Effects of Riparian Forest Harvest on Instream Wood Recruitment in the Clearwater and Salmon River Basins as Proposed by the Idaho Forestry Program for State and Private Timberlands

Report to

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EXECUTIVE SUMMARY

Effects of the proposed riparian forest harvest plan on instream wood recruitment will vary on a stand-by-stand basis. These range from little to no effect in low-density and younger stands, to substantial effects in older stands with abundant large-diameter trees. Multiple harvest entries will substantially reduce instream wood recruitment relative to a single entry. In terms of minimizing the effect of riparian timber harvest on instream wood recruitment, no-cut buffers are much more effective than buffers where thinning is allowed. A 150-ft no-cut buffer will retain essentially all potential sources of instream wood. A 100-ft no-cut buffer will retain, on average, 95% of all potential instream wood sources with a minimum retention level of 87% for any one stand. The riparian timber harvest plan proposed by Idaho Forestry Program will retain on average 75% of all potential instream wood sources, with a minimum retention level of 46% for any one stand.

The accuracy of estimated effects on future instream wood sources from different levels of riparian forest protection could be improved by:

1) Utilizing larger riparian stand plots.
2) Ensuring that the data collected are representative of the entire width of the riparian management area, and stratifying by stand type if necessary.
3) Calibrating the Forest Vegetation Simulator (FVS) growth model for individual species.

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INTRODUCTION

This report details an assessment of the effects of a proposed timber harvest along streams on the future abundance of down wood production from riparian forests. The assessment was conducted at the request of the National Marine Fisheries Service Idaho State Habitat Office in response to a proposal by the Idaho Forestry Program for State and Private Timberlands.

Wood that falls into streams affects sediment transport processes and stream hydraulics such that it creates habitat important to juvenile and adult salmonids for spawning, rearing, egg incubation, migration, and overwintering. The importance of instream wood to salmonids has been reviewed extensively elsewhere and is not discussed further in this analysis. The riparian timber harvest rules considered here were proposed by the Idaho Forestry Program (IFP), and the proposal is being reviewed by NMFS in the context of Section 7 of the Endangered Species Act.

In developing the proposed riparian timber harvest rules, the IFP gathered data for 119 riparian stands in the general project. These stands were used as sites to model the effects of timber harvest on future instream wood recruitment using a forest growth model (forest vegetation simulator, northern Idaho variant) and a wood recruitment model (based on the equations of McDade et al. 1990). Details on these models were reported in the IFP environmental impact statement (IFP 2009).

Of the 119 stands surveyed, many were sparsely forested, and only 27 had enough trees for harvest to be considered under the proposed rules (described in Table 1). These stands varied in the composition of tree species, but grand fir was the most abundant species and was present in almost all harvestable stands (23/27). Grand fir was followed in abundance by western red cedar (15/27) and then Douglas fir (12/27). Douglas fir was generally present where cedar was sparse or absent. In terms of dominant species, there were three major forest types among the 27 harvestable stands: Cedar/Grand fir (10/27), Douglas fir/Grand fir (9/27) and Spruce/Alpine fir (4/27) (See Table 1).

Table 1. Species abundances and sizes for each harvestable stand. Abbreviations: TPA, trees per acre; DBH, average diameter breast height (inches); TPA > 8, trees per acre over 8-in DBH (minus the 88 required to remain under the proposed thinning rules); D, Douglas fir; G, grand fir; A, Alpine fir; C Western red cedar; S Engelmann's spruce. Other species included, in order of frequency of occurrence, larch (L), Ponderosa pine, western hemlock and western white pine.

