Forest Practices and Riparian Management in Washington State: Data Based Regulation Development

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Abstract.—In the past, forest practice regulations for riparian zones in Washington have been based primarily on political, rather than scientific, considerations. In 1986 a new process, called Timber, Fish and Wildlife, attempted to formulate regulations based on technical data. Separate regulations were devised for eastern and western Washington due to the differences between the two regions in vegetation, climate, and timber management strategies. In western Washington, where clear-cutting is the predominant harvest method, regulations were based on existing data on large organic debris (LOD) loading in channels coupled with simulation models of stand dynamics. The regulations were designed to provide for the maintenance of LOD at the levels observed in streams in old-growth timber. Data for eastern Washington riparian zones were collected specifically for the purpose of designing new regulations. Uneven-aged management is the most common silvicultural technique practiced in this area. Information was collected on riparian stand characteristics and LOD size and frequency in streams. Regulations were designed to maintain LOD levels observed in unmanaged stands and were based on a relationship between stand density and LOD frequency. Wildlife needs were addressed by providing sufficient numbers of larger trees to generate snags, provide desired levels of canopy cover and maintain a multi-storied canopy.

Forest practices in Washington State were drastically altered in January 1988, as a result of the implementation of a negotiated agreement called the Timber Fish and Wildlife Agreement, or TFW. A prototype of this process of natural resource management through consensus was available: the negotiations between Washington State and northwest Indian tribes over a series of salmon harvest management plans through the early and mid 1980s. Participants in the negotiations producing the TFW agreement included the Washington State Departments of Fisheries, Wildlife, Natural Resources and Ecology, Indian tribes, timber companies, nonindustrial forest-land owners, and environmental groups. The core of the agreement was an understanding between the participants that public resources must be protected while at the same time enabling economically-viable timber management.

The groups involved in the negotiations leading to the TFW agreement were willing to participate because all felt there were shortcomings in the existing forest practice regulations. The timber industry had been faced with recurring regulatory changes that compromised their ability to schedule timber harvest and forest management activities. The state agencies, Indian tribes, and environmental groups felt the public resources were not receiving adequate protection.

The TFW agreement dealt not only with riparian zones, but provided regulatory and voluntary guidelines for road construction and maintenance, cumulative effects, upland management areas, temperature and sediment control, and a method for correcting past forest practices impacts. This paper will focus only on those aspects of the TFW process relating to the management of riparian areas. The majority of the riparian regulations developed during negotiation of the TFW agreement apply only to fish bearing waters. Intermittent streams and waters without fish populations do not require riparian management zones under the present forest practices. However, there are studies in progress to determine if these systems have been afforded adequate protection.

A set of primary goals was established for riparian zone management. The goals, as stated in the agreement were as follows: "The fisheries resource goals are long-term habitat productivity for natural and wild fish, and the protection of hatchery water supplies. The wildlife resource goal is to provide the greatest diversity of habitats (particularly riparian, wetlands, and old growth), and to assure the greatest diversity of species within those habitats for the survival and reproduction of enough individuals to maintain the native wildlife of Washington's forest lands. The water quantity and quality goals are protection of water needs of people, fish and wildlife. The timber resource goal is the continued growth and development of the state's forest products industry which has a vital stake in the long-term productivity of both the public and private forest land base. The archeological and cultural goals are to develop a process to inventory archeological/cultural spaces in managed forests; and to inventory, evaluate, preserve and protect traditional cultural and archeological spaces and assure tribal access."

It was the responsibility of the Riparian Regulations Committee to use available technical information to formulate rules that would meet these goals. However, it was recognized that the lack of technical information on some topics would necessitate basing the regulations on untested assumptions. Therefore, the TFW process created a research and monitoring program to determine the effectiveness of the regulations and test the assumptions that were made during their formulation. Contributions have been made by all TFW participants to the research effort, augmented by appropriations from the state legislature. This research effort was then coupled with an adaptive management procedure that enables regulations to be altered as information becomes available.

The institution of the research and monitoring effort was a critical feature of the TFW agreement. This process provided an avenue for resolution of points on which the participants could not reach consensus. An interim rule was usually agreed upon for these items, and they were then referred to the research and monitoring process for resolution through cooperative research on the topic. In order to minimize disagreements over the applicability of new data to the regulations, most research is cooperative, with two or more of the participating parties involved, and the approval of the entire process. Thus, all parties have a vested interest in the information collected and are familiar with the strengths and weaknesses of the data. It is envisioned that through this process regulations will be refined to provide adequate environmental protection and minimize unwarranted restrictions on timber harvest and management.

The first priority of the Research and Monitoring Committee was to identify a series of projects that would evaluate some of the assumptions made in formulating the regulations and assess the overall effectiveness of the new rules. The projects identified that relate to management of riparian areas include:

(1) Determination of riparian stand characteristics before and after timber harvest on a statewide bases.

