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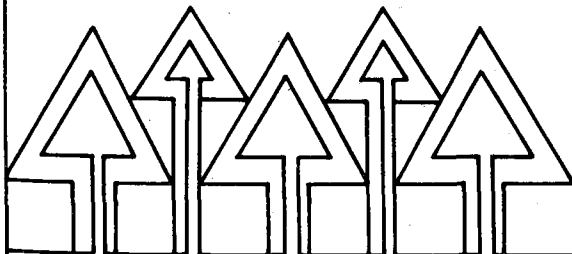
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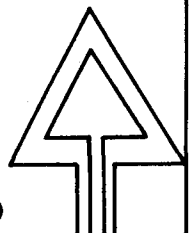
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# **Economic Impact of Proposed Oregon Forest Practices Rules on Industrial Forest Lands in the Oregon Coast Range: A Case Study**

Eldon D. Olsen  
David S. Keough  
Diane K. LaCourse



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## Abstract

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A case study was performed on a 1336-acre drainage in the Oregon Coast Range to determine the harvesting and transportation requirements of three alternative prescriptions for riparian management areas (buffers) on industry land. Timber-related activities were modeled and the associated costs estimated for each prescription in order to demonstrate the economic impact of changing buffer width and length and increasing

harvesting constraints. The results indicate that landowners' costs would be significantly greater than present costs if new Forest Practices Rules similar to those modeled in the more restrictive scenarios are implemented. In this study, cost increases ranged from \$75 to \$653 per acre, a large component of which is attributable to restrictions on conifer harvest in buffers.

## Introduction

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The Oregon Forest Practices Rules (OFPR) protect streams from logging damage by establishing riparian management areas, or buffers, along streams. Timber-harvesting activities within buffers are subject to restrictions that protect the shade, wildlife habitat, soil stabilization, and water-filtering effects of streamside vegetation.

In May 1986, a revision of the current OFPR was drafted by the Riparian Zone Task Force, a committee co-chaired by representatives of the Oregon Department of Fish and Wildlife and the Oregon Department of Forestry (ODF). This proposal increases restrictions on harvesting and other activities in the riparian zone.

The proposed rules may affect landowners' costs in several ways. First, changes in buffer requirements can change logging layout, and additional roads may be required because timber is no longer accessible by current road systems. New roads often must be located in terrain where construction costs are high. Second, costs for felling, yarding, and construction of landings may increase because (a) additional directional felling may be required within and adjacent to buffers, (b) payloads may decrease where buffers restrict tailhold locations, and (c) additional landings may be required where buffers limit access from centralized landings. Third, buffers contain merchantable timber which can be defined by the OFPR as necessary for habitat, and the value of such unharvestable timber is an uncompensated cost to the landowner.

There is considerable variation of opinion among industry, government, and university representatives as to what classes and lengths of streams will require buffering under the proposed rules changes. In this study, three different harvesting scenarios were developed for one Coast-Range site in order to estimate the potential economic impacts of proposed changes in width, length, volume-removal, and logging requirements within stream buffers. The first scenario represents industry practices under the current OFPR; the second and third scenarios represent progressively more restrictive interpretations of the proposed OFPR. Road costs, logging costs, value of merchantable timber left in buffers and inaccessible areas, and revenue lost from acreage taken out of production (e.g., for roads and landings) are summarized for each scenario. Several weeks of engineering work would be required for setting up and evaluating scenarios similar to these. Although some small cost elements were assigned average values, the majority of costs were estimated by conventional techniques for each specific harvest unit under each scenario. All comparisons utilize before-tax direct costs and foregone revenues.

Within the past year, private companies have done several case studies on the economic effects of various buffer-strip scenarios. The present study is different in that it focuses on harvesting variables and excludes more case-specific effects such as those on taxes, employment, overhead, and yield reductions adjacent to riparian management areas.

## Site Selection and Description

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A telephone survey was conducted to determine the characteristics of imminent harvest sites and of operations typical of industrial forest land in the central Coast Range. The survey data represent a total of 1.5 million acres, and include stand age, net volume per acre on uplands and in

stream bottom lands, site productivity in terms of mean annual increment, densities of ODF Class I and Class II streams, sizes of cutting units or average yarding distances, road density after harvest, percent tractor ground, percent slope, harvesting systems used, and rotation

length. Weighted averages of these values were modeled as closely as possible and are assumed to represent the majority of Coast-Range industrial sites and operations.