	Dom	Grand Fir			Cedar			Douglas Fir			Spruce			Alpine Fir			Lodgepole Pine			Other species		
Site	Spp	TPA	DBH	TPA>8	TPA	DBH	TPA>8	TPA	DBH	TPA>8	TPA	DBH	TPA>8	TPA	DBH	TPA>8	TPA	DBH	TPA>8	TPA	DBH	TPA>8
Clearwater																						
1,043	D-G	653	9	93	400	2		212	7	39										39	10	39
1,166	C-G	12	29	12	80	31	80															
1,339	D-G	127	11	45	13	30	13	97	12	97										110	11	110
3	C-G	68	15	68	322	16	38															
6	G	356	13	135																		
13	D-G	391	8	112				31	11	31												
19	D-G	345	14	27				67	20	67												
20	C-G	44	18	44	91	23	91													5	26	5
21	S-A										68	15	68	60	13	60						
22	D-G	48	13	48				42	19	42										40	20	40
26	S-A	45	9	45							7	24	7	181	8	29	28	12	28			
30	C-G	35	29	35	100	21	100													5	27	5
31	C-G	22	21	22	71	28	71				5	28	5									
40	D-G	1319	5	119				12	18	12												
41	S-A	27	12	27							183	8	37	360	7		48	20	48			
Craig Mountain																						
2	D-G	73	21	73				22	19	22	31	19	31									
3	S-A										59	8		118	13	118						
4	D-G	285	10	285				50	9	50												
Maggie Creek																						
2	C-G	40	14	40	53	8	53															
6	C-G	192	12	135	920	16	36															
7	C-G	961	7	175	415	8	15				65	8										
9	C-G	145	12	70	64	11	64															
Ponderosa																						
2	D-L	1125	2					362	8	139							12	16	12	125	1	
14	D-G	73	16	73	1250	1		76	17	76												
St. Joe																						
478	C-D				20	14	20	81	12	12										93	9	93
7	C-G	5	28	5	98	40	98													3	37	3
15	C-S				48	34	48				29	25	29							40	18	40

PROPOSED RIPARIAN HARVEST RULES

The proposed IFP riparian harvest rules along fish-bearing streams call for a 25-ft no-cut buffer adjacent to the stream, followed by an additional 50-ft buffer out to 75-ft. Within this second buffer, thinning is restricted to no less than 88 trees per acre (TPA) greater than 8 inches diameter (at breast height). The distribution of diameters among the remaining 88 trees must approximate that of the pre-harvest distribution. There is no requirement that post-harvest tree species abundances approximate pre-harvest species abundances. Beyond 75 feet from the edge of the stream, there are minimal restrictions on timber harvest, and clear-cutting is allowed such that beyond 75 feet, essentially no wood has the potential to enter the stream.

ANALYSIS

The IFP used the Forest Vegetation Simulator (FVS) model (see the FVS website http://www.fs.fed.us/fmsc/fvs/), to project the growth of 27 harvestable sites for 100 years under 1) a no-harvest alternative and 2) a harvest alternative consistent with the proposed rules outlined above. The time step for the simulation was 5 years. Details on model parameterization are discussed in the IFP environmental impact statement (IFP 2009, Section III.B.3)

Output data from the FVS simulation were obtained from the Parametrix FTP website, where all data pertaining to this proposal are stored (Parametrix 2013). These data were used to estimate instream wood recruitment under several management scenarios. Using the equations described by McDade et al. (1990), I estimated the total wood expected to be delivered to streams for 100 years. The assumptions applied to the McDade model and other assumptions related to this analysis are described in Appendix Table 1.

I focused the assessment on individual site-level effects, but also provided summary statistics for the 27 sites where harvest is proposed. For each of the 27 sites, I compared the relative and absolute effects on instream wood recruitment for 100 years post harvest under the following four scenarios:

1) Proposed IFP harvest rules (described above)
2) A 75-ft no-cut buffer
3) A 100-ft no-cut buffer
4) A 150-ft no-cut buffer

I assumed that a 150-ft no-cut buffer would provide the maximum possible amount of wood (i.e. 100%), though probably some wood comes from beyond 150 feet, especially on steep slopes. There are numerous assumptions that go into forest growth models and instream wood recruitment models (Dixon 2002; Appendix Table 1), and model uncertainties were not quantified. Therefore, the absolute numbers reported here may not necessarily be an accurate approximation of the number of pieces of wood likely to fall into a given stream. For this reason, an important aspect of this analysis is to compare relative effects of the four different buffer scenarios.