(2) Determination of large organic debris (LOD) recruitment rate in clear-cut and selectively harvested stands.

(3) Monitoring of fish habitat following timber harvest.

(4) Development of habitat/fish use relationships.

(5) Evaluation of LOD addition to streams as a site-specific, riparian management option.

(6) Development of predictive temperature models and evaluation of biological response to temperature.

(7) Evaluation of effectiveness of regulations on smaller (first- and second-order) streams that do not have significant fish populations.

(8) Development of a predictive tool to relate riparian stand characteristics to canopy cover.

(9) Evaluation of the relationship between LOD size and its ability to affect stream morphology.

(10) Assessment of wildlife habitat conditions and use of riparian zones.

Work is currently underway on most of these projects.

Development of Riparian Management Regulations

Forest practice regulations for riparian areas in Pacific Northwest states historically have focused on maintaining shade and minimizing sediment and forest chemical introduction to the stream during forest management activities (Washington Forest Practices Board 1976; Oregon Department of Forestry 1985). However, recent research has indicated that the presence of large pieces of wood in streams is key to maintaining productive fish habitat (Bisson et al. 1982; Tschaplinski and Hartman 1983; Lisle 1986). Since this aspect of riparian management had not been addressed in previous regulation packages in Washington, the Committee focused on developing standards that would maintain a source of large wood for the stream and incorporate provisions to protect water quality.

In order to develop regulations that would provide for wood input to streams, a target level for amount of wood in
wood input to streams, a target level for amount of wood in
stream channels had to be established. Data were available on the amount and characteristics of LOD in streams flowing through old-growth timber in some areas of western Washington. This information was utilized as a basis for developing estimates of the appropriate number of trees that should remain standing along streams in western Washington after harvest. Quantitative information on habitat requirements of wildlife in the riparian zone was generally unavailable. Therefore, those aspects of the regulations designed specifically to meet wildlife needs were based on the opinion of local experts.

Due to the geographical limitations of the information on which the western Washington riparian regulations were based, we recognized that they might not be appropriate for areas of the state displaying different environmental conditions or where harvest methods other than clear-cutting are used. There are large differences in climate, vegetation, hydrological regime, and timber harvest methods between the wetter timberlands of western Washington and the more arid lands east of the Cascade Mountains. Recognition of these differences prompted the development of two separate sets of riparian regulations.

In recognition of the fact that conditions in riparian zones in Washington may vary widely, an option was included in the regulations that permits any operator to develop a site-specific plan for any type of activity in the riparian zone, if the proposed action provides protection for non-timber resources equal to or better than that afforded by the regulations. The appropriateness of any plan deviating from the regulations is determined by a group of individuals with expertise in various aspects of resource management, termed an "interdisciplinary team". Membership on these teams varies according to the situation being considered and the availability of qualified personnel. The site-specific plan option of the riparian regulations is viewed as being critical to the ultimate success of the process since it builds a great deal of flexibility into the system and enables it to adapt to virtually any conditions which might be encountered.

Western Washington

Knowledge of two variables is essential in formulating effective regulations aimed at providing for the continued input of stable debris to streams: how much debris is required and the characteristics of stable debris for a given stream. The amounts of LOD necessary to provide "optimum" levels for any stream ecosystem function are not known and certainly vary widely from one system to another. However, information was available on LOD amounts in streams flowing through undisturbed, old-growth forests for a series of streams in southwestern Washington (Bilby 1988) and the Olympic Peninsula (J. Cederholm, personal communication).

The LOD density varied as a function of stream size, with a sharp decrease in the frequency of wood as streams increase in size (Figure 1). This pattern is likely caused by the increased capacity for larger streams to move bigger pieces of wood downstream. A difference in LOD frequency was also observed between streams with predominantly gravel and cobble substrate and those systems with beds composed of larger materials; the latter streams contain approximately half the LOD found in similar-sized streams with finer substrate (J. Cederholm, personal communication). Average piece size of wood in the channels was also seen to increase as stream size increased (Figure 2). Again, this relationship is due to the increased capacity for larger systems to move bigger pieces of wood.

Figure 1.—Relationship between channel width and frequency of occurrence of pieces of woody debris for systems in southwestern Washington. The curve has the equation $\log^{10}$ frequency = 1.12 $\log^{10}$ width + 0.46; r^2 = 0.68 (from Bilby 1988).

