Cumulative Effects of Contemporary Timber Harvest on Fish Abundance and Distribution

Investigators: Robert E. Gresswell and Christian Torgersen, U.S. Geologic Survey, Forest and Rangeland Ecosystem Science Center, Douglas S. Bateman and David Hockman-Wert, OSU College of Forestry, and Marc Novick, OSU Department of Fisheries and Wildlife.

Introduction

On public lands, restoration activities addressing the effects of land-use activities on aquatic habitats rely increasingly on ecosystem principles across large spatial scales. However, in western Oregon, public lands often occur in a matrix of private timberlands where harvest activities are subject to other regulations. These industrial forest systems have rarely been considered in the integrated management of forested landscapes. The goal of this research is to expand the understanding of physical and biological processes in streams subjected to contemporary forest harvest by studying a privately owned watershed in western Oregon. This study will initiate a long-term program examining fish and riparian invertebrates associated with temporally varying harvest activities. Changes in distribution and behavior of biota at different spatial scales, from local to basin-wide habitats, will be examined in the headwaters of Hinkle Creek on land owned by Roseburg Forest Products.

Interpreting effects of land-management activities on aquatic habitat, and ultimately on aquatic organisms, is hampered by the complexity of relationships among physical, chemical, and biological characteristics of terrestrial, riparian, and aquatic systems, especially at broader spatial scales. These complexities require integrated research across the landscape for extended periods. To date, most studies have been conducted at the site scale for a year or two, and protocols for examining these data in a broader context have not been well developed.

These research shortcomings are especially relevant to aquatic habitats on private timberlands. Industrial forestlands are the product of intensive management focused on continued production of wood resources through time. Much of the information concerning the effects of timber harvest in these areas is based on logging practices before 1990. The influence of current forest regulations is not adequately documented.

Small headwater stream channels can represent greater than 70% of the cumulative channel length in mountain watersheds. These small headwater channels are often directly affected by land-use activities, but the value of small channels and their associated riparian habitats has rarely been addressed by previous policies and management activities. Even where fish are not present, these headwater channels transport water, sediment, and wood that move from hillslopes to larger streams. Both ephemeral and permanent headwaters provide habitat for invertebrates that may be food for fish either locally or downstream. Quantifying the spatial and temporal extent of these processes will enhance the ability to anticipate potential downstream effects of harvest activities.

Critical questions concerning contemporary timber harvest practices on private industrial forests remain unanswered. Fundamental to answering these questions is determining how harvest activities in headwaters affect fish assemblages and behavior across the stream network. It is anticipated that changes in habitat, water quality, or food supply will affect fish in a dynamic way. The research proposes to address the following questions: 1) How do changes in physical and biological characteristics of tributaries without fish seasonally influence habitat quality in other portions of the stream network? 2) How do seasonal hydrologic changes in headwater streams affect fish abundance and distribution? 3) Does the abundance or diversity of fish fauna decline in response to changed habitat quality, or do organisms seasonally move to areas where habitat quality remains high?

Instream Habitat Evaluation

Sampling began in Hinkle Creek in 2001. During field surveys, geomorphic stream reaches were classified in each segment, and channel units were delineated in each geomorphic reach. Stream habitat was inventoried using a methodology developed in 1998 (Gresswell and Bateman, see 1999 CFER Annual Report). Physical variables that describe habitat unit size (e.g., length, depth, and width), substrate size class, channel type, valley segment type, and woody debris accumulations were estimated or measured for all sampled habitat units.

Estimating Fish Abundance and Distribution

Fish abundance is being estimated annually in all pools and cascades, with electrofishing as the primary means of fish collection. During each sampling period, beginning in 2002, coastal cutthroat trout (*Oncorhynchus clarki clarki*) and steelhead trout (*Oncorhynchus mykiss*) ≥100 mm (fork length) in Hinkle Creek have been implanted with a passive integrated transponder (PIT) tag prior to release. Stationary receiver antennae were placed so that movement could be monitored, at the stream segment scale, continuously (24 hours/day, 7 days/week). In the fall of 2003, additional stationary receiver antennae were placed in the South Fork, bracketing discreet patches representing different densities of fish. In the fall of 2004, a second stationary receiver antennae antenna was placed adjacent to existing segment scale antenna to allow a more accurate assessment of direction of fish movement. Additionally, portable sensing units are being used for detecting the location of tagged individuals during subsequent surveys, typically occurring during December, March, and June. This information will provide a means to detect shifts in the fine-scale fish distribution and movement patterns (e.g., timing, direction, and distance) that can be compared with reach-scale stream discharge, substrate composition, water temperature, food availability, and geomorphic structure.

