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USING THE HISTORICAL RECORD AS AN AID

TO SALMONID HABITAT ENHANCEMENT[1]

James R. Sedell and Karen J. Luchessa[2]

Abstract.--Historically, wild anadromous fish stocks evolved with stream systems that were obstructed by fallen trees, beaver dams, and vegetation growing in and beside the channels. River systems as large as 7th order had large numbers of fallen trees in their channels and often were obstructed by drift jams that were up to 1500 m long. The main river channels contained abundant gravels and fine sediments. Habitat complexity was great because of scour around boulders and fallen trees, and the presence of numerous and extensive stable side channels and sloughs. These pristine streams interacted intensively with their flood plains. Historical records document over 100 years of "diligent" stream and river cleanup. Primary activities included removal of boulders, large woody debris, and other obstructions from channels. We believe that historical documentation of the ways unmanaged streams interacted with the streamside forest allows us to know how far we have deviated from the optimum habitat requirements for various salmonids. Until we understand the structure of undisturbed habitats that wild stocks develop within, and the sequence of changes that have occurred in those habitats, our present protection and enhancement efforts will lack both a rational context and effective direction.

INTRODUCTION

Anadromous fish resources in Oregon and Washington streams have declined over the past several decades, prompting calls for intensified protection and enhancement measures. The quality and quantity of habitat available to wild stocks has diminished because of diverse and steadily increasing use of other land-based resources (timber, agriculture, hydropower, ranching). Increased harvest rates threaten the survival of many wild populations of salmonids. Most fishery management as well as land management agencies have some program for habitat enhancement or rehabilitation. The goal in all of these programs is to rehabilitate habitat that has been damaged, or enhance habitat that is naturally low in productive capacity.

A goal of both Oregon and Washington enhancement programs for anadromous fish is maintenance of natural stocks that still exist and preservation of genetic variability wherever possible. Increasing concern about the effects of large-scale hatchery programs on both genetic integrity of wild stocks and carrying capacity of the natural environment may be the strongest argument for improving quality and quantity of stream habitats. Although interspecific differences between the species of salmonids are obvious--such as appearance, size, habitat preference, time of migration, and feeding behavior--equally important differences occur within species, such as coho salmon or steelhead trout. These differences are determined by the nature of their freshwater natal streams and by the location and duration of their ocean rearing. Each stock within a species has developed physical and behavioral characteristics, that are specifically adapted to survival and reproduction in a particular home stream. These traits have a high probability of becoming incorporated into the stock largely because of a strong, genetically controlled homing ability. Because of continuous genetic selection for individuals best suited for

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specific streams, home stream stocks should survive and reproduce better than introduced stocks. Stocks introduced to a new environment usually have lower survival rates than native stocks and often lower the survival of the native stocks through interbreeding or competition (Oregon Department of Fish and Wildlife 1981).

Wild stocks evolved within "natural" stream systems. An understanding of the historical nature of these streams is important if we wish to rehabilitate streams or maintain and enhance wild stocks of fish. We assume that natural selection in freshwater was focused on the structure of these streams and the spawning, rearing, and migration habitats available to endemic salmonids.

We recognize that the best conditions for survival of a species, or stock within a species, are usually found in the center of its range. Much attention is currently being given to Oregon and Washington's geographical location as an important determinant of future potential for several anadromous species (Oregon Department of Fish and Wildlife 1981). It is equally important to identify the historic range and optimum of habitat conditions within a river system. Although important components of stream habitat--such as size of pools, quality of gravels, or pool/riffle ratios--were not historically quantified by early explorers and fur trappers, the general character of the streams and rivers of the Northwest was described. Historical records document how unmanaged stream systems interacted with streamside forests, and provide a comparison between present managed habitats and historic pristine habitats. Without an understanding of pristine streams as a point of reference, our present protection and enhancement efforts may lack an adequate context or conceptual rationale to assure success.

Old cannery records document the relationship of fish abundance to historic habitat conditions. Everman and Meek (1898) estimated about 11,000 chinook salmon and about 87,500 coho salmon were harvested per year from the Siuslaw River in Oregon between 1889 and 1896. If we assume a catch efficiency of 40 percent (Mullen 1981a), runs of chinook and coho salmon in the Siuslaw River in the 1890's would have been about 27,500 and 218,750, respectively. The current Oregon Department of Fish and Wildlife (1981) Coho Salmon Plan has an annual escapement goal of 200,000 to 250,000 wild coho adults to all coastal Oregon streams after habitat rehabilitation. The Siuslaw is one of over 30 major rivers and streams on the Oregon coast. The point is that the habitat available in the early 1890's on the Siuslaw River was able to support large numbers of the chinook and coho salmon. By 1960, virtually no chinook were caught off the mouth of the river and only 7,000 coho were landed (Mullen 1981a). Although fishing pressure has been tremendous over the last 80 years, drastic changes have also been documented in the character and structure of streams and rivers in which salmon spawn and rear. The rehabilitation of wild stocks depends on good habitat and reduced harvests. New habitat will have to be created, damaged habitat restored, and good habitat protected. The historical perspective presented in this paper can help provide a needed rationale for this effort.