RESULTS

For the 27 sites examined, a single harvest entry under the proposed IFP riparian harvest plan will provide between 46 and 97% of the wood relative to a 150-ft no harvest buffer in the 100 years following harvest (Table 2). On average, the proposed buffers provide 75% of instream wood relative to no harvest (100%). Average proportions of instream wood relative to no harvest within 150-ft of a stream were estimated at 85% for a 75-ft no-cut buffer and 95% for a 100-ft no-cut buffer. These numbers suggest that the proposed riparian thinning in the 25- to 75-ft zone will reduce wood recruitment by an average of 10%. Another 10% would be lost if there is no riparian forest protection in the 75- to 100–ft zone, and another 5% lost if there is no riparian forest protection in the 100- to 150-ft zone (Table 2).

Tree species composition and average tree diameter and density vary considerably among sites. Therefore, the expected effects of thinning on both on tree removal and wood recruitment will vary such that comparisons of average recruitment are not insightful. For example, 5 of the 27 harvestable stands produced 48% of the harvestable wood (Figure 1), and just one stand (Craig Mountain 4) produced 17% of all the harvestable wood (Table 2). Similarly, just 8 of the 27 harvestable stands produced 51% of the total amount of instream LWD (Figure 1).

Substantial loss of future wood recruitment can occur at the individual stand level. As an example, for Craig Mountain stand 4, the proposed riparian harvest will result in a loss of more than half (56%) of future instream wood supplies. In contrast, many of the stands examined have fairly low densities of trees, and few trees in these stands will be removed under the proposed rules. Because of these low tree densities, even if not harvested, these stands will provide limited amounts of large wood to streams.

Table 2. Instream LWD produced under various buffers, expressed both as pieces per 1000 ft of stream and as a percent of the amount provided by a 150-ft no-cut buffer with continuous riparian forest to the channel edge. Percentage of harvestable trees indicates the proportion of harvestable trees per acre in a given stand relative to total harvestable trees from all stands. Abbreviations: DBH, diameter breast height; LWD, large woody debris; IFP, Idaho Forestry Program; C, cedar; G, grand fir; D, Douglas fir; S, spruce; A, alpine fir; L, Larch.

		Stand descriptive metrics					Pieces per 1,000 ft stream					Percent of 150-ft no-cut buffer			
Plot	Dominant trees	Trees/ acre	Mean DBH	Trees/ acre >8 in DBH	Harvestable trees/ acre	Percent harvestable trees (%)	150-ft no cut	All LWD (%)	100-ft no cut	75-ft no cut	IFP proposed	150-ft no cut (%)	100-ft no cut (%)	75-ft no cut (%)	IFP proposed (%)
Clearwater															
3	C-G	390	16	107	19	1	205	4	198	185	176	100	97	91	86
6	G	356	13	135	47	3	227	5	220	200	184	100	97	88	81
13	D-G	423	9	143	55	4	267	6	266	256	243	100	100	96	91
19	D-G	413	18	95	7	0	150	3	141	126	127	100	94	84	84
20	C-G	140	22	140	52	4	117	2	104	88	62	100	89	75	53
21	S-A	128	15	128	40	3	65	1	64	60	47	100	99	93	72
22	D-G	130	18	130	42	3	130	3	122	103	78	100	93	79	60
26	S-A	261	12	108	20	1	111	2	110	105	100	100	99	94	90
30	C-G	140	25	140	52	4	133	3	116	97	68	100	87	73	51
31	C-G	98	27	98	10	1	68	1	64	55	50	100	93	80	73
40	D-G	1,331	7	131	43	3	231	5	225	215	223	100	98	93	97
41	S-A	618	13	111	23	2	309	6	301	282	280	100	97	91	90
1043	D-G	1,304	8	171	83	6	263	5	258	239	245	100	98	91	93
1166	C-G	92	31	92	4	0	49	1	44	38	37	100	90	78	75
1339	D-G	346	16	264	176	12	355	7	333	291	192	100	94	82	54
Craig Mountain															
2	D-G	126	20	126	38	3	130	3	115	95	73	100	88	73	56
3	S-A	177	12	118	30	2	120	2	115	99	85	100	96	83	71
4	D-G	335	10	335	247	17	298	6	290	263	138	100	97	88	46

Table 2. Continued.