Survey data provided the following criteria for site selection: average slope of 55%, ODF Class I stream density of 0.66 to 2.0 mi/mi<sup>2</sup>, and ODF Class II stream density of 1.4 to 8.9 mi/mi<sup>2</sup>. Other selection criteria included site accessibility, size of approximately 1,500 acres, and availability of maps, aerial photographs, and other resources. To better characterize natural variations in geomorphology and to minimize bias in any one logging/buffer interaction, one large acreage was modeled rather than several smaller ones.

According to these criteria, a 1336-acre study site was chosen in the Nettle Creek drainage

## Model Design

### Preharvest Timber Volumes

Preharvest timber volumes assigned to the study site represented those of typical industrial timber stands scheduled for harvest within the next decade. They were first determined from our telephone survey data and then compared with other data sources for Coast Range timber volumes, including unpublished plot data collected by the Pacific Northwest Forest and Range Experiment Station, the 1980 Oregon Timber Supply Assessment (Stere et al. 1980), and survey data collected by the Oregon Forest Industries Council (Vomocil 1986).

Because timber-volume information was limited and potential variability is high, two conifer volumes were modeled for the uplands—one for small and one for large timber. Small timber was assigned a volume of 36 mbf/ac and an average diameter at breast height (dbh) of 18 inches; large timber was assigned a volume of 60 mbf/ac and an average dbh of 28 inches; and conifers in riparian zones were assigned a volume of 29 mbf/ac and an average dbh of 28 inches.

### Riparian Zones

Stream classifications were determined from an aquatic map provided by the USDA Forest Service (USFS). USFS stream classifications I and II were considered equivalent to ODF Class I, and USFS

(Sections 20, 21, 27, 28, 29, 33, and 34, T12S, R9W, Willamette Meridian) on the Siuslaw National Forest in the Oregon Coast Range. This site was chosen from among 11 candidates because it best represents the typical geomorphology of industrial forest land. Timber type and density, management goals, logging practices, and road systems on National Forest land may not represent those of industry, but these factors were modeled to represent current industry practice.

Characteristics of the Nettle Creek site include (a) approximately 1 mi/mi<sup>2</sup> of ODF Class I and 5 mi/mi<sup>2</sup> of ODF Class II stream, (b) average slope of 50%, (c) moderately stable soil conditions for road construction, and (d) 9.1 miles of existing ridgetop road at 3.6 mi/mi<sup>2</sup> density.

classifications III and IV equivalent to ODF Class II. These assumptions were field-verified by a local Forest Practices Forester (FPF), and, except as otherwise noted, references to stream classifications hereinafter refer to ODF classes.

Aerial photographs of the Nettle Creek drainage were measured to determine the widths of riparian vegetation zones (as indicated by changes in vegetative type) for Class I and II streams. Average widths were 75 feet on each side of Class I streams and 25 feet on each side of Class II streams.

### Roads

The study site was initially assumed to be unroaded except for the ridgetop roads that outlined the drainage; road locations were modeled according to the requirements of each scenario. Design criteria used in modeling road construction were a composite of industry standards and Oregon Forest Practices requirements, and included

- 13% maximum adverse grade, 18% maximum favorable grade.
- 14-foot subgrade width, 12-foot running surface.
- Surface consisting of 6 inches of pit-run and 4 inches of crushed aggregate.

- Balanced sections for sideslopes <50%, full bench for sideslopes >50%.
- Sidecast construction on slopes <65%, endhaul near headwalls and on most sideslopes >65%, 100% endhaul on sideslopes >85%.
- 10% of excavation quantity ripped, 90% common excavation.
- Production rates as follows: endhaul, 44.4 yd<sup>3</sup>/hr; rock haul, 16.7 yd<sup>3</sup>/hr; loader, 151 yd<sup>3</sup>/hr.
- Company-owned rock pits; pit development unnecessary.

Road locations which appeared on the map to be in particularly difficult terrain (e.g., sideslopes >80%) were field-checked for feasibility, and all locations were inspected for major construction obstacles such as large slumps, sag ponds, or rock outcrops. Road grades were not actually laid out in the field, but switchback curve locations were checked in some cases. Culvert requirements for each road project were determined from average road grade, length of road, and erosion class.

## Harvest Systems

### Felling

Directional felling was employed exclusively in and within 50 feet of buffers. Besides protecting vegetation in the buffer, directional felling within the adjacent 50-foot protective strip establishes a

felling pattern in which logs fall parallel to the ground contours, thus minimizing log breakage. On slopes  $\geq 70\%$  where directional felling was needed, line-pulling of larger trees was assumed; small timber (18-in. dbh) within buffers or protective strips was assumed to be felled by jacking or by directional techniques other than line-pulling.