EARLY SURVEYS AND DESCRIPTIONS OF NORTHWEST RIVERS

Most early descriptions of Northwest rivers are recorded in British and United States Army journals. They tell of valleys so wet that trails followed "the borders of the mountains." In Oregon and Washington, a common practice in very early times was to travel on the edges of the hills and not along the valley floors (Dicken and Dicken 1979). British Army journals described the Tualatin Valley as "mostly water connected by swamps" (Ogden 1961, p. 122). Much of this flooding was a result of beaver activity and accumulated sediment, fallen trees, and living vegetation in the channels. Because bottom land had accumulated fine silts and organic material of alluvial origin, the land was fertile and the task of draining the land for farming began early in Oregon and Washington.

Oregon State Agricultural College soils scientist I. A. Williams (1914, p. 114) wrote of the condition of Willamette Valley streams in 1910:

"Many of the smaller streams that have their course through these flat sections of the valley flow sluggishly and frequently overflow their banks during periods of heavy winter rainfall. It is found that most of these have sufficient grade to carry even more water than ordinarily comes to them; seldom less than 3, and usually more, feet of fall per mile. The annual overflow is caused from the obstructing of the channel by the growth of trees and the extension of their roots, the dams thrown across the channels by beavers and the consequent accumulation of sediment and other debris, etc. The particular streams in which such a state of affairs has been especially brought to the writer's attention are the Little Muddy and Long Tom Rivers, south of Corvallis in Benton and Lane counties; the Little Pudding River, in Marion County; the Tualatin and its branches in Washington County. It is a common condition, however, and usually all that is necessary is a clearing out and opening up of the clogged channel of the stream to afford entire relief from overflow and the discouraging handicap which it is to the farmer in such a locality."

Descriptions of the Puget Sound lowland streams are similar to those of Willamette Valley streams. Most streams consisted of a network of sloughs, islands, beaver ponds, and drift dams with no main channel. The Skagit River lowlands encompass about 512 km^2 of which over 128 km^2 were beaver marsh, sloughs, and wet grass meadows. Early U.S. Army Corps of Engineer maps for the lower Nooksack, and Snohomish Rivers in Washington show large areas of sloughs, swamps, and grass marshes (Reports of the Secretary of War 1875-1891). All of the coastal valleys in Oregon contained marshy areas and a complex of numerous sloughs. For lowland streams in both States, the area and volume of standing water and interaction of the stream with its flood plain was great before they were cleared and channelized by pioneer farmers (U.S. Congress, House, 1848).

In the rivers and stream channels themselves, the record shows that fast turbulent rivers as well as low-gradient rivers, regardless of alluvial or bedrock control, had large amounts of wood influencing their channels. The lower Siuslaw River and lower North Fork Siuslaw River were so filled with fallen trees that explorer-trappers in 1826 were unable to explore much of these river systems (Ogden 1961). The Willamette River between Corvallis and Eugene flowed in five separate channels in 1870 (Report of the Secretary of War 1875). The Captain of the Portland district reported that the "obstacles were so great above Corvallis" and that the river banks were heavily timbered for a distance of 1/2 mile on either side. In a 10-year period, over 5,500 snags and drift trees were pulled from a 50-mile reach of river, and the river was confined to one channel by engineering activities. These trees ranged between 5 and 9 feet in diameter and from 90 and 120 feet long (Report of the Secretary of War 1875). Table 1 is a partial list of rivers in Oregon and Washington that were completely blocked in their lower main channels by drift wood. The Skagit River drift jam was 3/4 of a mile long and 1/4 mile wide. The Stillaguamish River had six debris-jam closures from the head of tide to river mile 17. Snags were so numerous, large, and deeply imbedded in the bottom that a steam snag boat was required to operate for 6 months to open a channel 100 feet wide on the Stillaguamish (Secretary of War 1881). Another lower gradient stream system, the North River, had 11 drift jams along the main river system (fig. 1).

Drift jams in high-gradient systems often set up where the channel gradient decreased abruptly; the Nooksack River is an example (fig. 2). Of the South Fork Nooksack, Morse (1883) wrote:

"...we came to a place where the river, during freshets had ground sluiced all the earth away from the roots of the trees, and down some 6 feet to the gravel. This covered a region of country a mile in width by five in length. Overgrown yellow fir timber had once covered most of that section. If the river below there was only clear of jams that place would be a paradise of hand loggers. On the gravel lay many million feet of sound fir timber, which only needed to be junked up during the summer and the winter freshets would float the logs down to the sea. Immediately below this place, the jams first extend clear across the river, and for the next 20 miles there is a jam across the river nearly every mile."

These illustrations are important because large woody debris is currently thought to play a minor role in larger rivers. Most large wood is randomly spaced in very small streams (1st and 2d order) because flow volume is insufficient to float and transport large logs downstream. Intermediate-sized streams (3d to 5th order) have lesser amounts of wood. Large wood typically occurs in distinct accumulations where major, immobile logs, channel constrictions, or other conditions provide persistent sites for accumulation of small and intermediate sized debris moved downstream at high flows. The larger streams or rivers (6th to 8th order) generally have most of their debris on the flood plain or on the outsides of bends (Swanson et al. 1976, Swanson and Lienkaemper 1978). The large wood in rivers is about 3 percent of that found in small streams on an area basis (Naiman and Sedell 1979, Franklin et al. 1981). The historical record shows that even in big rivers, large wood contributed significantly to in-channel structure that trapped sediments, ponded water, and created many side channels and sloughs.

Table 1.--Partial list of rivers in Oregon and Washington that had drift jams completely blocking the channels for 100-1500 meters in the mid 1800's (Reports of the Secretary of War 1875-1899).