		Stand descriptive metrics					Pieces per 1,000 ft stream					Percent of 150-ft no-cut buffer			
Plot	Dominant trees	Trees/ acre	Mean DBH	Trees/ acre >8 in DBH	Harvested trees/ acre	Percent harvested trees (%)	150-ft no cut	All LWD (%)	100-ft no cut	75-ft no cut	IFP proposed	150-ft no cut (%)	100-ft no cut (%)	75-ft no cut (%)	IFP proposed (%)
Maggie Creek															
2	C-G	93	12	93	5	0	53	1	48	41	39	100	90	76	73
6	C-G	1,112	14	171	83	6	272	6	266	246	203	100	98	90	75
7	C-G	1441	7	190	102	7	368	8	363	343	331	100	99	93	90
9	C-G	209	11	134	46	3	164	3	155	134	111	100	94	82	68
Ponderosa															
2	D-L	1,624	6	151	63	4	298	6	297	279	264	100	99	94	88
14	D-G	1,399	14	149	61	4	113	2	105	89	97	100	93	79	86
St. Joe															
7	C-G	105	39	105	17	1	63	1	55	49	42	100	87	77	67
15	C-S	117	28	117	29	2	95	2	91	80	65	100	96	85	69
478	C-D	194	11	125	37	3	153	3	148	132	111	100	96	86	73
Average		496	16	142	54	4	178	4	171	155	136	100	95	85	75
Min		92	6	92	4	0	49	1	44	38	37	100	87	73	46
Max		1,624	39	335	247	17	368	8	363	343	331	100	100	96	97
SD		510	8	54	54	4	97	2	96	91	85	0	4	7	14

