structure before and after logging, in Caspar Creek, California.

Using experimental manipulation of fishes to detect changes due to logging.

The influence of physical habitat on habitat suitability and the distribution of fishes in a coastal stream.

BUDGET

FY 86

Salaries:	
Decker,(30%)	6600
Lisle (10%)	3600
Field Technicians (2 @ GS-5, 8 pp)	9500
Computer Programmer (GS-5, 8 PP)	4750
Per Diem:	800
Vehicle: (4.5 mos.)	1000
Equipment:	1000
Trap construction:	500
Sub-total:	27750
Station overhead (18%):	4995
FY 86 Total	32745

Yearly Totals (4% inflation)

FY 87	34050
FY 88	35400
FY 89	36800
FY 90	38300
FY 91	39850
FY 92	43450
FY 93	45200
FY 94	47000
Grand Total (if 9 year project)	352795

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