Oregon	
Tualatin	Wilson
Yamhill	Trask
Lukiamute	Clatskanie
Necanicum	Nestucca
Long Tom	Pudding
Willamette	
Washington	
Nooksack	Puyallup
Stillaguamish	Black River
Skagit	Chehalis
Samish	Satsop
Snohomish	North
East Fork Quinalt	Quilicene
Most Gray's Harbor Rivers	Duwamish
Most Willapa Bay Rivers	Nisqually

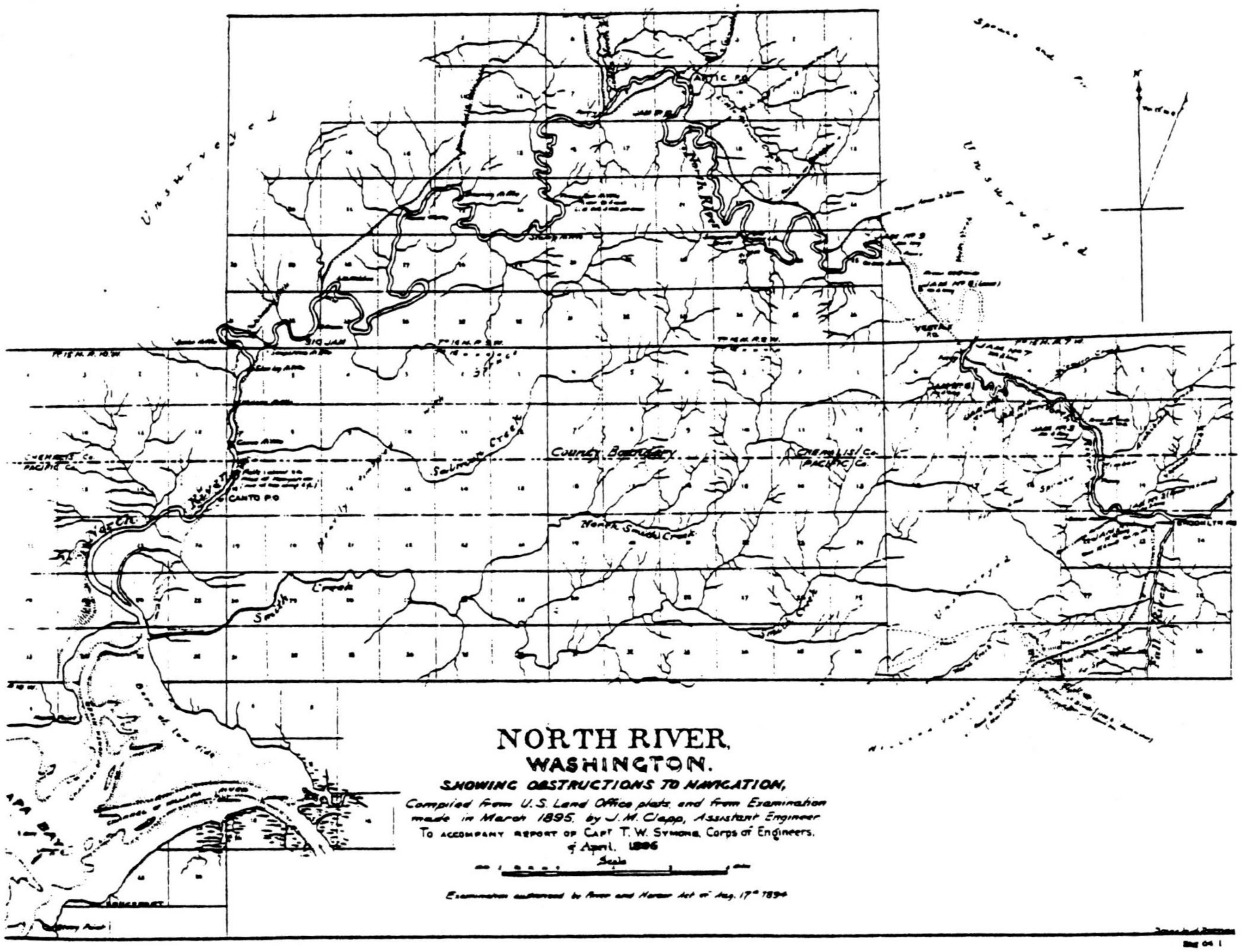

Figure 1.—Map of North River, Washington, showing 10 drift jams in the upper part of the basin. Before logs could be driven on the North River in 1896, these drift jams had to be removed. They were removed by 1898 (Reports of the Secretary of War 1896, 1899).