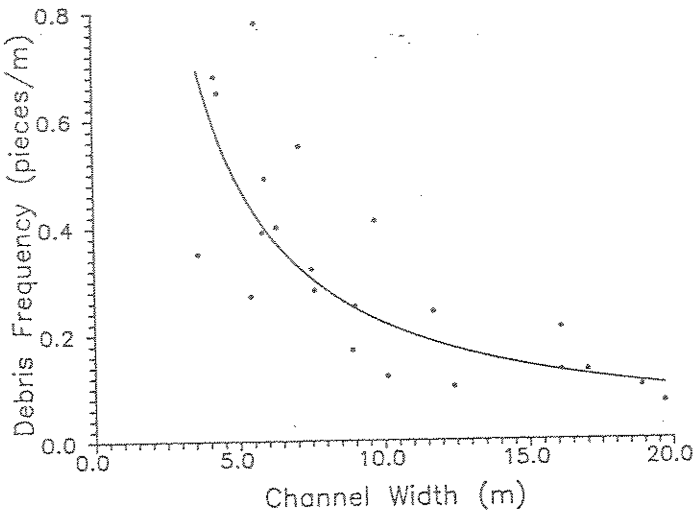


Figure 2.—Relationship between channel width and mean debris diameter for systems in southwestern Washington. The curve has the equation diameter = 2.14 width + 26.43; r^2 = 0.76 (from Bilby 1988).

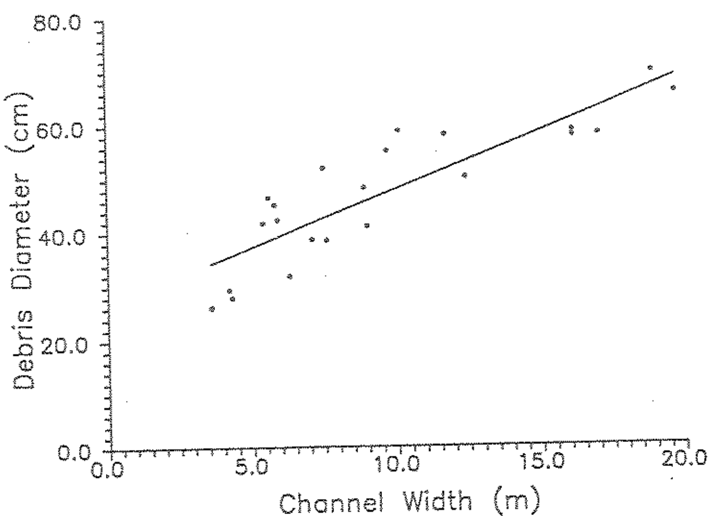
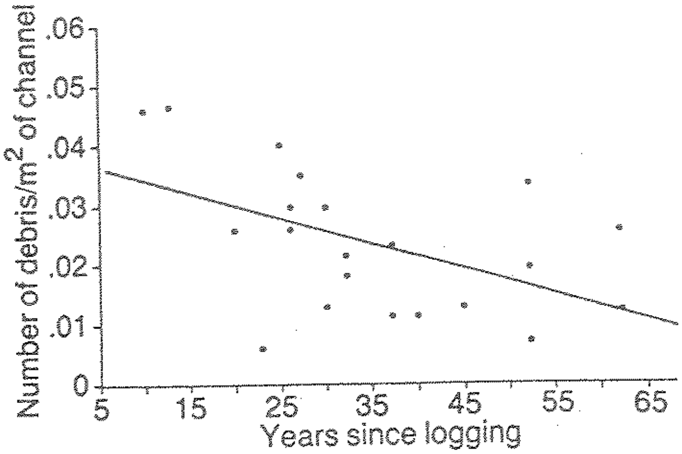


Figure 3.—Relationship between number of pieces of woody debris from an old-growth stand and the years since logging of that stand occurred for sites on the Olympic Peninsula of Washington. The curve has the equation pieces of large organic debris (LOD) remaining = 0.00042 years since harvest + 0.038; r = -0.51 (from Grette 1985).



The amount of wood in a stream ultimately depends upon its rate of input and disappearance. The rate of disappearance of LOD for streams on the Olympic Peninsula (Figure 3) is about 1%/year (Grette 1985). Information on the input rate of wood from a streamside zone after timber harvest of adjacent areas was not available. However, we estimated the input rate based on average stem density and size in second growth stands (Hall et al. 1985) and some assumptions about the rate at which these trees would enter the stream after harvest of the adjoining area.

Using the available data and our assumptions on input rates, we were able to estimate the number of trees required to maintain the LOD levels found in old-growth systems. Due to the observed relationships between stream size and LOD frequency and size, different sets of requirements were developed for each of four stream channel-width categories; > 23 m, 15-23 m, 2-15 m, and < 2 m. In addition, we separated streams with gravel/cobble beds from those with boulder/bedrock beds, based on the observation of lower LOD frequency in those systems with coarser substrate.

