A Guide to Placing Large Wood in Streams

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"Stewardship in Forestry"

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Introduction

The 1994 Oregon Forest Practices Rules allow landowners to lower their leave-tree requirements in riparian management areas by placing large wood in streams. The leave-tree reduction is given as a "basal area credit." This publication tells how to place wood in streams to receive a basal area credit.

If a proposed woody-debris placement project meets the Oregon Department of Forestry (ODF) guidelines presented in this publication, the project requires prior approval of a written plan only from the local Forest Practices forester.

Other stream and riparian area projects can be done to reduce the riparian leave-tree requirement. These other projects require consultation with and approval from the Oregon Department of Forestry in consultation with the Oregon Department of Fish and Wildlife (ODFW).

The effect of large wood on streams

In the last 20 years, we have learned that large wood is an important part of the forest stream ecosystem and is critical to the survival of trout and salmon that inhabit the streams. Woody debris diverts water flow, creating pools and providing cover. In the past, large wood's role in forming stream habitat was not understood or was ignored. In some smaller streams, splash dams were built to drive logs down to larger bodies of water. After a splash dam was opened, a large torrent of logs and other materials would move down the stream channel, often scouring it and removing all woody debris. Also, logging operations in the past typically cut right to the edge of the stream, depriving the stream of wood input from the adjacent riparian area. Over time, this lack of input can cause a depletion of wood in the stream. Streams also were cleared of large wood for navigation and to improve fish migration.

Pristine and managed streams vary a lot in their debris content, depending on their geographic location, fire history, time since debris flows, and time since floods or windstorms.

Past efforts to place large woody debris

There have been many attempts to add large woody debris to streams, beginning in the 1930s with the help of Civilian Conservation Corps work crews. In the Midwest, many of these efforts have led to documented increases in fish production. However, many of the past efforts in the Pacific Northwest have not increased fish production because the structures were not designed to handle the variation in flows and the greater stream slopes that occur in this region. For instance, stream flow on a typical July day has little or no bearing

on what the stream is capable of doing during channel-forming, high-flow periods. So, when planning a project or placing debris in the stream at low flow, it may seem that the debris is oversized for the stream when in fact it is not.

In the early 1980s, after managers in the Pacific Northwest understood the beneficial role large wood plays in fish habitat, they increased efforts to add wood to streams. These efforts emphasized creating pools to increase coho salmon smolt production, among other objectives.

In addition to wood placement, other channel alterations have been completed. They include creating off-channel habitat, placing gabions, and placing boulders and boulder berms. Other near-stream enhancement efforts include fencing out cattle, developing alternate water sources for cattle, and planting soil-stabilizing vegetation such as willows in the riparian area.

Placing large wood in streams for basal area credit

Stream suitability for large woody debris additions

In planning a placement project, the first step is to decide whether the stream next to the harvest operation is suitable for a large woody debris placement project. Three important questions are:

1. Is the stream fish bearing?
In order to qualify for the basal area credit, the stream has to be classified as fish bearing. Consult a Stream Classification Map, available from any ODF district office, to find out the stream's fish-bearing status.

2. Is the riparian area well stocked with conifer?
The basal area credit applies in riparian management areas that have basal areas greater than the "active management target." This stocking-level target varies throughout the state (see Oregon Forest Practices Rules OAR 629-640-100).

3. Does the stream meet width and slope requirements?
Larger and steeper streams have more stream power and so can lift and move large wood more easily. On steeper and larger streams, therefore, large-wood placement is more complex and may require more expertise. Figure 1 shows the limits for stream slope and bankfull width which, taken together, make for "ideal," "acceptable," or "unacceptable" placement. Basically, a stream with less than a 40-foot bankfull width and little to moderate stream slope is eligible for the kind of in-channel large woody debris placement work described in this publication. Figure 1 is based on literature review and experience. As placement projects are monitored, the guidelines in Figure 1 may be modified.