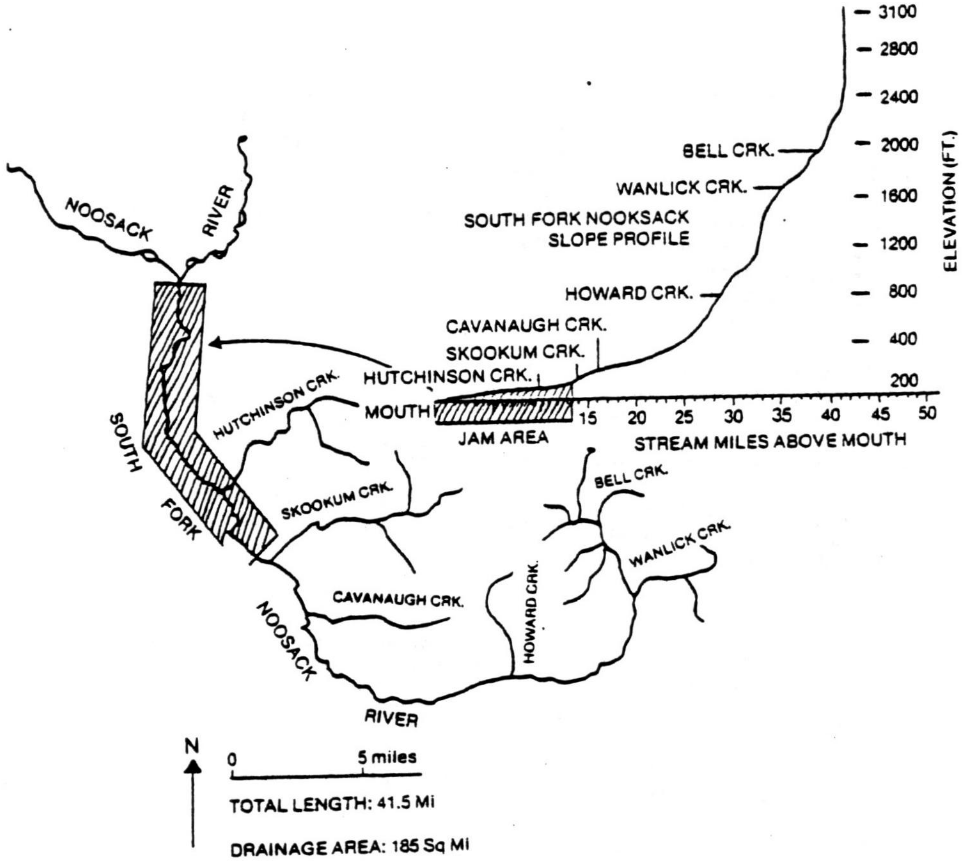

Figure 2.--Location of drift jams on the South Fork Nooksack River, Washington. Area prone to drift jams was reported by E. Morse (1883). When the gradient of the river decreased, the drift jams formed. The Nooksack represents a typical high-gradient river in the Pacific Northwest.

MANAGEMENT ACTIVITIES AFFECTING LARGE ORGANIC DEBRIS IN OREGON AND WASHINGTON STREAMS

The Pacific Northwest has a 150-year history of cleaning woody debris and boulders out of streams. The sequencing of various activities is illustrated in table 2. Farming and initial removal of drift jams were the first order of business in the mid-1800's. Rivers were the only highways for transporting goods and supplies in and out of the interior from the seaports. During this time, many rivers in Washington and Oregon were not only cleaned of woody debris, but the pulled snags were used to dike off sloughs and side channels to consolidate the main channel. Thus, supply boats could use the rivers for longer periods during the low-flow season.

Recent research has shown that side channels are the most productive habitats for salmonids in large rivers (Sedell et al. 1980, Yuska et al. in press). In the pristine South Fork Hoh River, they found that the greatest standing crop of salmonids occurred in side channels and spring-fed flood-plain tributaries. The main river channel, despite the large surface area, has the lowest salmonid densities and biomasses. Yuska et al. (in press) found that these side-channel and terrace-tributary habitats accounted for 6 percent of the total salmonid habitat available on the South Fork Hoh and reared about 70 percent of the potential smolts from the basin. For the Upper Queets River system, side channels and terrace tributaries accounted for about 23 percent of the available fish habitat and 54 percent of the potential coho salmon smolts. Both Sedell et al. (1980) and Yuska et al. (in press) reported that large woody debris was important in creating, stabilizing, and providing excellent cover in these productive habitats.

Table 2.--Chrono-sequence of disturbance to fish habitat in the Northwest.

- Early settlers in Willamette Valley and Puget Sound - 1848-80: snagging and millponds, small-scale localized clearing on lower rivers and main rivers for transportation.
- Corps of Engineers and timber companies "river and stream improvement for navigation" - 1880-1905: Very intensive and extensive:
  - Bowlder (sic) blasting
  - Debris removal
  - Splash damming and sluicing
- Ditching and draining - 1870-1920.
- Logging into streams - 1920-50's: Road building along streams.
- Diking and WPA snag and brush removal - 1930's-40's.
- Road building mid-slope and ridge tops - 1940-present: Road failures increased. Smaller tributaries in headwaters adversely affected by sluicing and large debris jams.
- Forest Practices Act Oregon - 1972, and Washington - 1976:

  A. Overzealous debris cleanup in 1st-and 2d-order streams, as well as intermediate-sized streams.

  B. Leave strips salvaged as quickly as they are undercut or blown down.

  C. Debris-jam removal as the primary fisheries habitat improvement activity.

Log Drives and Splash Dams

The timber industry was well underway by the 1860's as the California gold rush provided an economic demand for timber. The State of Washington, with excellent ports in large estuaries (Grays Harbor, Willapa Bay, Puget Sound), was the first to initiate its timber industry. By 1880 the land along the western banks of Puget Sound and all around Hood Canal had been cleared of trees for 2 miles inland and up to 7 miles around the major streams and rivers (Buchanan 1936).

Log driving is simply the process of transporting logs by floating them in loose aggregations in water with the motive power supplied by the natural or flushed streamflow. First, all timber within easy access of the stream was cut and floated down the adjacent river. If timber was too far to be profitably hauled by oxen to the mill or stream, the logger moved to another location. Gradually, loggers had to go greater distances for the timber, which introduced the use of river landings, log yards, log driving, rafting, towing, and booming. Still later, the more distant timber required the use of splash dams and sluiceways, expensive stream improvements, canals, tramways, trestles, log chutes and slides, trucking, and railroads for floating and driving.