Fish sampling at a variety of temporal and spatial scales is providing the opportunity for incorporating natural variation in the project analysis. Terrestrial and aquatic habitat conditions for coastal cutthroat trout demographics will be available for 4 years before timber harvest (2001–2004) and 6 years following harvest (2005–2010).

Preliminary Research Results

Fish abundance by species and age-class has varied within and between watersheds among years (Figure 1). South Fork Hinkle has consistently contained more age-1+ steelhead than the North Fork. However, cutthroat trout have been the most abundant age-1+ fish in both watersheds through out the study period. To date, cutthroat trout have accounted for 84, 64, and 83% of the fish large enough to receive PIT tags in 2002, 2003, and 2004 respectively.

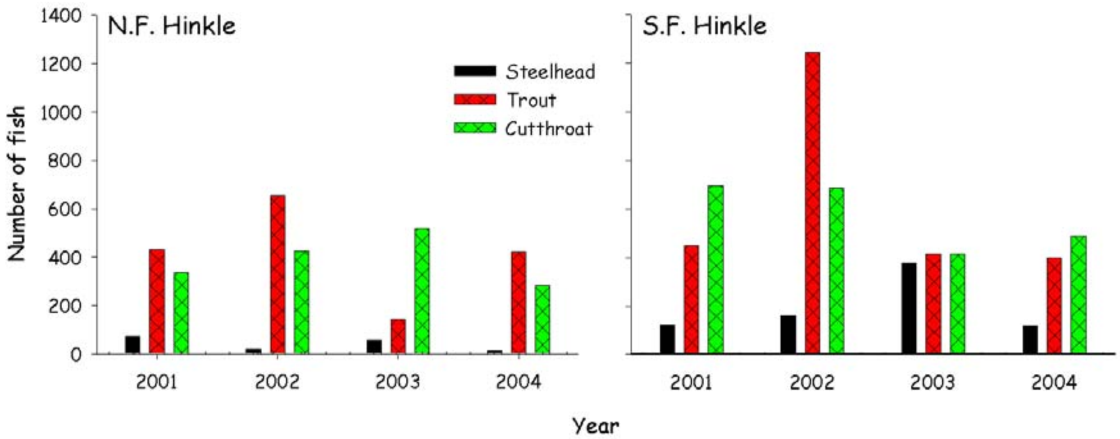

Figure 1. Total catch from summer electrofishing surveys for Cutthroat, age-0 trout, and steelhead 2001-2004. Age-0 represent all trout < 80 mm fork length.

Recaptures of PIT tagged fish are beginning to provide information on growth rates for cutthroat trout (Figure 2). Although these data suggest that growth rates are tracking between watersheds, results are very preliminary due to small sample size and limited temporal scope. Growth data from PIT tagged fish will be used to verify growth increments from scale analysis. Scale samples are collected from 10 fish for each 10 mm size increment per stream segment throughout both watersheds.

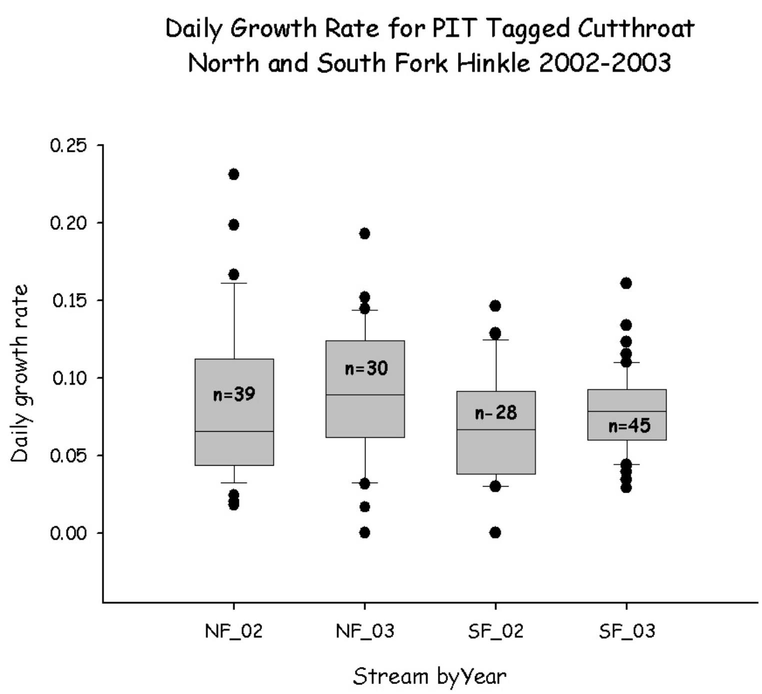

Figure 2.   Growth data represents fish recaptured a minimum of 330 and a maximum of 380 days after initial tagging. NF_02 and NF_03 represent fish initially tagged in North Fork Hinkle during summer electrofishing surveys in 2002 and 2003 and recaptured in 2003 and 2004 respectively. SF_02 and SF_03 represent fish with same capture and tagging history from South Fork Hinkle.