An average second-growth stand at harvest age would contain approximately 500 stems/hectare, with an average diameter at breast height (DBH) of 45 cm (Hall et al. 1985). Mortality would affect approximately 25% of the trees remaining along the stream over the next 70-year rotation (Hall et al. 1985). In addition, we estimated, based on observations of Committee members, that an additional 25% of the trees would contribute wood to the channel due to the increased risk of blowdown over this time interval. The validity of the assumption is currently being evaluated. We limited the number of pieces supplied by a single tree to one, although very often a tree will contribute multiple pieces of LOD to a channel, especially in smaller streams.

Larger pieces of wood are required in larger streams. Average piece diameter for the two largest channel width categories were calculated at 65 cm and 75 cm. Trees remaining along the stream were estimated to reach this size at 25 and 35 years after harvest, respectively. Therefore, contribution to LOD levels in the stream from the riparian zone would not occur until this time. The trees remaining along the stream after harvest are large enough to supply stable wood to the two smaller stream size classes at harvest.

Trees planted or sprouting after harvest within the riparian zone would reach a size sufficient to contribute LOD to the two smaller channel-width categories during the 70-year period after harvest. For the smallest streams, young trees are large enough to supply LOD approximately 20 years after the harvest, but for the next larger size class, pieces would not be of sufficient size to make a contribution until 60 years after harvest. Because of the older timber remaining in the streamside area after harvest, it was assumed that density of young trees would be about half that which would normally be observed during regeneration of a cleared area. Thus, the stand would thin from

370 stems/hectare at age 20 to 250 stems/hectare at age 70 (Hall et al. 1985). Input of this material was limited to trees located within 15 m of the channel, due to the relatively short length of the younger trees.

We estimated appropriate levels of trees to be left along each of the four channel-width categories using the formula: Target LOD density = (Input from remaining trees) + (Input from regrowth) + (Residual LOD) (Table 1). The target LOD densities for each of the channel-width categories were estimated by a regression analysis (Figure 1). For the largest streams, 50 trees/305 m on each side of the channel were required. This value increased to 100 trees for the next smallest category, due to the observed increase in piece frequency in the smaller systems (Figure 1). As the regrowing trees were able to make a contribution, numbers of trees remaining along stream after harvest were reduced to 75 trees/305 m in the 2-15 m class and to 25 trees/305 m for the smallest channel-width category.

The estimated frequency of LOD in streams in the three largest width classes at the end of the rotation following institution of the regulations all exhibited LOD frequencies in excess of the levels seen in old-growth systems (Table 1).

Table 1.—Values used to formulate riparian tree requirements for western Washington streams and estimated values of large organic debris (LOD) frequency 70 years after application of the regulations. Values in the row labeled "Years after harvest to reach stable size" indicate the time needed for the average tree left in the riparian zone after harvest to reach a size sufficient to produce pieces of wood with diameters equal to the average piece measured in streams of similar size flowing through undisturbed areas (Figure 1). Values listed in the row entitled "Years until input from new stand" indicates the length of time necessary before trees planted or germinated in the riparian zone after harvest can provide stable pieces of wood to the channel.

	Channel width (m)			
	> 23	15-23	2-15	< 2
Old-growth LOD frequency (pieces/m)	0.03[a]	0.11[b]	0.26[b]	0.60[c]
Mean diameter of stable LOD (cm)	75	65	45	20
Years after harvest to reach stable size	35	25	0	0
Years until input from new stand	—[d]	—[d]	60	20
Estimated LOD at end of rotation				
Residual in-channel LOD (pieces/m)	0.01	0.03	0.08	0.18
Input from leave trees (pieces/m)	0.08	0.21	0.25	0.08
Input from new stand (pieces/m)	0	0	0.04	0.18
Total LOD at end of relocation (pieces/m)	0.09	0.24	0.37	0.44

[a]Data from Cederholm (personal communication).

[b]Data from Bilby (1985).

[c]Estimated values.

[d]Trees regenerated after harvest do not reach sufficient size during the ensuing rotation to contribute LOD to streams in these size categories.

The smallest stream size class shows levels somewhat lower than those seen in undisturbed situations. However, in these very small streams, branches or tops from trees left along the stream are often large enough to provide stable debris and this form of input may increase the LOD frequency sufficiently to make up the estimated deficit.

Size of the leave trees varies with stream size class. Along the smallest streams, the remaining stems must be 15 cm or larger and 30 cm or larger along streams from 2-15 m wide. These values are less than the mean diameter of stable pieces of debris in these systems, but since they represent minimum values, the average size tree remaining would approximate the size needed to provide stable material to the stream. For the two largest size classes of stream, the diameter distribution of remaining trees is representative of the distribution present on the site prior to harvest. This requirement ensures that some of the largest trees on the site remain after harvest. These larger trees will be capable of supplying suitably sized material to the channel sooner than smaller stems. Theoretically, this approach will also produce some very large trees within the riparian zone after several rotations.