Streams of all sizes had to be "improved" before a log drive could begin. Principal forms of stream improvement were as follows (Brown 1936):

- Blocking off sloughs, swamps, low meadows, and banks along wider parts of the streams by log cribbing, to keep the logs and water in the main stream channel.
- Boulders, large rocks, leaning trees, sunken logs, or obstructions of any kind in the main bed had to be blasted out or removed during periods of low flows. Obstructions or accumulations of debris--such as floating trees, brush, and rocks--often caused serious and expensive log jams during the driving seasons. Frequently, small low-gradient streams were substantially widened during log driving, as a result of the frequent flushing of the stream by splash dams and by the impact of the logs along the streambank.

The records of stream cleanup and improvement in the Northwest come from pioneer interviews, county court records, State court records, and U.S. Army Corps of Engineers reports. An example is from the Samish River, Washington, 1880, as told by E. E. Watkinson: "Since two logs had never been driven down the Samish River before, E. E. and Milbourne Watkinson began the backbreaking task of cleaning out the river which was then a network of sloughs, islands and jams with no main channel. For the purpose several indians were hired. Islands were cleared of brush which was towed ashore on a slab raft and burned. During this campaign the river was cleared from about 2 miles above Allen to saltwater" (Jordon 1962). The length of river was just a few miles and took 4 months to clear.

Court records also give good accounts of activities to clear obstructions on different rivers and streams. East Hoquiam Boom and Logging Company vs. Charles Nelson (1898) describe the continued improvement of the stream "by removing fallen trees, snags, roots, jams of logs and other obstructions" from the "narrow, crooked streams varying in width from forty to a hundred and fifty feet and containing numerous shallows and sandbars" (p. 143). "It also appears that the annual expense of keeping the streams clear of obstructions, so as to enable the logs to be floated, thereon, between plaintiffs upper dam and tide water, amounts to hundreds of dollars" (p. 145).

By 1900, over 130 incorporated river and stream improvement companies were operating in Washington. The distribution of major splash dams in western Washington and western Oregon is illustrated in figures 3 and 4. Over 150 major dams existed in coastal Washington rivers and over 160 splash dams were used on coastal and Columbia River tributaries in Oregon. The splash dams shown represent only the main dams that operated for several seasons. On many smaller tributaries, temporary dams were used seasonally, but no record was kept. Wendler and Deschamps (1955) were mainly concerned with these dams as obstacles to fish migration. Many were actually barriers, but the long-term damage was probably caused by the stream improvement before the drive and the scouring, widening, and unloading of main-channel gravels during the drive.

Small streams were heavily impacted by cedar logging, which occurred many years before clearcut harvest. Because cedar was used for shingles and not just lumber like Douglas-fir, it could be cut up into small bolts (< 1 m lengths). They could then be driven down very small streams. "By taking out shingle bolts from inaccessible localities far from the mills and driving them down streams impossible for logs, it is possible to utilize overmature cedar that would deteriorate before general logging on the tract was possible" (West Coast Lumberman 1914). Much of the best and most plentiful cedar timber occurred along streams in Puget Sound and in rich, moist, coastal valleys; it was exploited more rapidly than Douglas-fir. Even for driving cedar bolts, small streams had to be cleared of fallen trees, big boulders, and rooted vegetation in the channels. Streams were maintained clear of obstructions until the cedar logging in the drainage was completed.

Snag boats operated on Puget Sound streams from 1890-1978 and generally averaged 3,000 snags a year for a total of 200 miles of snagging in the Skagit, Nooksack, Snohomish, Stillaguamish, and Duwamish Rivers. The Coquille River system in Oregon started a county snagging operation in 1890, which continued to operate until the early 1970's.

During the 1930's when the WPA was active, most of our lowland streams were cleared of brush, particularly in agricultural areas. After every major flood, and particularly after the Federal Flood Control Act of 1936, funds were made available to clean almost any size stream in any locale.

Clearing of streams and rivers for passage of boats and logs has reduced the interaction of the stream system with its flood-plain vegetation. Draining, ditching, and diking of valley bottoms and lowlands has also reduced terrestrial-aquatic interaction. Flood-control levees have insured that complex sloughs and side channels, which are valuable rearing areas (Sedell et al. 1980), are reduced or eliminated.

Removal of Fish Barriers and Debris Jams

Stream cleanup of debris jams to benefit fisheries was initiated on a major scale in the late 1940's and early 1950's in Oregon and Washington. In the late 1950's and early 1960's, the California Department of Fish and Game conducted a program to remove old log jams on nearly every major coastal river that supported anadromous fish (cited in Hall and Baker in press).

During this period, log and debris jams and loose aggregations of debris with the potential to form jams were cleared. This was a period of timber harvest abuses and excess of unstable slash in streams. The result of the programs for debris-jam removal, however, was to put fishery biologists into the position of being river engineers, a role they were not fully equipped to carry out. In general, debris in streams was negatively viewed, as:

- An accumulation that would either hamper fish passage upstream or downstream, or block it altogether;
- A potential source of material for the consolidation of larger jams (with the same results as above); or