Fish movement is being investigated at a variety of spatial and temporal scales. Fixed site PIT tag antennas provide temporally continuous data on fish movement at spatial scales that range from patch to the watershed (Figure 3).

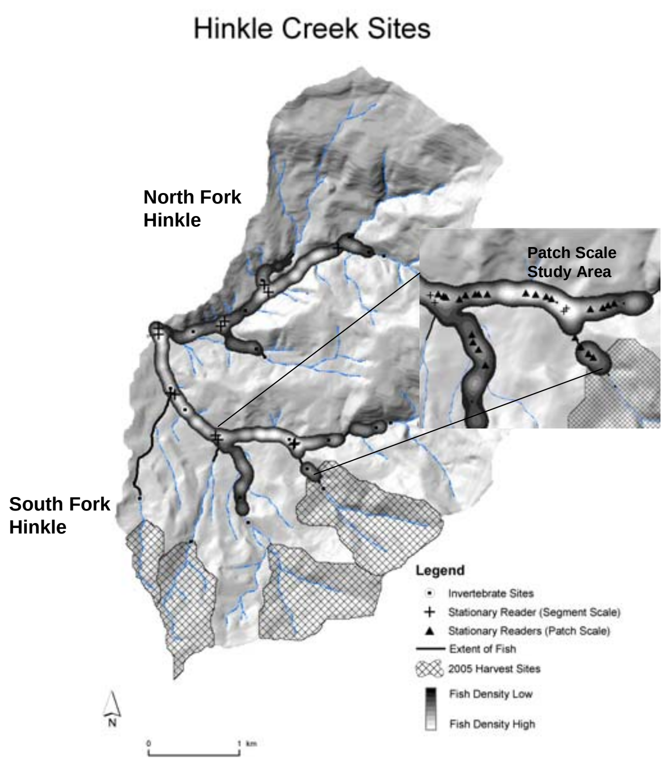

Figure 3. Location of segment and patch scale stationary PIT tag antennas. At the patch scale, antennas bracket discrete habitat patches of varying fish densities.

Preliminary analysis of data collected at the patch scale indicate variation in movement between mainstem and tributaries. Median extent of movement (i.e., difference between most upstream and downstream locations) and variation in the extent of movement were significantly different between fish of mainstem and tributary origin. In addition, differences in the median extent of movement and variance for fish originating below and above Tributary 2 in the South Fork were significant. Two fish tagged in Tributary 2 during the spawning season subsequently moved >190 habitat units and were detected in the mainstem South Fork of Hinkle Creek (Figure 4).