A number of studies have indicated that coniferous debris persists longer than hardwood material in streams (Anderson et al. 1978; Swanson and Lienkaemper 1978; Keller and Tally 1979). In order to ensure that conifer trees would not be eliminated from some riparian zones, ratios of conifer/hardwood leave trees were established. Retention of a species composition representative of that present on the site prior to harvest was instituted for the two largest channel-width categories. For channels from 2-15 m wide this value was set at 2/1 and reduced to 1/1 for the smallest systems. In those situations where these ratios cannot be met, removal from the riparian zone of the type of tree in short supply is precluded.

The boundary of the riparian zone varies, following the transition from wetland to upland vegetation at those sites where true riparian zones exist. In cases where upland vegetation extends to the channel edge, zones were set at 8 m on each side of the stream. A maximum zone width was also established, in response to concerns of land owners that the regulations might result in severe restrictions on timber harvest in areas with extensive floodplains. The maximum widths increased with increasing channel width. These values were set at 8 m, 15 m, 23 m, and 30 m for the four channel-width categories. Provisions were included to expand these zones as necessary to encompass swamps, bogs, marshes, or ponds adjacent to the stream.

The provisions in the regulations to provide sufficient standing timber along the stream to maintain LOD levels should also aid in the protection of water quality. However, several additional stipulations were added to the rules to help ensure that sediment and temperature levels would not damage aquatic resources. Minimizing sediment delivery to the channel from or through the riparian zone depends, in large part, on avoiding disturbance to soils within this area. Transport of significant amounts of sediment to streams requires overland flow. Most forest soils possess infiltration capacities high enough that overland flow is a rare phenomenon in undisturbed situations. In order to protect this property of the soil in the riparian area, any use of yarding equipment within the zone must be approved by the Department of Natural Resources and damage to understory vegetation must be avoided. In addition, bank and bed stability were protected by requiring that woody debris embedded in the channel or bank not be disturbed during yarding operations, felled trees not enter the water, trees with root systems stabilizing the bank not be cut, and high stumps be left when needed to prevent felled timber from rolling into the water.

In situations where a potential problem with water temperature is perceived, provisions are included in the regulations to require either 50% or 75% of the pre-harvest shade to remain along a stream after logging, depending upon the degree of sensitivity of the system to elevation of water temperatures. Research is presently ongoing to produce a process to identify temperature sensitive streams and to assess the effectiveness of the regulations at mitigating water temperature increases.

The need for large trees by some species of wildlife may not be met in managed forests. In order to provide some of this habitat, the 12 largest trees per hectare zone are left.

The data used in developing these regulations were collected from a restricted geographical area. Systems with significantly different vegetation, hydrologic regimes, or geologic composition are likely to exhibit considerable deviation from the values on which the regulations were based, as proved to be the case when data was gathered on streams in eastern Washington. The inclusion in the regulation package of a provision for research and adaptive management enables the rules to be continuously updated as new information is obtained.

Eastern Washington

During the summer and autumn of 1987, data were collected on a series of stream sections east of the Cascade Mountains for the purpose of obtaining information on which technically justifiable regulations could be based. This information was collected as a cooperative effort between state agencies, Indian tribes, timber companies, and environmental groups.

A total of 72 stream sections was examined during this process. Sites were located on forest lands throughout the eastern half of Washington state. Sites in unmanaged areas and in locations from which trees had been selectively harvested in the recent past were examined. A range of stream sizes, from the smallest fish-bearing stream up to sections with channels in excess of 20 m were surveyed. The length of the sections varied but generally included at least 50 pieces of LOD and extended a minimum of 150 m. Sites heavily impacted by mass failures or showing evidence of effects of off-site influences that might have influenced LOD, such as an upstream bridge, were avoided.

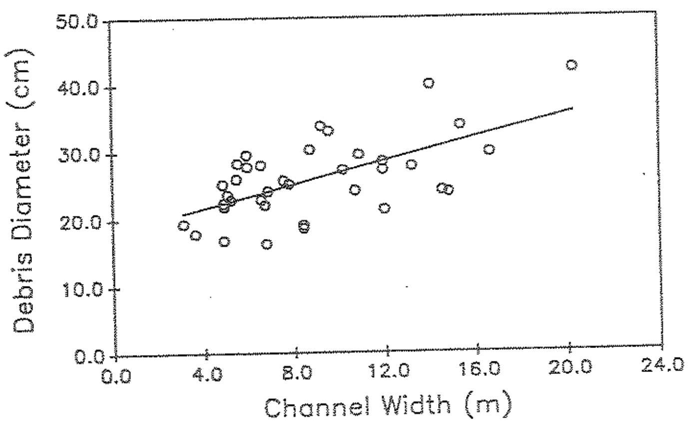
Data gathered on each stream included bankfull channel width and gradient, measured every 15 m. A visual estimate of the percent of the bed material in each of four size categories was made (gravel and finer < 6 cm; cobbles 6-25 cm; boulders > 25 cm; and bedrock). Diameter, length in the channel, and length out of the channel for each piece of woody debris was measured and the species of tree that produced the piece was identified.