Felling production rates, listed in Table 1, were the same for all scenarios. Rates for conventional felling were estimated from a computed hourly felling cost and USFS regional average values per mbf. Production rates for jacking and line-pulling were estimated from values published in current forest-engineering literature and from discussion with local felling contractors.

### Yarding

Individual logging plans were developed for each scenario and were based on conventional systems and current industry practices. Lateral yarding systems were designated for logging through or near buffer strips in scenario I based on a telephone survey of industry representatives regarding procedures currently in use.

The study area was initially divided into settings. Landing locations and setting boundaries were planned so that only the four conventional logging systems were required: shotgun, hi-lead, slackline, and live skyline with a slackpulling carriage. Setting boundaries and system requirements were determined according to slope, yarding distance, whether lines were running through a

TABLE 1.  
PRODUCTION RATES AND UNIT COSTS FOR FELLING AND YARDING.

System	Small timber				Large timber			
	Scenarios I and II		Scenario III		Scenarios I and II		Scenario III	
	Rate	Cost/ mbf	Rate	Cost/ mbf	Rate	Cost/ mbf	Rate	Cost/ mbf
Felling (mbf/worker-hour)								
Conventional <sup>1</sup>	1.95	15.47	1.95	15.47	2.78	10.83	2.78	10.83
Jacking	0.90	31.16	0.90	31.16	1.65	16.99	1.65	16.99
Line-pulling	—	82.89	—	82.89	3.10 <sup>2</sup>	68.47	3.10 <sup>2</sup>	68.47
Yarding (mbf/hour)								
Hi-lead	3.36	57.79	3.42	56.77	8.24	28.99	8.57	27.87
Shotgun	3.73	52.05	3.80	51.10	9.15	26.11	9.53	25.06
Shotgun (tailtree)	3.49	55.85	3.52	55.38	8.28	29.07	8.45	28.38
Slackpuller	3.35	63.36	3.44	61.70	8.24	31.18	8.57	29.99
Slackpuller (tailtree)	3.27	65.14	3.35	63.59	7.96	32.51	8.22	31.48
Tractor	3.52	24.62	3.52	24.62	6.41	13.52	6.41	13.52

<sup>1</sup> Unit costs for conventional felling from USDA Forest Service (1985).

<sup>2</sup> Rate is given in mbf/crew-hour.

buffer, and payload analysis. A digitizer program was used to determine setting size, average yarding distances, and road lengths from contour maps of the area. Approximately 1% of the planning area in each scenario required downhill logging.

LOGGER, an unpublished computer program developed within the Forest Engineering Department at Oregon State University, was used for payload analysis. A minimum log payload of 10,000 lb was considered acceptable for each skyline profile analyzed, and was based on an estimated average turn weight of 6,200 lb for large timber and 4,100 lb for small timber. If payload analysis indicated that the minimum load could be yarded with the use of a tailtree, a tailtree was used to minimize line damage to streamside vegetation. No hi-lead systems were used adjacent to stream buffers.

Two tower sizes were designated for yarding—a 47-foot Madill 071 for small timber and a 90-foot Berger C-23 for large timber. (In one unit, topographical restrictions necessitated use of the large tower to yard small timber.) From a compendium of equations compiled by Aubuchon (1982) for various yarder sizes, we selected regression equations for predicting turn times for a live skyline system with lateral yarding capability (Madill 071) and for one without lateral yarding capability (Berger C-23). Cable-yarding production rates for each setting were computed from these turn times. When tailtree rigging was required, the base production rate was reduced by the ratio of tailtree rigging time to total logging time for that particular skyline road. The proportion of each unit requiring tailtrees was based on the proportion of skyline roads requiring tailtrees, as determined by reviewing payload analysis data and the topographic map. Cable production rates are summarized in Table 1.

Because the times required for landing changes, tower rig-up, and road changes were not included in the regression models, these values were estimated independently of production rates. Designated average landing-change and tower-rig-up times were 2 hr for the small and 5 hr for the large tower.

Landing sizes designated for the 90- and 47-foot towers were 6,600 and 4,800 ft<sup>2</sup>, respectively. Respective earthwork quantities

associated with these landings were 1,100 and 405 yd<sup>3</sup>; acreages were 0.15 and 0.11.