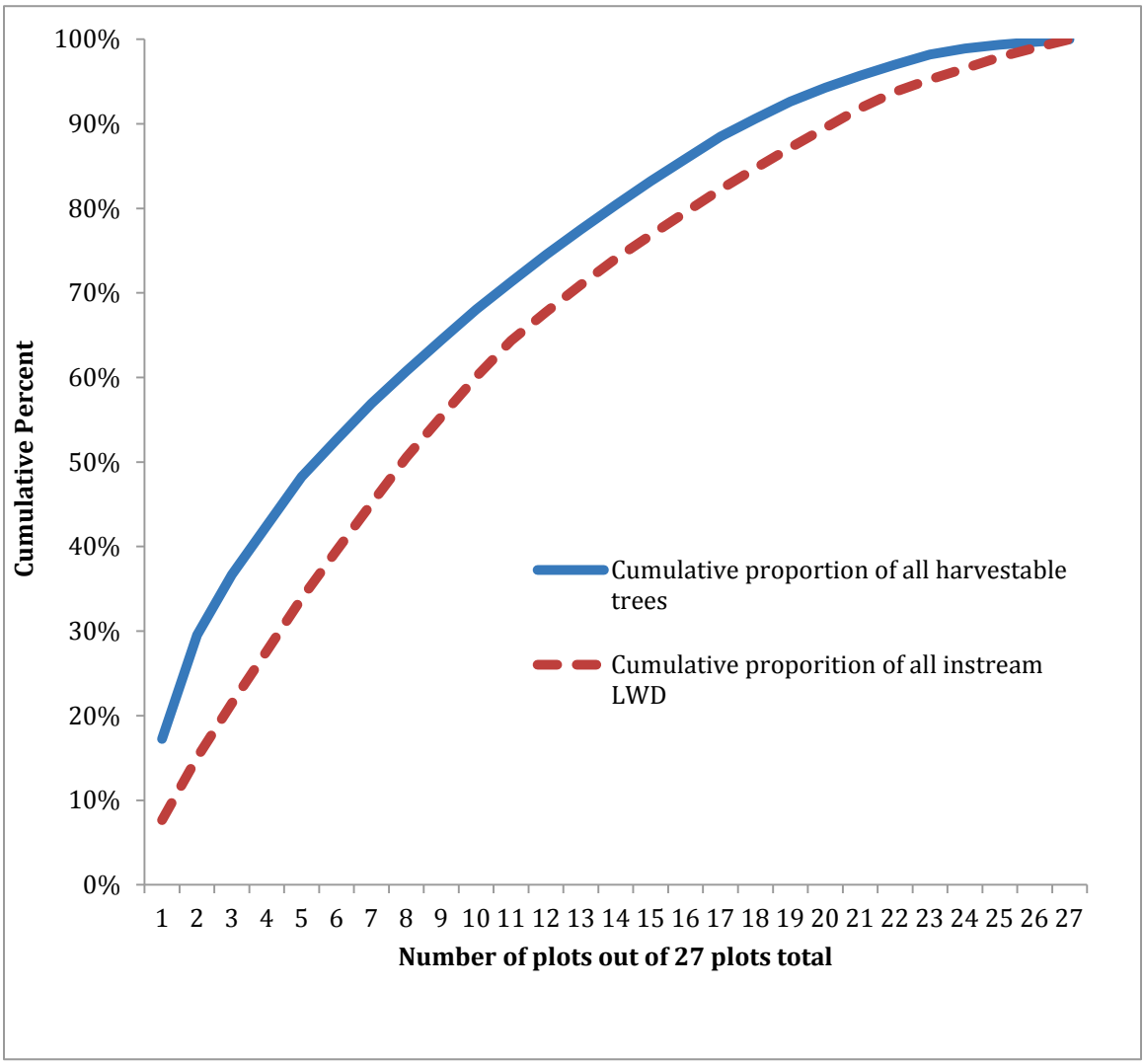

Figure 1. Comparison of cumulative contribution of each stand where harvest can occur relative to the total contribution of all 27 stands for both the amount of harvestable trees and the projected amount of instream wood provided by the stand for a 150-ft no-cut buffer. This figure illustrates that most of the harvestable wood (solid blue line) and most of the instream wood (dashed red line) comes from a relatively small number of stands. For example, about half of the harvestable trees come from just 5 of the 27 stands, while about half of the instream wood comes from just 8 of the 27 stands.

DISCUSSION

This analysis indicated that site-to-site variation is high, both in the number of harvestable trees and in the number of trees likely to be recruited to the stream. Much of this variation stems from the fact that these stands are quite disparate in terms of tree size, density, species composition, and presumably age. Thus, an examination of average metrics among these combined stands provided limited insight. More accurate assessments of the effects of thinning were gleaned by examining specific stands.

It was clear that most of the harvestable trees and instream LWD comes from a limited number of relatively high-density stands; however, this observation depends on the assumption of only a single harvest entry. Many stands that are presently projected to produce high amounts of instream wood during the next 100 years will fail to do so if there are repeated harvest entries.

As an example, Clearwater stand 41 has 618 trees per acre and is projected to produce 280 pieces of instream wood over the next 100 years, even with thinning. A single thinning entry, as proposed, will remove relatively few trees and will reduce wood-recruitment potential by just 21 trees relative to a 150-ft no-cut buffer. This is because Clearwater 41 contains numerous trees just below the 8-in diameter threshold. Thus, during a single immediate entry, few trees will be removed. If there is an additional harvest entry within 30 years, most trees that would have eventually fallen into the stream will be removed during thinning. Other stands are in a similar situation such that most instream wood projected to be recruited from these stands during the next 100 years will be eliminated if there are multiple harvest entries (e.g. every 30 years).

Stands with relatively high densities of large-diameter trees are also disproportionately affected by the proposed thinning rules. For example, Clearwater stand 30 has 140 trees per acre, which average 25 in DBH. If not thinned, a stand with this structure is well positioned to produce considerable amounts of instream wood of fairly large diameter in the near future. However, because so many trees in this stand are large diameter, many will be removed during thinning operations. According to projections of the FVS model, most remaining large trees would not be likely to die (and thus be recruited) any time soon because the thinning would reduce competition mortality. Thus, the overall effect of the proposed timber harvest in this riparian stand is a reduction to just 51% of its potential instream wood production.