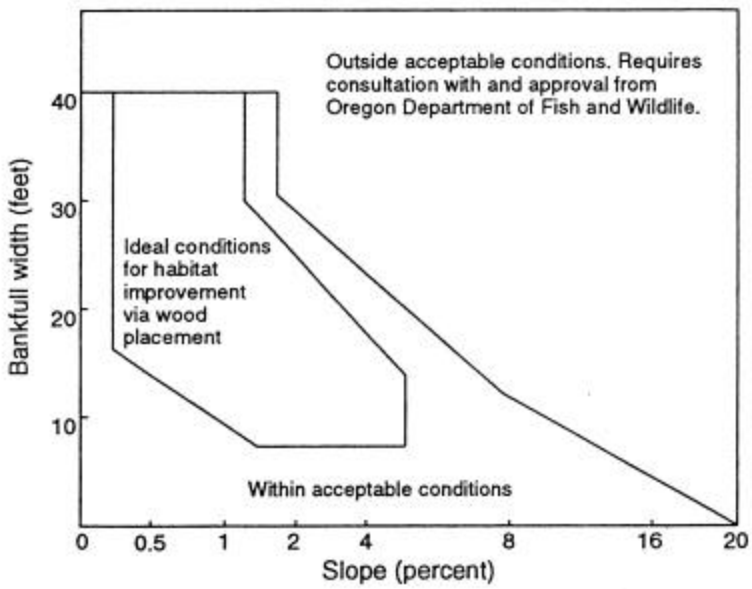

Figure 1. Stream slope and width dimensions that constitute "ideal," "acceptable," and "unacceptable" conditions for large woody debris placement under these guidelines.

Bankfull width is the width of the stream at bankfull flow, which happens every 1 to 2 years. Measuring bankfull width requires judgment in the field. In lower gradient streams and streams with little slope in wider valleys where the streams have not been incised (that is, cut down below the level of the surrounding land), the bankfull mark usually is where the bank slope changes from steeper to more gentle or even flat (see Figure 2, page 4). Unfortunately, most small streams that are candidates for placement work are either incised or confined by side slopes. In those cases, look for certain clues in order to find the bankfull flow mark on the bank. Abrupt change in vegetation is one good clue. Another is the level at which water-drifted material was left on the bank or on overhanging branches. Changes in rock color or in the growth of moss or lichen and abrupt changes in the texture of the bank material may also be clues.

Bankfull width is measured from one side bank mark to the other. The width of large islands that would be dry even under bankfull conditions should be subtracted from the bank-to-bank measurement. Measure bankfull width at 10 points, at least, along the part of the stream where the placement work will be done. Also, space width measurements one or two channel widths apart. Previous stream surveys, by the Department of Fish and Wildlife or by other agencies, may also be used to determine bankfull width. (The ODFW surveys describe bankfull width as "active channel width.")

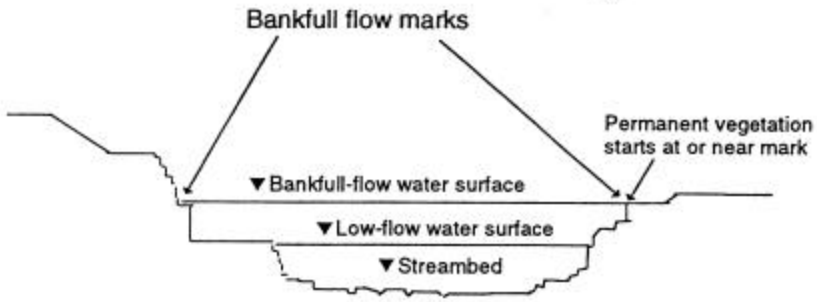

Figure 2. Location of bankfull width marks.