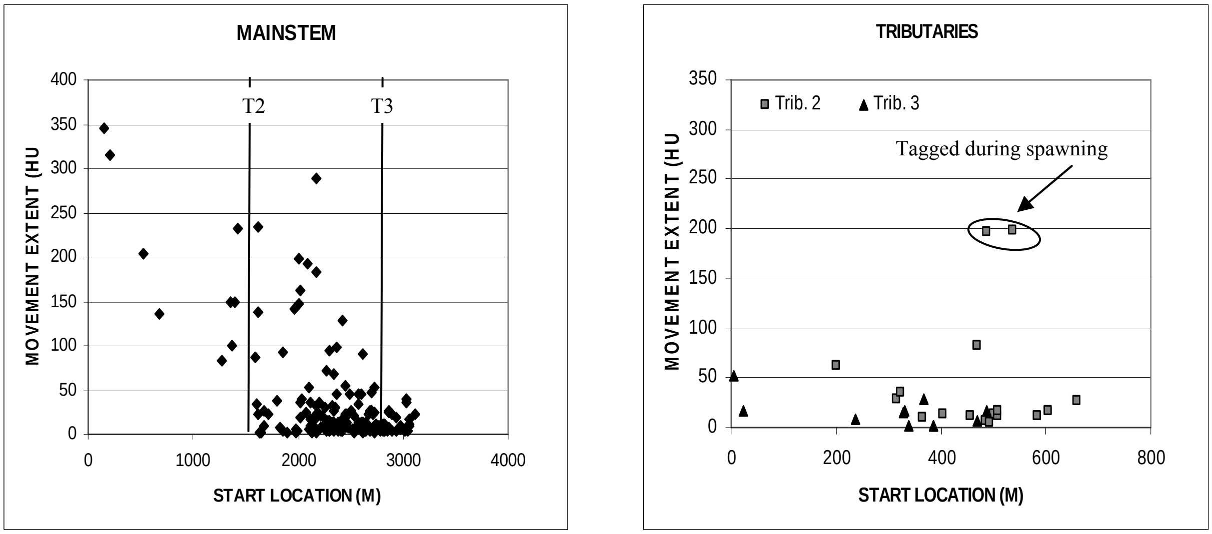

Figure 4. Movement extent (i.e., difference between most upstream and downstream locations in habitat units) for individual fish based on starting location from the mouth of South Fork Hinkle Creek. Lines labeled T2 and T3 show tributary locations.

Most coastal cutthroat trout moved during periods of low to moderate discharge (Figure 5). Approximately 57% (270/452) of longer distance "between-habitat patch" movements occurred at moderate stage heights, and 55% (353/640) of shorter distance "within-habitat patch" movements occurred during periods of low stage height. Sixty-one percent (279/457) of stationary behavior events (i.e., maintaining position within the detection field of an antenna for a minimum of 15 minutes) occurred during moderate stage levels. There was a two-fold increase in the median duration of stationary behavior events during times of high stage height (median = 3.8 hours) as compared to similar events at moderate (median = 1.6 hours) or low (median = 1.9 hours) stage heights. Movements from mainstem habitats to tributaries increased during periods of high stage height.

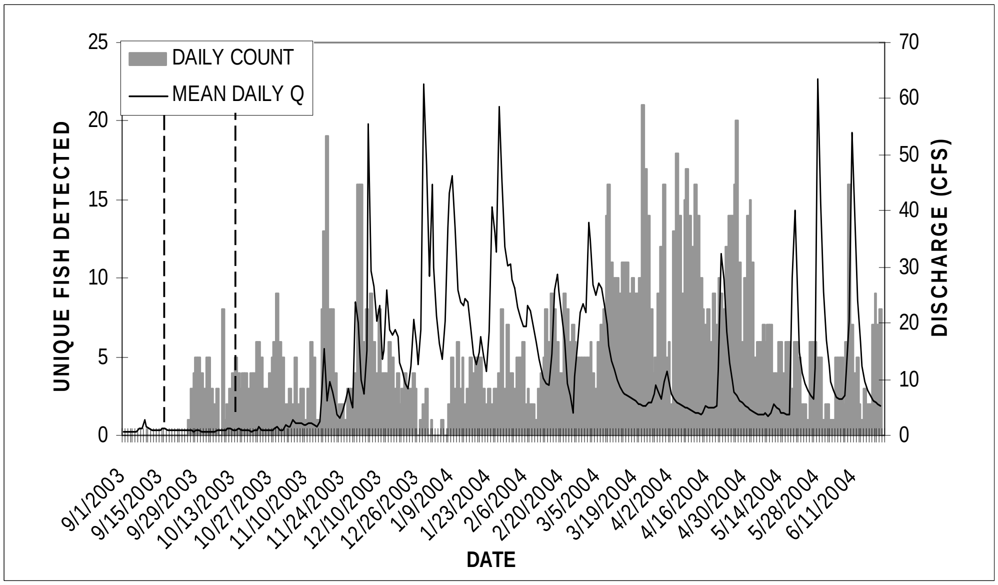

Figure 5. Time series plot of stream discharge superimposed on a frequency distribution of unique fish detections at stationary antenna sites. Detections are based on only the first detection of individual fish for each day. Both mainstem and tributary detections are represented

At the watershed scale, the patterns of fish movement detected at segment boundaries was similar between watersheds with more fish movement observed in late winter and spring (Figure 6) then declining with summer. This large-scale pattern is punctuated with brief spikes of movement throughout the year. The late winter early spring increase in movement follows the decline in mean daily discharge and corresponds with coastal cutthroat trout spawning.