A Caterpillar D5B track-type tractor without an integral arch was designated for logging areas whose sideslopes were <30%. Total ground-based area ranged from 112 to 129 ac in this study, averaging 8.5% of the planning area for each scenario. The procedure for estimating ground-based production rates was based on information in the Caterpillar Performance Handbook (Caterpillar Tractor Co. 1983). A weighted average production rate for all scenarios was calculated from production rates for individual units (Table 1).

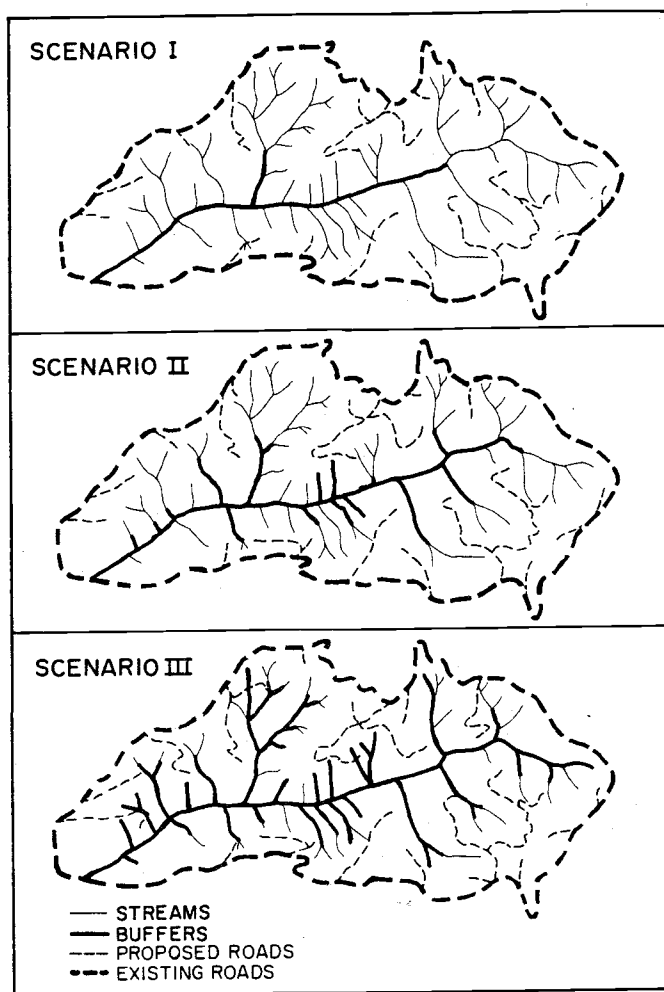


FIGURE 1. Three harvesting scenarios modeled for the Nettle Creek drainage. Existing ridgetop roads outline the study area.



## Scenario Descriptions

### Scenario I

Scenario I (Figure 1, Table 2) was modeled according to the current (1986) Forest Practices Rules. For this scenario, it was assumed that 75% of preharvest shading of streams could be maintained by hardwoods and unmerchantable conifers; all merchantable conifers within buffers were assumed harvestable. Only Class I streams were buffered, and buffer width averaged 35 ft on each side of the stream. Only cable logging systems were modeled adjacent to Class II streams and in or near buffers on Class I streams because no tractor ground exists adjacent to streams in the Nettle Creek drainage.

Under the current rules, live lines can be run through buffers on Class I streams upon approval by an FPF, and the telephone survey verified that approval is usually easy to obtain. It was therefore assumed that live lines through buffers were acceptable in scenario I with little restriction. Yarding assumptions, in order of priority, were (1) to yard away from streams and buffers, (2) to utilize tailtrees if they could eliminate live lines through buffers, and (3) to permit live lines through buffers if full suspension could not be achieved otherwise.

### Scenario II

Scenario II (Figure 1, Table 2) represents a moderate interpretation of the proposed rules (relevant portions of which are reproduced in the Appendix), and was modeled to provide greater stream protection than scenario I. Differences include moderate increases in buffer width and length, in timber volume left in buffers, and in other logging restrictions. Scenario II provides for protection of wildlife habitat as well as the shading, soil-stabilizing, and water-filtering effects of forest vegetation in buffers on Class I streams.

In scenario II, approximately 60% of the merchantable conifer volume in buffers was considered harvestable. Buffer width averaged 50 ft on each side of Class I streams, and approximately 20% of streams currently in Class II were reclassified into Class I. Of this 20%, one-half of the USFS Class III streams were randomly selected to be buffered for 100% of their length, and one-half were buffered for 20% of their length. No USFS Class IV streams were buffered.

Although the proposed rules include a recommendation to "avoid cable yarding through any Class I stream," they allow yarding across a Class I stream at the discretion of an FPF if logs are either fully suspended above the vegetative

TABLE 2.  
SUMMARY OF SCENARIO CHARACTERISTICS.