Data on the riparian system bordering the surveyed streams was gathered by establishing four to six plots at 20-m intervals on alternating sides of the stream. The plots were 6-m wide and extended 30 m perpendicular to and upslope from the channel's edge. The diameter, height, and species of each tree with a diameter over 10 cm was recorded within each plot.

The LOD frequency at unmanaged sites in eastern Washington ranged from 0.11 pieces/100 m to 0.61 pieces/100 m, which are similar to the values for western Washington (Figure 1). However, the frequency of LOD in eastern Washington streams was not related to stream size, unlike the pattern seen in western Washington. The difference between the two areas is likely due to two factors: (1) there was enormous variation in tree density in unmanaged riparian areas along the eastside streams, ranging from 105 stems/hectare to nearly 1,800 stems/hectare; due to the more homogeneous climatic conditions prevailing in western Washington, it is likely that variability in stand density is less, and (2) hydrologic conditions in eastern Washington probably display smaller extremes than on the west side, due to the fact that most high discharges in eastern Washington are governed by snowmelt runoff, versus heavy winter rains or rain on snow on the west side of the Cascades. Therefore, a stream in western Washington might have a greater capacity to flush wood from the channel than a stream displaying a similar channel width in eastern Washington.

There was a relationship between the average diameter of a piece of LOD and the size of the stream in which it occurred (Figure 4). This is similar to the pattern observed in western Washington, but piece size was smaller in eastern Washington streams than in similar sized systems west of the Cascades. Likely reasons for this pattern relate to the production of larger pieces of wood by west side forests and differences in hydrologic conditions.

Figure 4.—Relationship between channel width and mean debris diameter for sites in eastern Washington. The curve has the equation diameter = 0.87 width + 18.20; $r^2 = 0.37$).



We also observed a significant difference (t-test $P < 0.05$) in LOD frequency between gravel/cobble and boulder/bedrock bedded streams at both managed and unmanaged sites (Figure 5). This pattern was consistent with that seen in western Washington. As a result, predominant substrate size was used to stratify stream reaches for regulatory purposes. There was no significant difference (t-test $P > 0.05$) observed in LOD frequency between the managed and unmanaged sites for either substrate condition (Figure 5).

A relationship was also observed between density of trees in the streamside area and LOD frequency (Figures 6 and 7). These relationships were used as the basis for determining the number of standing trees needed to sustain levels of LOD in eastern Washington streams similar to those observed in undisturbed systems. All proposed riparian regulations for eastern Washington were evaluated by applying the suggested treatment to the streamside areas inventoried during our survey, determining the number and sizes of trees present after harvest and esti-

Figure 5.—Frequency of occurrence of pieces of woody debris in streams with different substrate characteristics and management histories. Error bars indicate 95% confidence intervals.

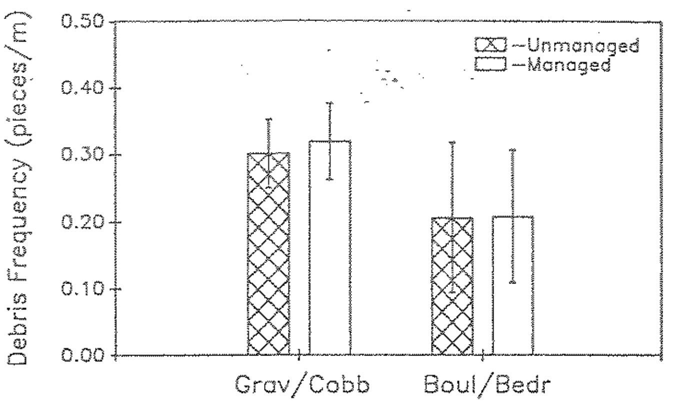


Figure 6.—Relationship between tree density in the riparian area and large organic debris (LOD) frequency in the stream for sites in eastern Washington with gravel/cobble beds. The curve has the equation LOD frequency = 0.0003 tree density + 0.151; $r^2 = 0.41$.