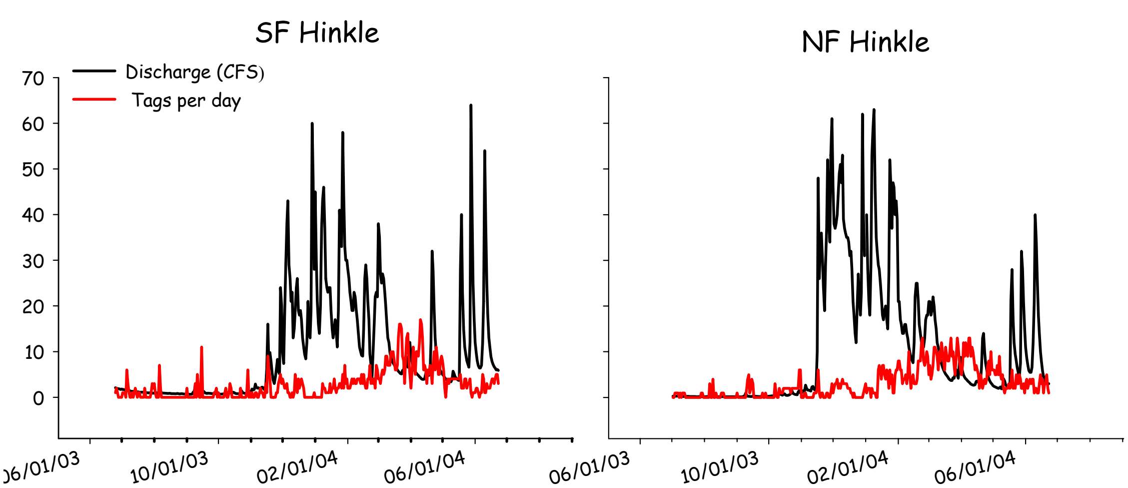

Figure 6. Mean daily discharge and the number of unique PIT tag detections per day from the North and South Forks of Hinkle Creek   Fish movement data is for all fish and all stationary antennas within a watershed.

Data collected from mobile antennas provides a seasonal evaluation of fish distribution and patterns of relative abundance. Through time, patches of varying densities of fish have been observed (Figure 7). Some patches consistent with regard to relative abundance among sampling events while other patches are highly variable. We are currently calculating means and variance estimates for all patches in both the North and South Forks for purposes of comparing habitat among patches of different relative abundance histories and establishing pretreatment conditions.

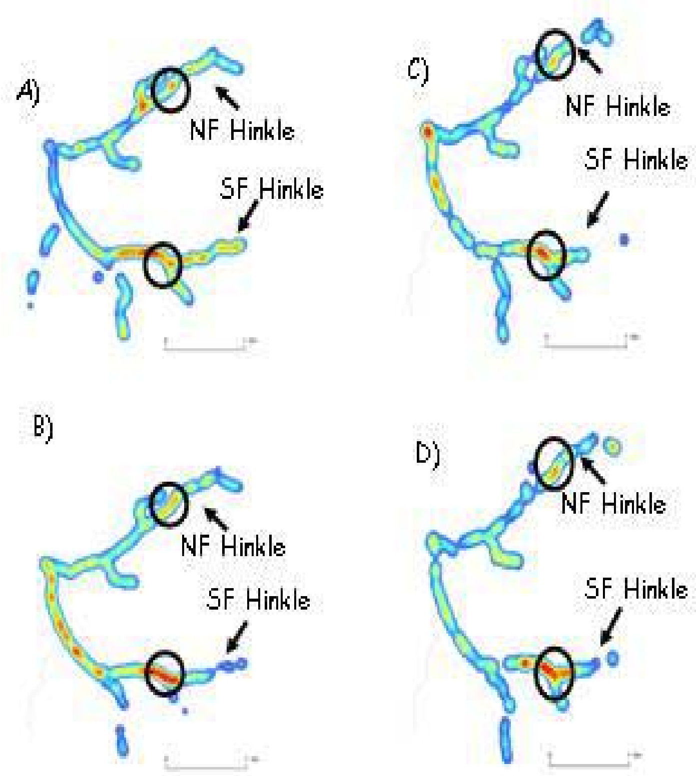

Figure 7. Relative density of cutthroat and steelhead trout ≥ 100 mm fork length in North and South Fork Hinkle Creek (hot colors indicate higher fish density). A) August/September 2001, derived from electrofishing, B) August/September 2002, derived from electrofishing, C) April 2003, derived from mobile PIT tag antennas, D) June 2003, derived from mobile PIT tag antennas.

Future Work

Data reduction and analysis are becoming more of a priority and preliminary work on the correlation between habitat data collected during summer surveys and seasonal fish distribution has begun. Winter projects included upgrading the yellow tag network throughout the fish-bearing portion of both watersheds, collecting more detailed information on the distribution of large wood, and mapping the location of all surface water inputs. In addition, data continue to be collected on a weekly basis from all fixed station antennas and mobile tracking events are scheduled for December, March, and June.