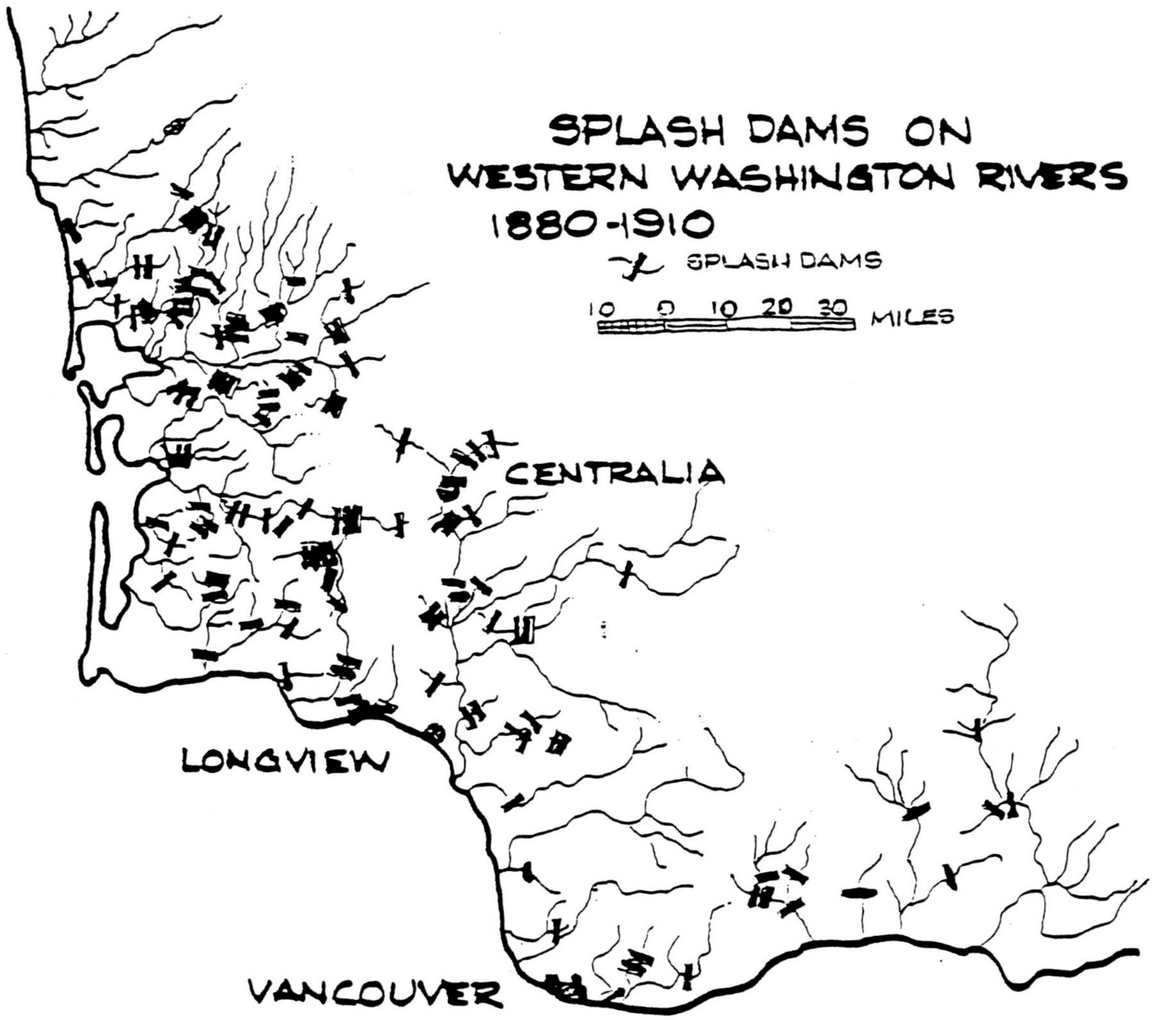

Figure 3.--Splash dams operating on western Washington rivers from 1880 through 1910. Data derived from Wendler and Deschamps (1955); Bryant (1949), and U.S. Army Corps of Engineers reports on file at Portland District Office.