The potential effectiveness of large woody debris placement varies with the stream's slope and width. For instance, on low gradient or very small streams, even with log placement the available stream power may not be enough to change the stream's shape. In very steep streams with very large substrate material, log placement will have little impact because the substrate is usually immovable. Figure 1 outlines a "sweet spot" where the combinations of stream width and slope mean that large wood will have the greatest impact on physical habitat for fish. The streams whose measurements are within this "sweet spot" have enough slope and width to scour and deposit substrate material, yet probably still contain smaller material which can be moved around when large-wood placements change flow paths. In larger streams, too, log placement can have a lot of benefit, but the logs probably will have to be placed in groups or complexes and even anchored to prevent movement. This will require additional expertise. The landowner or operator will need to negotiate the basal area credit for that kind of installation with the Department of Forestry and the Department of Fish and Wildlife.

A large-wood placement project is likely to most benefit fisheries in streams that are poorly stocked with large wood. It is quite possible that a given managed stream already has enough large wood in it, and so it may be better to place wood in a nearby stream or stream reach that has little or no wood. Additionally, stream reaches closer to the mainstem stream are more closely connected hydraulically to the mainstem and are more likely to show a positive fish response to any habitat improvement.

Getting approval for basal area credit

For projects that meet these guidelines, the landowner can get basal area credit for the related harvest operation along the stream. In order to get credit, the landowner must have prior approval from the local Forest Practices forester administering ODF rules on the harvest operation involved. Information about the large woody debris source, number of pieces, and basal area to be placed in the stream must be in the written plan for the harvest operation, which will be given to the Forest Practices forester for approval. **The basal area credit can, at most, reduce the leave-tree retention requirement from the "standard"**

target to the "active management" target. (See Forest Practice Rules OAR 629-640-110.) The basal area credit applied to an operation will depend on the basal area of the material placed in the stream. Basal area can be determined using Table 1 or by the following equation:

Basal Area (in square feet) =
0.0055 x diameter (in inches) x diameter (in inches)

Table 1. Basal area of a log or tree by diameter class.

Diameter (inches)	Basal Area (square feet)	Diameter (inches)	Basal Area (square feet)
6 to 10	0.3	41 to 45	10.1
11 to 15	0.9	46 to 50	12.6
16 to 20	1.8	51 to 55	15.3
21 to 25	2.9	56 to 60	18.3
26 to 30	4.3	61 to 65	21.6
31 to 35	5.9	66 to 70	25.2
36 to 40	7.9	71 to 75	29.0

To determine the basal area of a bucked log, measure the diameter of the larger end. To determine the basal area of a tree placed in the stream with the rootwad attached, measure the diameter at breast height.

The basal area credit can be used only on fish-bearing streams (that is, those that the Oregon Department of Forestry classifies as Type F). The amount of credit varies with stream size.

- For each conifer log placed in the channel of **a large or medium Type-F stream, the basal area credit is twice the basal area of the placed log.** (Note that "large," "medium," and "small" are ODF stream classification sizes. See Oregon Forest Practice Rules OAR 629-635-200.)
- For each conifer log placed in the channel of **a small Type-F stream, the basal area credit is the basal area of the placed log.**

The Oregon Department of Forestry asks landowners and managers to participate in a study of how streams and fish habitat are affected when large woody debris is put in the streams. Participants fill out a monitoring form (see "Monitoring Forest Stream Enhancement Projects" published by the Oregon Department of Forestry). The information will be used to get a general picture of woody debris placement efforts. Then the department will select certain sites, in cooperation with landowners, for more study.

The stream in which large woody debris is placed need not always be the stream right next to the harvest operation. Streams in the immediate vicinity of the operation (and under the same ownership) could be the project site; the basal area credit still goes to the harvest operation. The timing of a stream improvement project also can be varied to best meet the conditions of the site, to protect fish present in the stream, and for convenience (see "Project Timing and Fish Survival," page 11).

If the project will make stream alterations not covered by these guidelines, the basal area credit will be negotiated between the landowner and the Oregon Department of Forestry in consultation with the Oregon Department of Fish and Wildlife (see "Other Ways to Earn Basal Area Credit," page 11). Contact the Oregon Department of Forestry well in advance so that necessary project planning can be completed before the operation.

