

The Role and Management of Woody Debris in West Coast Salmonid Nursery Streams

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ABSTRACT

Debris removal is a frequently used management technique for small streams in logged watersheds, but many stream-cleaning techniques overlook important habitat requirements of juvenile salmonids. Reviews of some past management practices show little systematic evaluation or monitoring of physical or biological effects. A review of several studies (most of them not associated with debris removal) shows the importance of woody debris as salmonid habitat. The role of organic debris in small stream systems is discussed and a set of criteria for debris removal is proposed.

Small streams in the Pacific Northwest and southeast Alaska are an important link in the production of anadromous salmonids but, because of their small size and discharge, they have not always been recognized by resource managers as fish-producing streams. As a result, they often have been ignored during the planning of timber harvest and have received large amounts of logging residue ranging in size from needles to whole trees. With recognition during the early 1970's that these streams are important salmonid nursery areas, measures have been taken to correct apparent past damage and protect streams during logging operations (U.S. Department of Agriculture 1978). The most common treatment has been to remove all debris associated with logging.

The streams in this discussion are primarily small salmonid nursery streams supporting coho salmon (*Oncorhynchus kisutch*), Dolly Varden (*Salvelinus malma*), cutthroat trout (*Salmo clarki*) or rainbow-steelhead trout (*Salmo gairdneri*). These are often first- or second-order tributaries to main streams with an average gradient less than 5% and summer discharges often less than 0.9 liter/second. The discussion also includes larger systems used by pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*Oncorhynchus keta*) for spawning; however, debris management and removal guidelines discussed here are directed primarily toward the small nursery streams.

The objectives of this paper are to (1) discuss past and current management of woody debris-

primarily logging residue, (2) summarize the role of woody debris and its effect on salmonid habitat in small streams, and (3) present some general guidelines for debris management in anadromous salmonid streams of the western United States.

PAST AND CURRENT MANAGEMENT OF WOODY DEBRIS

Debris removal from streams is not a recent management practice. Sedell and Luchessa (1981) document cleaning and snag removal in streams and rivers throughout the United States. Historically, navigation channels in larger systems were maintained by snagging. In smaller streams, particularly in the Northwest, debris was extensively cleaned for log drives and little concern was given to salmon production (Sedell and Luchessa 1981). Logging debris in small streams was not considered. In the past 30 years, debris management has been directed toward salmonid production, although snagging for navigation and flood control still continues (McConnell et al. 1980).

When west coast salmon became recognized as an important and limited resource, debris management was implemented. At first, management was concerned with fish passage (Merrell 1951) and water quality (Narver 1971; Ponce 1974). Merrell (1951) and Holman and Evans (1964) discussed some of these projects which entailed heavy equipment and removal of large jams. More recently, Baker (1979) considered partial removal of log jams and studied in more

detail some of the effects of removal on fish habitat.

As small streams in southeast Alaska and in the Pacific Northwest were recognized as important nursery areas for juvenile coho salmon, efforts to "repair" logging damage by removing logging debris were initiated. The usual prescription was to remove all logging-associated debris (Sheridan, W. L. 1973. Cleanup of Anadromous Fish Streams. USDA Forest Service, Region 10). Often these projects were on streams logged 8-10 years earlier. During the period between logging and treatment, most of the volatile material and many of the fine organics were flushed out of the stream, leaving the larger material that the stream accumulated in the streambed and along the bank. As this material is removed, a new period of instability is induced accompanied by streambed scour and bank cutting (Beschta 1979).

In southeast Alaska, debris was recognized as important habitat for juvenile salmonids and it was generally removed without regard for the stability of the material or its potential as habitat (see Sheridan cited above). In some areas, debris removal has become more selective, and in certain cases larger pieces were left. Present guidelines for logging practices in Alaska require that logging slash be removed from streams 48 hours after deposition (U.S. Department of Agriculture 1978). Removal of older debris was not addressed. The present trend is to deal with each stream on a case-by-case basis, but systematic procedures have not been applied.

SOURCES OF ORGANIC DEBRIS AND EFFECTS ON CHANNEL MORPHOLOGY

Woody debris enters streams as a result of natural events such as tree mortality, winds, bank cutting, mass soil movement (Keller and Swanson 1979), and human activities such as logging and road construction. In timber harvest areas, felling, bucking, and yarding in and around streams contributes large amounts of woody debris. Clearcutting and road construction also may induce windthrow by exposing timber edges sensitive to wind.

Keller and Swanson (1979) listed biological agents (tree mortality caused by disease or insects) and physical agents (blowdown, streambank cutting, and debris avalanches) as the primary natural causes of large organic debris inputs to streams. The rates of entry and type of ma-

terial within those categories differ. In the case of tree mortality, inputs are sporadic and relatively sparse along the course of the stream. Trees entering the stream as a result of bank cutting may be sound, and usually the root wad goes with the tree into the stream. Again, this type of material is usually sparsely distributed along the stream. Inputs resulting from bank cutting may increase as a result of wind or may induce additional blowdown by opening the forest canopy. In either event, windthrow may consist of one or several trees. Under natural conditions, a dozen or more trees may be criss-crossed over the channel. Many of the trees may be above the channel, dropping down into the stream over a number of years. Large trees may be anchored in or along the bank by root wads which, along southeast Alaskan streams, may be as much as 2-3 m in diameter. Usually, this material enters during storms that tend to flush out fine particulate matter rapidly and reorient unstable material into a relatively stable alignment within the stream. Therefore, readjustment of stream morphology is fairly rapid following the natural input of large organic material.