There are numerous assumptions and caveats that go into forest growth and wood recruitment models (Appendix Table 1) that suggest instream wood recruitment could be overestimated. One important assumption that is probably not correct is that stand

conditions are homogeneous from the edge of the ordinary high water mark all the way to the outer edge of the buffer. Many riparian buffers are dominated by shrubs such as willow, and a substantial number of trees may not occur for some distance from the stream. Therefore, as an alternative analysis, I examined the amount of wood that would be recruited if the forest began 25 ft from the edge of the channel. That analysis is provided in Appendix Table 2. The analysis suggested that if few trees are immediately next to a stream, the potential for wood recruitment is substantially reduced and that assumptions that the stand data collected are actually representative of the entire width of the riparian forest need to be verified. There are a number of considerations other than riparian forest condition that will affect projected wood recruitment; these include side-slope angle, likelihood of landslides, and potential for stand-destroying events such as fire, drought, or insect outbreaks.

Additionally, it appears that the FVS model was not initially calibrated against growth data for individual tree species; it may be that generalized tree-growth models were used. A cursory review of projected growth suggests that more accurate growth and mortality rates could be obtained if the model were calibrated to the rates observed for individual tree species in the general area (data not shown). This was particularly apparent in the case of western red cedar, and to a lesser extent, grand fir, where the effect of thinning on the growth rate of remaining trees appeared to be overstated. This can lead to overestimates of the amount of instream wood that will be produced from a stand that is thinned.

Potential overestimates of wood production from the understory may also result from insufficient sampling of trees when the stand data were collected (9-17 trees measured for each stand). Although the plots were very small, data from a small number of trees was extrapolated and assumed to be representative of overall stand condition on a per-acre basis. Thus if a few understory trees happened to be in the sample, their numbers would be extrapolated to create a dense uniform understory for the purposes of modeling. In reality, understory regeneration is often quite patchy.

If a larger area were measured or several smaller areas combined, the sample data would capture that variability and reflect it in the average. This would provide more accurate projections as to how a stand will develop. In this case, the model may inappropriately assume that thinning will cause substantial understory release and result in more large wood than would have occurred in the absence of thinning.

A general effect of the proposed riparian thinning regime (proportional thinning down to 88 TPA) is its disproportional effect on instream wood recruitment. The proposed regime allows aggressive thinning in high-density stands that are “hotspots” for

instream wood production (Figure 1). Many of the stands examined had fairly low tree densities. Under the proposed regime, few trees in these stands would be removed; however, these stands will provide limited amounts of large wood to streams.

The fact that only 27 of the 119 stands examined had riparian tree densities high enough to support *any* timber harvest further suggests that most harvest will be concentrated in a relatively few, dense stands. These dense stands have the most potential to produce instream wood. Alternative silvicultural options that would minimize the loss of potential instream wood include 1) thinning from below rather than proportional thinning (i.e., leaving the largest trees) and 2) basing harvest on percentage of existing trees (e.g. 10%) removal, rather than on a fixed-density such as 88 TPA.

Another silvicultural consideration that would benefit the overall health of riparian forest is proportional species removal. The proposed riparian thinning regime does not specify which tree species can be removed. Without proportional species removal, it is possible that only the commercially desirable trees will be removed. This will slowly change the composition of the forest and potentially reduce both ecosystem function and overall diversity. In terms of instream wood, it is more desirable to have strong, slowly decaying species such as Douglas fir, cedar, and spruce. Species such as hemlock, grand fir and many hardwoods are less desirable because they are not as strong and tend to decompose more rapidly, thus providing fewer ecosystem functions for a more limited time.

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APPENDIX

Appendix Table 1. List of metrics and assumptions that go into the instream wood recruitment model used for this analysis (based on McDade 1990 and Van Sickle and Gregory 1990).