Large-wood specifications and sources

Woody debris can improve fish habitat only if the wood is large enough to stay put and to influence water flow. Larger diameter wood retains its size longer as abrasion occurs over the years. Larger diameter wood is more effective in creating pools and complex channels which improve fish populations. Larger diameter wood pieces also generate increased basal area credit more efficiently because basal area is a function of the piece diameter squared and increases exponentially as diameter increases. The minimum diameter required for a piece depends on the bankfull width of the stream. Requirements are:

Bankfull Width (feet)	Minimum Diameter (inches)
0 to 10	10
10 to 20	16
20 to 30	18
Over 30	22

The length of a woody debris piece also is important to stability. A piece that is longer than the stream is wide is less likely to be carried away when the water is high. **To be eligible for basal area credit, debris pieces must be at least twice the length of the stream's bankfull width. If the rootwad is still attached, then the wood piece (including the rootwad) must be at least one and one-half times the bankfull width.** We also encourage leaving limbs and branches as well as rootwads on the logs placed. Often, the branches provide additional cover and stability.

Only conifer logs are eligible for basal area credit when placed in streams. Among conifers, cedars and redwoods are the most durable. Spruce, pine, fir, and Douglas fir have similar decay rates. Conifer logs can last from decades to centuries depending on whether they are fully submerged and on prevailing air and water temperatures. Hardwoods generally decay more rapidly; this is why they are not eligible for basal area credit.

Logs and trees to be placed in streams are best obtained from locations where their removal will not conflict with other valuable functions they might serve. Wood within the bankfull flow marks of the streambed cannot be used for placement. Wood within 20 feet of the bankfull flow marks of fish-bearing (Type F) streams may be used only with prior approval from the Oregon Department of Forestry. Usually, those trees should be reserved for shade and long-term large-wood supplies. However, if there are other trees that can fill those functions, streamside trees may be pushed or pulled over into the stream with their rootwads intact. Wood in the outer zone of the riparian management area can be used if not dedicated to another purpose such as conifer retention or snag/green leave-tree requirements. Down wood within the riparian management area should generally be kept for wildlife habitat rather than relocated into the channel. However, if there is a high density of cull logs that are not too badly decayed, they can be moved into the stream and are eligible for basal area credit.

If smaller diameter and/or shorter wood is placed in the stream, it must be bundled, anchored, or combined in complexes so that it creates desired fish habitat and is no more likely to move than a piece of the generally required length and diameter. Options to the standard specifications may be approved in a written plan by the Forest Practices forester in consultation with the Oregon Department of Fish and Wildlife. If you want to propose options, consultation with the Forest Practices forester should begin before you start preparing the written plan.

Placement strategies for large woody debris

Large woody debris can be placed almost anywhere and potentially benefit the stream ecosystem. However, **to be effective, part of the wood must be in the water preferably during low flows and definitely during high flows in order to create pools and cover that fish can use.** Large-wood placement also can serve more than one purpose. For instance, stable woody debris jams upstream from culverts and bridges can trap damaging debris as well as provide fish habitat.

Placing wood in various different positions in the stream can vastly change the effect. For instance, wood placed across the stream, against the streamflow, gives maximum scour (see Figure 3a, on page 8). It can also widen the stream if the stream has a low gradient (that is, a slope of zero to 2 percent). If bank stability is a concern, wood placed as a flow deflector often can stabilize a bank (see Figure 3b). If the stream has little sediment (usually, that is a stream with a slope of more than 4 percent), wood placed in a series of downstream or upstream V's often can store sediment to provide spawning habitat (see Figure 3c).