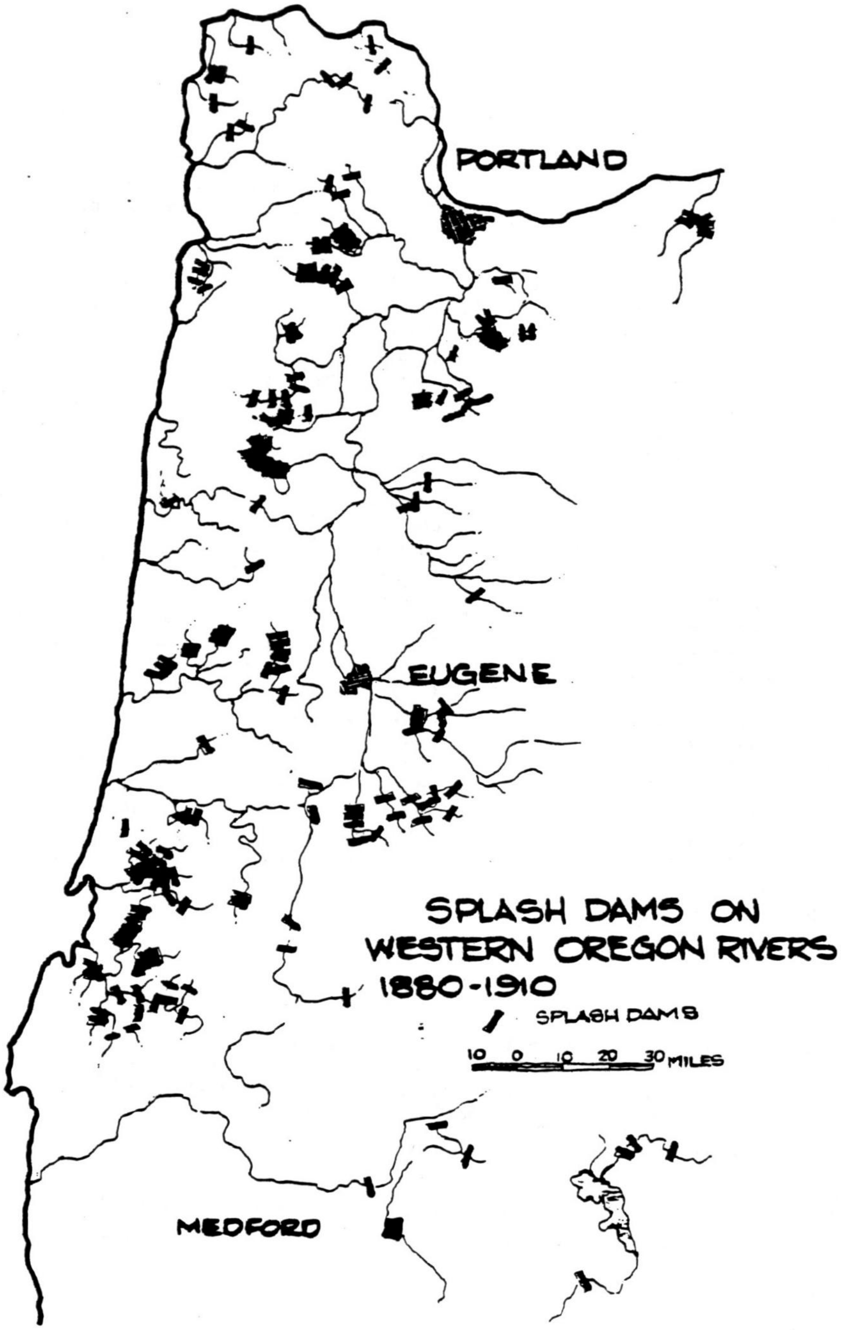

Figure 4.—Splash dams operating on western Oregon rivers from 1880-1910 (some on the Coos Bay rivers operated until the mid-1950's). Data was derived from research and reports by Dr. James E. Farnell of the Division of State Lands, Salem, Oregon.

- A potential source of channel destruction by scour resulting from jam failure during a storm event.

In the extreme cases during the 1940's and 50's, all of the above fears were well founded (McKernan et al. 1950, Gharrett and Hodges 1950).

Determining the historic magnitude of the debris jam problem or the historic distribution and abundance of jams in a basin is difficult. We studied old stream-survey records from the Oregon Fish Commission dating from the late 1940's and early 50's (Gharrett and Hodges 1950) for the Tillamook Bay rivers and the Coquille River system. In the Coquille River system, about 28 percent of the length of potential fish-producing streams was inaccessible to migrating fish. Natural bedrock blocks accounted for a little more than 16 percent of the total, and debris jams accounted for 12 percent. For all of the tributaries of Tillamook Bay, 26 percent of the length of fish-producing streams were blocked. Blocks from natural bedrock falls accounted for 6 percent of the total and debris jams, 20 percent. Many blocks in tributaries to Tillamook Bay resulted from salvage operations related to the Tillamook Burn of 1933.

Using USDA Forest Service low-flow stream surveys in the late 1970's from the Mapleton District in the Siuslaw National Forest in western Oregon, we calculated length of fishbearing streams (< 10-percent gradient) blocked by over 200 jams (table 3). Only 5.5 percent of the total miles of streams were blocked, and nearly all of the blocked area was in small streams at gradients between 5 and 10 percent. In coastal Oregon and Washington, very little rearing and spawning occurs in such high-gradient systems.

Fishery-management agencies have used explosives and heavy equipment to remove thousands of jams over a 40-year period. Land management agencies have also made removal of debris jams the focus of their programs for enhancing fish habitat. Until recently, up to 90 percent of the funds for fish-habitat work went for removal of debris jams. Little thought was given to rearing-habitat requirements of salmonids, or the impacts of releasing sediments downstream in large pulses. Full or partial barriers were thought to be such obvious negative factors that their actual role in stream ecology was not adequately defined or investigated. As a result of debris jam removal and the addition of fish ladders, more miles of streams in western Oregon and Washington are probably now available to migrating fish than were available 100 years ago. We question whether the bulk of funds for fish-habitat improvement should continue to be spent on improving 5 to 20 percent of the mileage in high-gradient streams of the upper watersheds, when 80 to 95 percent of the stream mileage at lower gradients within the basin is available to migrating fish, and is lacking in habitat complexity necessary to rear many salmonids.

Table 3.--Length of stream blocked by log jams in different-sized basins in the Mapleton District of the Siuslaw National Forest, western Oregon (data provided by M. Parsons, Siuslaw National Forest).

Basin size (km^2)	Mean basin area (km^2)	No. of streams	Mean stream length (km)	Mean stream blocked (km)	Percent blocked
5	4.6	7	5.2	1.1	22
6-12	9.1	12	9.2	2.1	22
13-25	17.5	8	12.7	0.5	4
26-100	38.0	7	31.4	1.6	5
100	129.5	1	27.0	0	0

LARGE WOODY DEBRIS AND FISH HABITAT

The important role large woody debris plays in creating and maintaining spawning and rearing habitat has been recognized and documented by researchers only within the last 10 years. In streams of the Idaho Panhandle National Forests, large wood forms 80 percent of the pools found in streams between 1-and 6-percent gradient (R. Rainville, Coeur D'Alene, Idaho, personal communication). The earliest descriptions of the role of big wood in streams came from Swanson et al. (1976) and Swanson and Lienkaemper (1978), who recorded amounts of wood in streams and documented that debris torrents tended to set up when the stream gradient flattened to 3 to 4 percent.