Metric	Model assumption	Likely effects
Treefall direction	Random	Probably a reasonable assumption on flat ground near streams. Farther away on steeper slopes, treefall direction is probably biased towards the direction of the stream. Thus, the assumption of randomness probably minimizes the relative importance of wood contributions from trees farther away from the stream on steep slopes.
Timing of treefall	Trees are assumed to fall the year they die	Many trees, especially smaller trees, remain standing upon death and slowly decay in place as standing snags. Small trees that do fall often lack the mass to break through the branches of adjacent trees and thus never enter the stream. The effect is an overestimate of both the amount of wood entering the stream in general and the amount of wood provided by small trees near the stream in particular.
Tree breakage	No breakage	An assumption of no breakage potentially underestimates the number of pieces of wood in a stream, since a tree that falls into a stream and then breaks would count as two (or more) pieces of instream wood. However, the model also assumes that the tree does not break between death and when it falls into stream. This assumption would tend to overestimate the amount of wood in a stream, since the top of a tree may break off before it falls, and in this case the tree is less likely to enter the stream when it does fall.
Functional tree height	Entire length of tree is functional, but no branches are large enough to be functional	Some wood recruitment models cut off "functional" tree height at 10 cm. I counted a tree as entering the stream if it passed through the plane at the edge of the bankfull channel. This was done because such trees can be important to riparian zone function and also can become instream wood if the bank erodes or if flooding moves the piece into the stream. Also, large trees do not typically follow the assumption of simple taper equations (e.g. cone-shaped) in that their top diameters are often larger than predicted. Further, the branches of older trees are often large enough to count as large wood, but branch wood is ignored in the model. The effect of these assumptions is that trees further away from the stream become more likely to contribute large instream wood, relative to the assumption of a diameter cut-off that lowers the height of the tree, but that the amount of large wood provided may be lower than what is actually provided because it is assumed that the trees that fall have no large branches that would break off and be counted as additional pieces of large wood.

Appendix Table 1. Continued.

Metric	Model assumption	Likely effects
Transport and decay	No transport or decay	I counted the number of trees likely to fall into the stream under different management scenarios over a 100-year period and did not estimate transport and decay rates. Assumptions of instream transport and decay are unnecessary to compare the relative effects of various management strategies; these assumptions, add a further source of unquantified error and uncertainty to the model outputs. Also, including transport and decay rates can obscure the relative differences between management strategies.
Wood amounts	Relative vs. absolute comparison	I emphasize the importance of making comparisons between the different management strategies. These comparisons are important because both the forest-growth and instream-wood recruitment models were not calibrated for this area and did not provide error estimates. Thus, while an absolute number can be generated in terms of wood produced, the likelihood that that number is accurate is unknown. Relative comparisons (e.g. percentages), on the other hand, allow for the relative effects of different management strategies, under the assumption that all variables are held constant except for the management options. The drawback is that a very small effect can appear large. For example, management may reduce wood recruitment from 2 to 1 trees on one site and from 100 to 50 trees at another, but they will both have the same relative effect (a 50% reduction). Thus, both relative and absolute effects must be considered to appropriately interpret the data.
Comparison of individual sites vs. averages	Both were examined	An average that lumps disparate groups of data together can produce misleading conclusions. In this case, a number of different forest types, featuring a wide range of ages and stand densities, were lumped together to produce an average that was of limited usefulness in evaluating effects of management. Examinations of individual stand data provide a much clearer sense of the effects of proposed management on different stand types.
Stand homogeneity and extents	Assumption that modeled stands are homogenous all the way to the bankfull edge of the stream	Many forests are heterogeneous near streams; that is, a band of trees near a stream often tends to be more hardwood-dominated relative to upslope stands, which tend to be conifer-dominated. Also, trees do not often extend to the edge of the bankfull channel, but there are shrubs or emergent vegetation. This is mostly due to floods or high water tables, beaver activity, etc. Most stands examined were conifer-dominated and appeared to be representative of more upland forest types. It was probably incorrect to assume that this forest type extended to the edge of the ordinary high water mark. The effect of this assumption is that both absolute and relative wood inputs may be substantially overestimated. This is a large source of potential error in wood recruitment estimates. As an example, Appendix Table 2 demonstrates the relative and absolute effects of having no trees within 25 ft of the ordinary high water mark (OHWM), as might be the case if there were a wet area near the stream dominated by willows and other shrubs. This can be compared with Table 2 to get some sense of the potential effect that such a scenario would have on wood recruitment under different management scenarios.