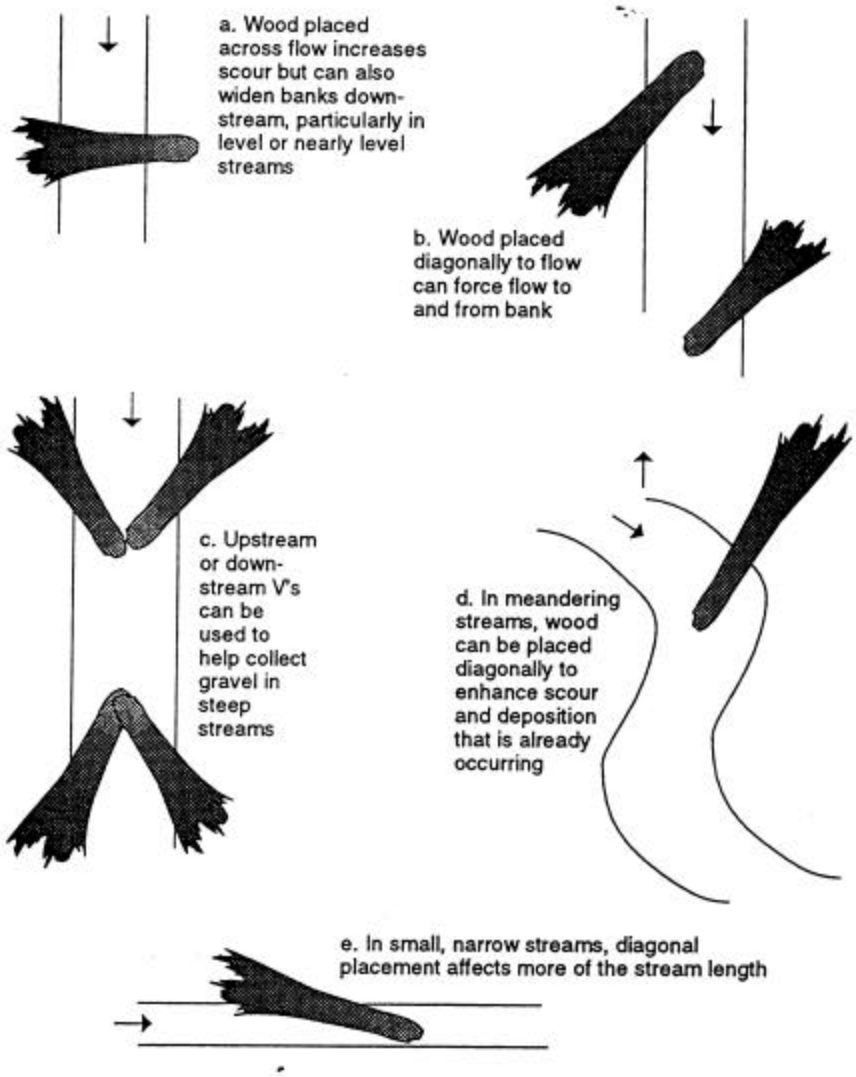

Figure 3. Effects of various placements of large woody debris.

As stream slope and size vary, so does the typical configuration of large woody debris and its effects on channel formation. In small, steep streams (less than 20-foot bankfull width and a gradient of 4 percent or more), large wood often spans the stream and creates plunge pools and a stepped profile (see Figure 3a). As gradient decreases (generally, to 2 percent or less) and stream size increases (to a bankfull width of 30 to 50 feet), flow deflection (see Figures 3b and 3d) and underflow (submerged jet) pools become more prominent. In larger streams (40- to 80-foot bankfull widths), debris tends to clump more, and the clumps provide larger pools and more cover than individual pieces.

Clearly, different strategies are required for different stream types. If the stream is meandering, with a low gradient and a lot of sediment, perhaps debris placed as shown in Figure 3d might be best. However, if the channel is steeper, perhaps a spanning log or a number of logs placed in a series of V's (as in Figure 3c) would be better. In small streams, laying a large log diagonal to the flow rather than across the flow may affect more of the stream length and provide more cover (see Figure 3e).

To anticipate what kind of large-wood placement project would be most effective is very site specific and requires experience. Often, stable wood already in the stream is a good indication of the minimum size needed for a particular project site and may also give clues to the kinds of habitat that different placements will create.

