RESEARCH ON THE H. J. ANDREWS EXPERIMENTAL FOREST ON THE EFFECTS OF LOGGING PRACTICES ON FISH HABITAT

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I INTRODUCTION

The H. J. Andrews Experimental Forest has been the site of research on the influences of forest practices on fisheries resources for more than 30 years. Research in the Andrews Forest has played a pivotal role in the development of management practices in forested landscapes of the Pacific Northwest. Many of the pioneering studies on the effects of forest practices on whole watershed nutrient dynamics, large woody debris in forest and stream, spotted owl habitat, and functions of riparian areas were located in the H. J. Andrews Experimental Forest (1-3). The combination of recently harvested units and undisturbed, old-growth forests has provided an invaluable context for interpreting the nature of forested landscapes and the consequences of our harvest of forest resources.

II DESCRIPTION OF THE H. J. ANDREWS EXPERIMENTAL FOREST

The H. J. Andrews Experimental Forest is located in the Blue River Ranger District of the Willamette National Forest and encompasses the 15,815 acre Lookout Creek watershed, a tributary to Blue River in the McKenzie River drainage. One-third of the Lookout Creek watershed has been harvested since 1950; approximately 45 percent of the basin contains undisturbed, old-growth forests more than 400 years of age. The elevation of the Lookout Creek watershed ranges from 412 m to 1630 m; forests of the lower elevation are dominated by Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*), gradually shifting into stands of true firs and mountain hemlock at higher elevations. Red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), willow (*Salix stichensis*), and vine maple (*Acer circinatum*) are common components of riparian communities in the drainage. Annual precipitation exceeds 250 cm, largely concentrated in the winter months; and deep snowpacks are common at elevations above 1000 m.

Lookout Creek is a fifth-order mountain stream with two major tributaries, Mack and McCrae Creeks. The geology of the basin is characterized by recent volcanic terrain, and the streambeds are composed of basaltic substrates that are dominated by cobble and boulder size classes. Channel gradients range from 3 percent to more than 45 percent, but fish are not found in channels with gradients more than 20 percent. Large woody debris is abundant in streams flowing through undisturbed stands and is a major geomorphic feature in these streams. Clearcuts and a few shelterwood cuts are located throughout the drainage, but the upper 240 ha of

the Mack Creek watershed is largely an undisturbed, 450-year-old, old-growth forest.

The native fishes of the H. J. Andrews Experimental Forest include cutthroat trout (Salmo clarkii), torrent sculpin (Cottus rhotheus), longnose dace (Rhinicthys cataractae), and blackside dace (R. osculus). Rainbow trout (Salmo gairdneri) occur in Lookout Creek but probably were introduced by stocking. All of these species occur in the lower section of the drainage, but only cutthroat trout occur in the upper reaches.

III FISH HABITAT RESEARCH

In the early 1950's, research on the effects of logging practices on trout populations in the Lookout Creek basin began. Wustenberg (4) found that trout populations were totally eliminated from three tributaries after logging. Four years later, one of those streams was repopulated but only the lower 30 to 40 m of the other tributaries contained trout (5). Wyatt also observed that a landslide on another tributary to Lookout Creek in 1958 totally eliminated trout populations. In the main stem of Lookout Creek, results of fish population surveys were inconclusive as to the effects of clearcuts. High concentrations of suspended sediments and frequent landsliding were commonly associated with the logging practices in the Andrews Forest in the 1950's.

From 1973 through 1975, Aho (6) compared cutthroat trout populations in a small clearcut and an upstream, old-growth forest on Mack Creek, eight to ten years after logging. Cutthroat trout were approximately twice as numerous in the reach in the clearcut than in the reach in the old-growth forest. Rates of fish production were three times greater in the unshaded section than in the shaded reach. At first these results astonished many people, but additional research substantiated Aho's findings and provided possible mechanisms responsible for the response.

The increased production of herbivorous invertebrates associated with the increased algal production, particularly mayflies and midges, was suggested as a possible mechanism responsible for the greater fish production in the clearcut (6,7). Studies of insect emergence in these streams revealed that aquatic insect production was also greater in the clearcut section. These results were consistent with observations by Wustenberg and Watt 20 years earlier. Wustenberg (4) found insect abundances were reduced immediately following logging, but after two years the insect numbers in these streams began to increase. Wyatt (5) observed that aquatic insect densities in streams in a clearcut were three times greater than those in an upstream reach in an old-growth forest.

In the late 1970's, Murphy followed up on Aho's investigations in Mack Creek and extended the survey to include 33 stream reaches in recent clearcuts, second-growth, and old-growth forests

(8). Again, abundances of trout were found to be highest in unshaded streams in recent clearcuts, but trout populations in streams in second-growth forests were equal to or less than populations in reaches in old-growth forests. Murphy hypothesized that the decreased abundance of fish in streams in second-growth forests was associated with decreased primary production resulting from lower light intensities under the low deciduous canopy. He also found that another vertebrate predator, the Pacific giant salamander (Dicamptodon ensatus), was more abundant in high gradient streams in clearcuts; however, their densities decreased in clearcuts in low gradient streams as compared to old-growth sections of the same streams because interstitial habitats were eliminated by sedimentation. Murphy noted that aquatic insects exhibited similar patterns of abundance in unshaded and shaded streams.