Because trees entering the stream as a result of mortality from insects or disease may be partially decomposed, their residence time will be shorter than sound green trees entering as a result of bank cutting or blowdown. The partially decomposed tree will be more apt to shatter on impact and will be more easily processed into the carbon cycle of the stream system. The net result will be a more rapid assimilation into the biological cycle and potentially less effect on channel morphology.

Debris torrents may be a natural event or induced by land management activities. In either case, a large amount of organic and inorganic material enters the stream. The effects often tend to be severe when accompanied by channel scouring. On the other hand, as the toes of older slides are incorporated into streams, they may provide lower gradient plateaus which, in turn, form pool habitat for juvenile salmonids and store gravel for spawning areas in "sediment-poor" stream systems (Everest and Meehan 1981).

Debris deposited as a result of logging usually consists of branches, limbs, short boles, and some non-merchantable trees. Large intact trees usually were removed from the streams during logging. Nearly all of the material is from sound,

Table 2. Factors that contribute to the stability of large pieces of debris in streams.

Stability	Length of piece	Percent of piece anchored on bank	Percent of piece in water	Angle of orientation to Row	Location of anchor points
High	At least one-third greater than channel width	70	15	30°	Both ends
Moderate	Equal to or greater than two-thirds of channel width	30-70	15-40	30°-60°	One end on bank
Low	Less than two-thirds of channel width	30	40	60°	One end in water or not anchored

is given in Table 2. As the size of the stream and water power of the stream increase, larger material will be moved, and scour and erosion are likely to be greater. In smaller or lower gradient systems, these factors may not be as critical.

As a general "rule of thumb," remove as little debris as possible. It is usually easier to remove additional pieces later than to repair the damage of excessive removal. Removal methods may range from a running skyline log-yarding system to hand removal. The best method is usually the method that does the least amount of damage to streambank integrity. Removal criteria will depend upon the management objectives, and should be tailored to the specific system. In practice, treatment should be predicated on the condition of each stream and the objectives of debris

removal, explicitly stated before treatment begins.

Some general guidelines for removing debris from small salmonid nursery streams are presented in Table 3. After about 5 years, most of the fine material and small floatable material should be washed out. BOD should be reduced and most of the potentially toxic leachates will be flushed out. At gradients less than 4 or 5%, smaller material will tend to be more stable and fine material may accumulate in backwater areas. Both age and gradient values in Table 3 are used only as examples of setting criteria for treatments. Actual treatment should depend upon the specifics of the system.

Practices to avoid during treatment of nursery streams for coho salmon are removing small de-

Table 3. General guidelines for removing debris from small streams, based on age of debris and channel gradient.

Age of debris	Description	Recommended treatment	
		Less than 4% gradient	4% gradient or more
Less than 5 years	Whole tree not decomposed, but possibly split and broken. No evidence of invertebrate colonization. Material stabilized by weight, but usually not embedded in bank. Limb and needle material present in or above stream. Little sediment accumulation around material. Stream actively cutting around or under material.	Remove all accumulations of needles and needle-bearing branches up to 10 cm in diameter. Leave material larger than 10 cm unless it is loose or completely blocks flow or fish movement; then remove parts of block. Do not destabilize the material. Cut green branches trailing in streams.	Proceed as for gradients of less than 4%. In addition, remove loose, floatable material that may be moved during high flows.
More than 5 years	Whole tree may or may not be decomposed, split, or broken. Some evidence of colonization if submerged. May be stabilized by association with bank or embedded in bank or stream bottom. Limb material may be present, needles absent. Sediment may be accumulating behind in-stream material. Flow patterns around pieces established.	Remove loose material smaller than 10 cm in diameter and dense accumulations of fine organic material. Thin small branches attached to in-stream and suspended trees but leave trunks.	Remove loose, floatable material and dense accumulations of fine organic detritus.

bris dams, and notching or completely cutting through stable logs across stream channels. Large material that creates upstream pools should not be removed or cut. Avoid practices that tend to reduce pool habitat. Because of the possible detrimental effects of increased BOD and toxic leachates, fine green organic material (such as needles and bark) should be removed from streams as soon as possible.

The best solution is to prevent material from entering streams during logging. In most cases, directional felling and yarding away from streams is required. Full suspension is required when logs are yarded across streams. This policy not only keeps most of the fine material out of streams but also maintains the integrity and stability of streambanks. Although new large debris may promote local instability of streambanks and streambeds during the first year by causing channel cutting, selected large material creates flow deflectors, dams, pools, and cover. Large streamside trees which will eventually fall into the channel are the source of this material. After several years, large material will stabilize as the channel reforms around pieces embedded in the streambed and bank. Therefore, an important consideration is to leave at least some streamside timber.

Decisions in debris treatment frequently are subjective because information on the effects of treatment and response of streams is scarce. Because most decisions are subjective, follow-up evaluation must be part of debris-removal projects. Monitoring effects of the treatment is as important as pre-treatment planning. It can help avoid continuation of past errors and improve future management of debris.

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