Large woody debris placements are particularly useful in these locations:

- Below the mouths of tributaries, particularly tributaries with less than a 5 percent gradient
- Floodplains, especially those with multiple braided channels
- Streams flowing through broad valley floors
- Near elevated streamside terraces where placed wood will back up water onto the terrace floodplain
- Below or within deep pools, to increase cover
- In natural or constructed side channels and off-channel alcoves
- At the heads of islands, to help stabilize the islands and to create side channels and backwater areas

Stream improvement is encouraged wherever the opportunity is available, as long as the risk of downstream damage is low enough. Wood placement in some locations is too likely to cause damage and should be avoided:

- Near high, actively eroding stream banks, where placement would aggravate the erosion
- Where the diverted flow would erode stream banks that define property boundaries
- Where the diverted flow would threaten buildings or other improvements such as pump houses, culverts, or bridge abutments

Judgment is important in selecting favorable sites and in avoiding sites likely to cause more damage than improvement.

Anchoring large wood for stability

We advocate that placement of large wood should be designed to achieve stability by virtue of the size and orientation of the pieces rather than by resorting to anchoring devices. In addition to using wood that is large enough, stability can by ensured by retaining rootwads, embedding one or both ends, entangling the pieces, placing the wood in the best positions, and cabling.

Natural or artificial anchoring is needed for the placed logs if wood movement cannot be tolerated. One natural technique is to embed the wood in the banks and/or streambed so that it will resist any movement. Another technique is to wedge wood between two standing trees on the banks.

When placing large wood, disturb soil as little as possible by using heavy equipment to force large wood pieces into streambanks rather than excavate soil to anchor wood. Operating equipment directly in streambeds requires prior ODF approval which is granted only when the benefit is greater than the disturbance. Often, equipment can be used from a distance; for example, placing wood with the long reach of a loader or placing large wood using a cable logging system that spans the riparian management area in an existing yarding corridor.

Placing large wood pieces near each other, whether attached by cables or not, can create desirable habitat complexes more quickly. Such groupings work together to more quickly trap additional woody debris, accumulate nutrients, provide cover, and store sediment.

It is desirable for the stream to redistribute the wood to some extent, as long as damage is avoided. However, movement of large wood must be limited so it is not carried downstream to damage road culverts, bridges, or other streamside improvements. Cabling may be used if the risk is great of downstream damage from a large debris washout. Use cable that is strong and durable enough. To anchor the wood pieces, secure one end of the cable to the pieces' larger ends, and secure the cable's other end to large standing trees or to a deadman structure. The best anchors are clumps of trees rather than single trees, and large conifers are better than hardwoods because of their durability. Bundles of wood pieces can be tied together with cables and piled in the streambed. These will be less likely to move in high flows and will accumulate more woody debris to form complex fish habitat.

The ideal approach to a large-wood placement minimizes costs and disturbs the riparian management area very little. That can be done by taking advantage of equipment capabilities and existing operational positioning. The Oregon Department of Forestry encourages operators to reduce their costs with new ways of placing logs in streams. Ideas include:

- Placing logs in the stream immediately below yarding lines that span the stream
- Using a loader, where a road closely parallels the stream, to place logs in the stream

- Pushing down trees with a crawler tractor or loader (after cutting or undercutting the roots on the uphill side) so that the tree falls directly into the stream
- Felling trees so that they land directly in the channel and do not have to be placed in the channel with machinery
- Using **untreated** sound logs from old stringer bridges and railroad trestles to place in the stream
- Using yarding equipment to pull trees over, or using explosives to blast trees over into the stream with the rootwad and limbs attached

Project timing and fish survival

Ideal timing for a large-wood placement project is during the harvest operation or immediately afterward. Water Protection Rules allow delaying stream improvement work to protect critical life stages such as fish eggs in the gravel. However, the rules specify that log placement work must be completed no later than 6 months after the harvest operation is finished.