Additional studies by Murphy et al. (9) and Hawkins et al. (10) examined effects of forest practices on fish populations in an array of streams from the Andrews Forest to the Willamette Valley and Coast Range. These studies found that the pattern of fish abundance in shaded and unshaded reaches observed in Mack Creek also occurred in streams across Oregon. Other vertebrate predators did not exhibit the same response and were more strongly affected by sedimentation.

Greater trout abundances in unshaded reaches were attributed to the greater primary production and greater insect abundance that were measured in these streams in the Andrews Forest. In the early 1980's, Wilzbach studied the feeding behavior of cutthroat trout in three streams located in or around the H. J. Andrews Experimental Forest in a recent clearcut, a 40-year-old alder stand, and the old-growth section of Mack Creek. Her studies demonstrated that efficiency of prey capture was greater at higher light intensities (11). This response was verified under artificial manipulations in the stream in the clearcut and in unmanipulated forested and clearcut reaches. In winter, she observed that cutthroat trout moved into interstitial spaces in the substrate in the forested reaches but did not move out of the water column in the clearcut reaches. Wilzbach related the difference in behavior to differences in food availability between the shaded and unshaded reaches. In the laboratory, habitat availability and food supply were manipulated; cutthroat trout would stay in a channel if food was abundant, regardless of habitat availability, but trout migrated out of the channels at low food abundance even if habitat was plentiful.

Most studies of fish habitat focus on main channel features and neglect habitats adjacent to the main channel. Moore (12) investigated the geomorphology, hydraulics, and ecology of lateral habitat in the three streams in the different riparian types described above in Wilzbach's studies. He observed that cutthroat trout fry are found only in stream margins and backwaters after emergence from the gravel. Gradually during the summer, some of the fry will move out into pools in the main channel. However, they remain in close proximity to the lateral habitat in which they reared. Reduction of the area of lateral habitats results in a concomitant reduction in fry abundance, and increases in lateral habitat area produce increases in fry densities with a reach. These lateral habitats make up only 15 to 20 percent of the total wetted habitat at summer low flow, but comprise almost all fry habitat, contain more than 75 percent of the detrital storage in the entire stream, and support densities of aquatic invertebrates that are more than five times greater than invertebrate densities in the main channel. Lateral channel features are important components of stream channels that have been neglected by both geomorphologists and fisheries biologists.

Much of the early research on the role of large woody debris in streams originated in the H. J. Andrews Experimental Forest (13). All of the fish habitat studies described above have demonstrated numerous roles of woody debris in fish habitat. Fish densities are higher around complex accumulations of woody debris in the Andrews Forest, and wood plays a major role in the creation and stability of lateral habitats that provide winter refuge. Debris accumulations retain food resources for consumers, and serve as major habitats for aquatic invertebrates (14). Investigations of the abundance of woody debris in streams, loading rates, movement, influence on geomorphology of channels, decomposition, role in nutrient cycling, importance for aquatic invertebrates, and role in fish habitat have continued through the present (15).

In February 1986, a debris torrent (5000 m^3) devastated a 300 m reach of Quartz Creek, a third-order stream in the Blue River drainage, terminating in a massive debris accumulation at the bottom of the reach. This reach had been the site of an intensive description of channel geomorphology, riparian vegetation, aquatic biota, and fish habitat. This provided a unique opportunity to examine the effects of debris torrents on stream ecosystems and fish habitat. Within one month after the torrent, we sampled the torrented reach, an upstream control, and a reach immediately downstream of the debris dam. Macroinvertebrates gradually recolonized the torrented reach and were dominated initially by vagile taxa such as chironomids and baetid mayflies. By late summer herbivorous invertebrates dominated the torrented reach, probably in response to increased rates of primary production. Cutthroat trout populations in the torrented reach were reduced by two-thirds as compared to the control reach, and were intermediate in abundance below the debris dam. Age structure of the cutthroat populations was also modified; fry and 1+ fish were nearly absent from the torrented section but were abundant in the other two reaches. Recruitment for 1986 was eliminated in the torrented reach along with most of the adult population, and migration of trout into the torrented reach consisted almost entirely of older fish. Movement of fry into the torrented section was minimal, a pattern consistent with Moore's observations of trout fry behavior in other streams in the area.

IV STREAM ECOSYSTEM RESEARCH

This discussion of research in the H. J. Andrews Experimental Forest has focused on studies of fish habitat, but the major strength of the research program in the Andrews Forest is the integration of aquatic research with studies of geology, hydrology, geomorphology, nutrient cycling, microbial ecology, terrestrial plant ecology, terrestrial invertebrate ecology, climate, wildlife ecology, and other aspects of the landscapes of the west slope of the Cascade Mountains. Fish habitats cannot be managed appropriately without a thorough understanding of stream ecosystems, but studies of stream ecosystems themselves must be placed within the context of geomorphic processes that create channels and terrestrial processes that create the adjacent forests (2). This interface between land and water is one of the most dynamic components of the landscape. We hope that research in the H. J. Andrews Experimental Forest will continue to contribute to the development of integrated ecosystem management on public and private lands for the future.

V LITERATURE REFERENCES

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