Appendix Table 1. Continued.

Metric	Assumption	Likely effects
Bank erosion	None	Assumptions of bank erosion can increase the relative importance of trees next to the stream towards wood recruitment. I did not include bank erosion for the following reasons: 1) The proposed management regimes will not affect bank erosion rates; thus a relative assessment of bank erosion was not necessary 2) Assumptions of forest homogeneity were not verified (see comment above), and there may be few trees next to the stream that are likely to be recruited by erosive processes 3) It appears that no harvest is allowed in channel migration zones, and outside of these zones, wood recruitment from bank erosion is likely to be minimal.
Harvest frequency	Single harvest entry at year zero, then leave alone for 100 years.	The assumption of a single harvest entry substantially increased estimates of wood that will be recruited under riparian thinning regimes. If there are multiple harvest entries, such as once every 30 years (i.e. four times in 100 years), then wood recruitment will be substantially reduced relative to a single harvest entry.

Appendix Table 2. Instream LWD produced under various buffers, expressed both as pieces per 1,000 ft of stream and as a percent of the amount provided by a 150 ft no-cut buffer, assuming no trees from 0-25 ft and then a continuous forest from 25 to 150 ft from the edge of the channel. TPA, trees per acre.

	Pieces per 1,000 ft for no-cut				Percent of a 150 ft no-cut buffer (%)			
Plot	150-ft no cut	100-ft no cut	75-ft no cut	25-ft NC/ 25-75 ft 88 TPA thin	150-ft no cut	100-ft no cut	75-ft no cut	25-ft NC/ 25-75 ft 88 TPA thin
Clearwater								
3	110.3	103.9	91.2	81.8	100	94	83	74
6	137.6	129.9	110.7	94.3	100	94	80	69
13	135.0	134.0	123.7	110.3	100	99	92	82
19	95.8	87.0	71.9	72.5	100	91	75	76
20	82.1	68.8	52.5	27.3	100	84	64	33
21	37.9	37.6	33.6	20.0	100	99	89	53
22	89.4	80.8	62.3	37.4	100	90	70	42
26	61.3	60.3	55.0	50.5	100	98	90	82
30	94.6	77.9	59.2	29.9	100	82	63	32
31	46.0	41.4	32.5	27.9	100	90	71	61
40	115.9	110.3	100.5	108.2	100	95	87	93
41	179.9	172.1	153.0	150.4	100	96	85	84
1043	156.6	151.4	132.3	138.1	100	97	85	88
1166	32.5	27.6	22.0	20.4	100	85	68	63
1339	231.8	209.5	167.7	68.0	100	90	72	29
Craig Mountain								
2	93.5	78.1	58.3	35.7	100	84	62	38
3	79.5	75.0	59.3	44.5	100	94	75	56
4	184.3	176.6	149.4	24.5	100	96	81	13
Maggie Creek								
2	36.8	31.4	24.2	22.4	100	85	66	61
6	162.0	156.2	135.7	92.9	100	96	84	57
7	206.3	201.1	180.9	168.9	100	97	88	82
9	109.1	99.5	79.4	55.8	100	91	73	51
Ponderosa								
2	169.3	167.7	150.2	134.8	100	99	89	80
14	77.1	68.9	53.6	61.3	100	89	70	80
St. Joes								
7	41.9	33.9	27.4	20.8	100	81	65	50
15	61.9	58.4	47.4	32.4	100	94	77	52
478	96.4	90.9	75.3	54.7	100	94	78	57
Average	108.3	101.1	85.5	66.1	100	92	77	61
Min	32.5	27.6	22.0	20.0	100	81	62	13
Max	231.8	209.5	180.9	168.9	100	99	92	93
SD	54.9	53.7	48.0	44.3	0	6	9	21