The proper timing of wood placement varies with the species of fish; therefore, it's important to consult the Oregon Department of Fish and Wildlife biologist about the stream involved. Proper timing also may differ with site conditions, project type, techniques, and machinery used. Projects should be timed to reduce stream bank and bed disturbance, to reduce the amount of sedimentation, and to avoid changing flow patterns. For most of the state, June through September is the best time to conduct stream improvement projects.

If the stream improvement project is delayed, the operator must notify the Forest Practices forester when all agreed-upon enhancement work has been done.

Other ways to earn basal area credit

Other types of stream habitat improvement may earn basal area credits if approved by a Forest Practices forester in consultation with a Fish and Wildlife biologist. The project design and any basal area credit will be negotiated between the landowner and the agencies on a site-by-site basis. These projects include:

- Fencing off the riparian area if grazing has an impact on stream quality
- Creating off-channel habitat including side channels and off-channel ponds for coho rearing

- Building low rock check dams (with rocks secured and cabled together) can be particularly effective when using V- or U-shaped placements in series to create spawning habitat in steeper streams
- Placing boulders, either individual boulders to create small pools or boulder weirs to create a step in the stream profile
- Re-installing or modifying existing culverts or redesigning them as bridges if they appear to be blocking or slowing fish migration

Conclusions

Placing large woody debris takes considerable judgment. The key is to place wood so that it is stable and interacts with water flow to create new habitat for fish. That requires placing at least part of the large-wood piece in or near the low-water level of the stream.

Stability of large-wood placements is critical when there are valuable resources downstream such as bridge abutments or culverts that can be damaged by wood movement. In some cases, it may be desirable to let wood move, especially if there is a wood jam downstream that could trap the moving piece.

Stability is achieved preferably by the sheer size of the piece compared to the size of the stream. Other ways to make a placement stable include anchoring it with cables, keying the wood into the banks, and grouping pieces together.

We still have much to learn about placing large woody debris. That is why the Oregon Department of Forestry has set up a debris placement monitoring program and encourages operators to participate in it. As our knowledge of wood placement techniques improves, information in this publication will become outdated. For this reason, it is essential that people involved in enhancement work look for updated guidance from the Oregon Department of Forestry in the future.

For more information about large-wood placement

If the following publications are not available in your local library, ask whether the librarian can arrange to get them on loan from a university library.

A good overall reference on large wood and stream dynamics

"Large woody debris in forested streams in the Pacific Northwest: Past, present, and future." Authors: P.A. Bisson and others. The article appears on pages 143-190 in a larger work, "Streamside Management: Forestry and Fishery Interactions," edited by E.O. Salo and T.W. Cundy and published in 1987 by the University of Washington Institute of Forest Resources.

A guide to placing wood in order to scour the stream channel

"Coarse woody debris and channel morphology: A flume study." Authors: J. Cherry and R.L. Beschta. The article appears on pages 1031-1046 of the Water Research Bulletin, volume 25, number 5, published in 1989.

A good overall reference on using instream structures to rehabilitate streams

"Rehabilitating and modifying stream habitats." Authors: G.H. Reeves and others. Appears as Chapter 15 (pages 519-557) in a larger work, "Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats," edited by W.R. Meehan and published in 1991 by the American Fisheries Society (Special Publication 19).

A map provided with this report can be used to locate streams where splash dams have been used to transport logs

"Influence of forest and rangeland management on anadromous fish habitat in Western North America: Water transportation and storage of logs." Authors: J.R. Sedell and W.S. Duval. Published in a Pacific Northwest Forest and Range Experiment Station General Technical Report (PNW-186) in 1985 by the U.S. Forest Service.

A study on log placement effectiveness in an Oregon Coast Range stream

"The effect of woody debris piece size and orientation on aquatic habitat in Oregon Coast Range headwater streams." Authors: A.L. Skaugset and others. The article appears on pages 3-6 of the COPE Report, volume 7, number 4, published in 1994.