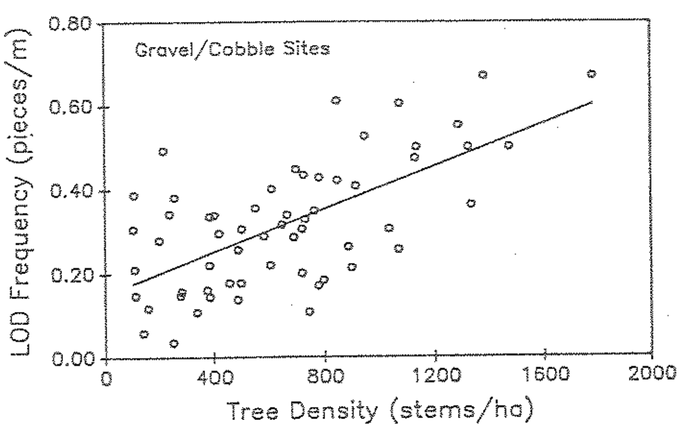


Figure 7.—Relationship between tree density in the riparian area and large organic debris (LOD) frequency in the stream for sites in eastern Washington with boulder/bedrock beds. The curve has the equation LOD frequency = 0.0003 tree density + 0.116; $r^2 = 0.31$.

mating the resultant LOD frequency from the regression in Figures 6 and 7.

In view of the great variability in stand density, riparian regulations for eastern Washington were constructed in such a way that average leave tree requirements would be met on a majority of the sites, but enough flexibility would be built into the system to enable some harvest of timber to occur on those sites which naturally exhibit very low tree densities. However, to ensure that no locations would be harvested to the point where non-tiber resources would be unacceptably compromised, minimum riparian stand densities were established below which harvest is precluded. These levels were set at 335 stems/hectare for gravel/cobble streams and 185 stem/hectare for boulder/bedrock systems.

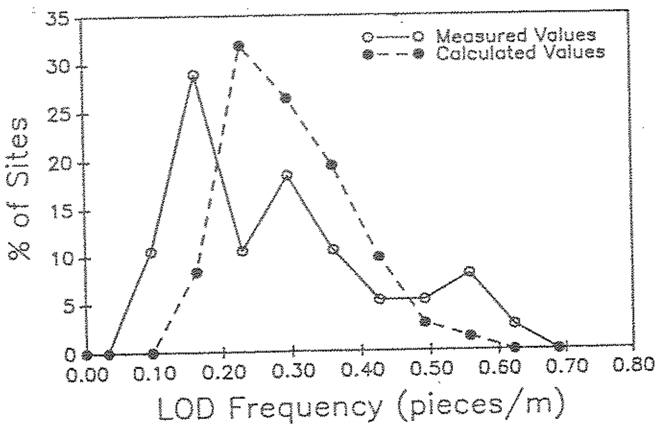
Unlike the regulations in western Washington, the eastern Washington rules do not set numbers of trees to be left in the riparian zone after harvest. This approach was selected in response to the very large variability in riparian conditions we observed during our surveys. All trees with diameters less than 30 cm will be left. In addition, 40 conifers/hectare between 30 cm and 50 cm and 7 conifers/hectare over 50 cm will remain after harvest. Twelve hardwood trees/hectare in excess of 30 cm diameter will also remain on the site, when available. All snags on the site which do not violate state safety standards will also be left.

The width of the riparian management zone for eastern Washington streams also varies somewhat from the widths required in western Washington. Riparian areas managed in association with a selective cut of the upland area will range from a minimum of 9 m to a maximum of 15 m on each side of the stream, with the boundary following the change in vegetation type from riparian to upland between these two extremes. Riparian areas managed in association with clear-cutting will average 15 m in width on each side of the stream and may range from a minimum of 9 m to a maximum of 90 m. The wider riparian zone along clear-cut sites was designed to compensate for elimination of LOD input to the channel from areas outside the defined riparian zone. At selectively harvested sites, a substantial number of trees remain standing outside the riparian zone after cutting and may contribute wood to the channel.

Applying these regulations to the sites surveyed during our study and using regression analysis (Figures 6 and 7), the estimated amount of LOD provided by the post-harvest stand will maintain the distribution seen in unmanaged stands (Figure 8). The calculated distributions seem to indicate that there will be fewer sites with very high or very low levels of LOD after harvest. However, these changes are largely an artifact of using the regressions to approximate LOD amounts. Nonetheless, the regulations appear to provide a satisfactory amount of LOD. Based on our data, the regulations would preclude harvest in riparian zones at 18.2% of the boulder/bedrock sites and 21.3% of the gravel/cobble sites. Along streams where harvest would be permitted, relatively few trees would be removed, with 87% of the pre-harvest stems remaining in the riparian zone after harvest at gravel/cobble sites and 81% at boulder/bedrock sites.

Aspects of the riparian management regulations developed for western Washington to address water temperature and sedimentation also apply to eastern Washington. Sediment input is minimized through limitations on heavy equipment usage, minimizing road construction, felling timber away from the stream, and maintaining bank and bed integrity. Entry of silvicultural chemicals into the water is managed through the establishment of buffers on

Figure 8.—Comparison of the frequency distribution of large organic debris (LOD) levels measured at unmanaged sites surveyed in eastern Washington and estimated values for all sites after harvest under the new regulations. The estimated values were based on the regression in Figures 6 and 7.



all water. It was also assumed that due to the relatively few trees that will be taken from streamside areas under these rules, that shading of the channel should be sufficient to prevent excessive increases in water temperature. All these assumptions are currently being evaluated as part of the ongoing research and monitoring effort associated with the TFW agreement.