Bisson and Sedell (in press) examined several streams in western Washington to compare population biomass in streams flowing through old-growth forests with those in recently clearcut areas. Although total salmonid biomass increased, species shifted from a mix of salmonid species to a predominately aged 0+ steelhead population. Coho salmon and 1+ and 2+ cutthroat trout were proportionately less abundant in the clearcuts. These authors related the shifts in composition of species and age group to habitat changes that accompanied timber harvest and debris removal from the channel. They found the frequency of large, stable debris had declined and unstable debris had increased after passage of the 1976 Washington Forest Practices Act, which mandated immediate debris removal after logging. Pool volumes appeared to decrease and riffle volumes to increase after clearcutting and channel clearance. The frequency (number per kilometer) of both pools and riffles appeared to decline in clearcuts, thus suggesting that normally stepped stream profiles had been altered to a more even gradient.

Pool volume has been documented by Nickelson et al. (1979) as being directly related to coho biomass in Oregon coast streams. Bustard and Narver (1975b), Everest and Meehan (1981), and Bisson et al. (this volume) found dammed pools and backwaters to be used by coho and large cutthroat trout.

Wood debris as a preferred cover for salmonids is thoroughly covered by Bisson et al. (this volume). Bustard and Narver (1975a) documented the preference of yearling steelhead for large debris, and both Osborn (1981) and June (1981) have shown that older cutthroat trout rely heavily on large wood debris for cover. The association of coho salmon with wood debris has been previously demonstrated by Lister and Genoe (1979), Bustard and Narver (1975a, b), and Toews and Moore (1982). The important role of large wood in large, high-gradient river systems, such as the South Fork Hoh River, was mentioned previously (Sedell et al. 1980, 1982).

Mullen (1981a, b) estimated coho salmon escapements to be nearly 1 million fish in the early 1900's and remained around 3/4 million in the 1930's. Coastal coho spawning escapements were believed to be less than 100,000 in 1977 and 1978 (Oregon Department of Fish and Wildlife 1981). The exact cause of the decline cannot be determined because concurrent influences are operating. Three primary influences, habitat alterations from timber harvest, commercial fishing, and ocean upwelling patterns, could have caused the large drop in escapements in the last 20 years (McKernan et al. 1950, Oregon Department of Fish and Wildlife 1981). We can reduce fish harvest and improve habitat, but not much can be done at present about improving coastal upwelling. Recent research and historical descriptions of rivers and streams that correlated with large anadromous fish runs strongly suggest that large wood in streams was an important habitat component in all sizes of streams; we can still manage streamsides to provide trees and large woody debris to the stream.

DISCUSSION AND CONCLUSIONS

What does the documentation of historical characteristics of streams and the history of channel cleanup mean to fisheries managers today? One, the historical record indicates many boulders, fallen trees, sloughs, and in-channel vegetation, and large numbers of fallen trees in river channels. Two, abundant salmonid populations were associated with these pristine rivers, from which we infer complex habitat resulted from these in-channel structures. Three, managers have been preoccupied with removal of debris jams in the upper parts of basins where the gradient is steep. Such activities effectively channelize streams right up to the headwalls. The 70 to 90 percent of basin stream lengths available to migrating fish are areas where anadromous fish can be increased significantly, but habitat improvment in these areas has been underemphasized.

Improving fish habitat using large wood will not be easy because the long-term stability of woody debris in many streams cannot be accurately predicted. Many hydrologists and fishery biologists will continue to recommend removal of potential jams and big merchantable trees because of risk to downstream bridges or culverts and not because of fish habitat. Leaving debris in place has a high probability of enhancing rearing and spawning habitat for salmonids--if not in the original location, then maybe around the bend after a storm. Rivers are dynamic, and fish evolve within their physical and chemical constraints. Predicting with certainty the stability of debris at a point in space will only occur if the stream is "trained" throughout its entire length. Dam construction, bank revetments and levees, and channelization efforts have shown the obvious: whenever you tinker with a stream, it makes an adjustment to the new change. These natural adjustments may not be compatible with basin-wide efforts at habitat improvement. Deciding to remove upper-basin debris dams should be made with great care and thought. The potential for sluicing downstream habitat must be weighed against the potential release of large pulses of sediments to downstream areas after removal. When in doubt, leave jams in, because in time they could well become a source for downstream habitat complexity.

Emphasis should be placed on restoring habitat complexity to channels of 4th to 7th-order streams. Bigger fish rear in these waters as compared to small streams (Skeesick 1970; Yuska et al. in press; Fred Everest, Corvallis, Oregon, personal communication). Over 70 percent of productive stream lengths are available to migrating fish, yet very little money or effort has been expended to restore or improve these rearing and spawning habitats. At the same time, we must renew efforts to improve road building, landing locations, road maintenance, and good land stewardship to protect existing habitat in small streams.

We cannot expect to restore wild stocks of salmonids when present habitats appear to be so unlike their historic conditions. Until we incorporate the structure of undisturbed habitats, like those where wild stocks developed, and understand the sequence of changes that have occurred in those habitats, our present protection and enhancement efforts will continue to lack both a rational context and effective direction.

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