Several features of wildlife habitat in riparian areas were emphasized during development of the eastern Washington riparian regulations. Particular attention was focused on retention and future recruitment of snags to maintain viable populations of cavity nesting animals, provision of coniferous canopy cover of 50% to 70% for thermal refuge, and retention of the vertical structural diversity of the vegetation.

Analysis of the data collected during the eastern Washington riparian study suggests that the regulations will provide most of these function. Retaining all stems less than 30 cm in diameter will provide a large number of small snags, contribute to canopy closure, and constitute the lower canopy layers. Requirements for leaving larger stems (40 conifers/hectare between 30 cm and 50 cm in diameter, 7 conifers/hectare greater than 50 cm in diameter, and 12 deciduous trees/hectare greater than 30 cm in diameter) will produce larger snags, provide year-round thermal buffering and form the upper canopy layers.

Riparian Zone Tree Requirements

The core of regulations produced from the above procedures are the requirements for the number, sizes, and species of trees to remain along streams after harvest. These rules are excerpted from the Washington Forest Practices Rules and Regulations (Table 2) (Washington Forest Practices Board 1988).

References

Anderson, N. H., J. R. Sedell, L. M. Roberts, and F. J. Triska. 1978. The role of aquatic invertebrates in processing wood debris from coniferous forest streams. American Midland Naturalist 100:64-82.

Table 2.—Requirements for numbers of trees to be left along streams in western and eastern Washington after timber harvest.

Western Washington

Water type and average width[b]	RMZ maximum width	Ratio of conifer to deciduous/ minimum size of leave trees	Number of trees/ 305 m each side: gravel/ cobble[a]	Number of trees/ 305 m each side: boulder/ bedrock
1 and 2 Water 23 m and over	30 m	representative of stand	50 trees	25 trees
1 and 2 Water under 23 m	23 m	representative of stand	100 trees	50 trees
3 Water 2 m and over	15 m	2 to 1/ 30 cm or next largest available[c]	75 trees	25 trees
3 Water less than 2 m	8 m	1 to 1/15 cm or next largest available	25 trees	25 trees

[a]Gravel and cobble streambeds are composed, predominately, of material < 25 cm in diameter.

[b]Washington water typing system is based on domestic water use, fish use, and size of streams. A detailed description of the criteria may be found in Washington Forest Practices Rules and Regulations (Washington Forest Practices Board 1988).

[c]"Or next largest available" requires that the next largest trees to those specified in the rule be left standing when those available are smaller than the sizes specified. Ponds or lakes which are type 1, 2, or 3 waters shall have the same leave tree requirements as boulder/bedrock streams.

For wildlife habitat within the riparian management zone, leave an average of 12 undisturbed and uncut wildlife trees per hectare at the ratio of 1 deciduous tree to 1 conifer tree equal in size to the largest existing trees of those species within the zone. Where the 1 to 1 ratio is not possible, then substitute either species present. Forty percent or more of the leave trees shall be live and undamaged on completion of harvest. Wildlife trees shall be left in clumps, whenever possible.

Eastern Washington

(A) Leave all trees 30.5 cm or less in diameter breast height (DBH).

(B) Leave all snags within the riparian management zone that do not violate the state safety regulations.

(C) Leave 40 live conifer trees/hectare between 30.5 cm DBH and 50.8 cm DBH distributed by size as representative of the stand.

(D) Leave 7 conifer trees/hectare 50.8 cm DBH or larger.

(E) Leave the 5 largest deciduous trees/hectare 40.6 cm DBH or larger. Where these deciduous trees do not exist, and where 5 snags/hectare 50.8 cm in DBH or larger do not exist, substitute 12 conifer trees/hectare 50.8 cm in DBH or larger. If conifer trees of 50.8 cm DBH or larger do not exist within the riparian zone, then substitute the 5 largest conifer trees/hectare.

(F) Leave 7 deciduous tree between 30.5 cm and 40.6 cm DBH where they exist.

(G) On streams with a boulder/bedrock bed, the minimum leave tree requirement shall be 185 trees/hectare 10.2 DBH or larger.

(H) On streams with a gravel/cobble (less than 25.4 cm diameter) bed, the minimum leave tree requirement shall be 335 trees/ hectare 10.2 cm DBH or larger.

(I) On lakes and ponds the minimum leave tree requirement shall be 185 trees/hectare 10.2 cm DBH or larger.

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PRACTICAL APPROACHES TO

RIPARIAN RESOURCE MANAGEMENT

AN EDUCATIONAL WORKSHOP

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