Characteristic	Scenario		
	I	II	III
Average buffer width (feet) on each side of stream	35	50	70
Percentage of Class II streams reclassified	0	20 <sup>1</sup>	80
Percentage conifer removal allowed in buffers	90-100	60	25
Logging practices	Current industry practices	FPF discretion allowed. Minimum corridor spacing 150 ft.	Same as scenario II
Allowable discretion	Current interpretations	Flexibility in application of rules	No deviation from 80% reclassification and 25% conifer removal

<sup>1</sup> Members of the Riparian Zone Task Force have estimated that only 1% to 2% of the current Class II streams would be reclassified into Class I under the proposed rules. This is subject to interpretation.

cover or yarded through "well-spaced" corridors to minimize damage to the buffer. In this study, "well-spaced" is interpreted to mean a minimum distance of 150 ft between corridors. This interpretation is based on lateral slackpulling distance, 75% canopy retention, number of conifers per acre to be left in buffers, and use of "common" corridors by running lines through them from landings on both sides of the stream. The minimum angle of intersection for two lines using the same corridor to meet these conditions was calculated to be 150 degrees (Figure 2), which extrapolates to a corridor spacing of 150 ft. Logging plans for scenario II were developed on the assumption that corridors would be cut through buffers on all units, and landings and corridors were located such that corridor spacing was restricted to 150 ft and corridors were shared when logging occurred on both sides of a stream. In actual practice, it is likely that full suspension, though more expensive, would be substituted for corridors through the buffers wherever possible. In this scenario, a slackpulling system was used when live lines crossed buffers.

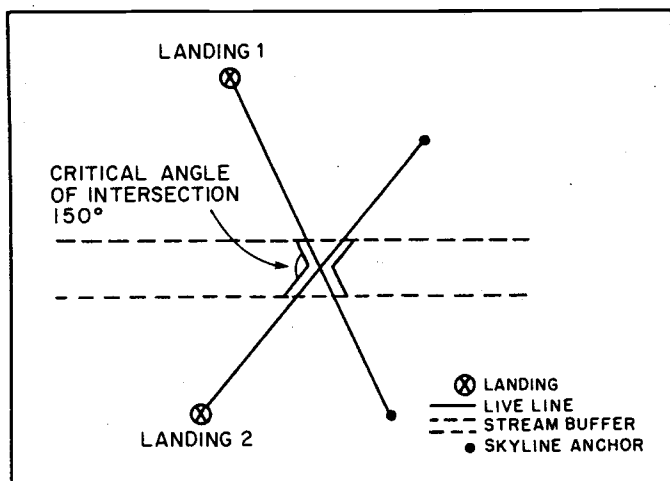


FIGURE 2. Design of a "common" skyline corridor through a stream buffer.

### Scenario III

Scenario III (Figure 1, Table 2) was modeled to provide stream protection under an interpretation of the proposed rules that is more restrictive than that of scenario II. This interpretation allows no FPF discretion in administering the proposed rules as they relate to buffer width, buffer length, or the timber volume to be retained in buffers.

In scenario III, no more than 25% of merchantable conifer volume within buffers was considered

harvestable. Regardless of site-specific conditions, average buffer width was 70 ft on each side of all Class I streams, and 80% of streams currently in Class II were reclassified as Class I. Of this 80%, all USFS Class III streams and one-half of all USFS Class IV streams (randomly selected) were upgraded to ODF Class I and were buffered for 100% of their length. The remaining USFS Class IV streams were upgraded to ODF Class I, but only 40% of their combined length was buffered. All streams currently in Class I were buffered for 100% of their length.

Except for the requirements above, harvesting assumptions were the same as those in scenario II.

## Costs

### Felling

Felling costs were generated by considering USFS timber-appraisal methods, costs published in current forest engineering literature, conversations with local felling contractors, and conventional equipment and labor costing techniques. These costs are summarized in Table 1. Unit costs for jacking and line-pulling were determined from production rates and machine and labor costs for personnel and equipment. The study site was divided according to felling method required and timber volume felled per acre, and felling costs were calculated by multiplying unit costs for each method by the volume felled.

### Yarding

Hourly machine and labor rates were determined for five logging configurations: hi-lead, shotgun/slackline with and without tailtree, and slackpulling with and without tailtree. Cost differences were caused by rigging requirements, the largest being the mechanical slackpulling carriage needed with slackpulling systems. Unit yarding costs were determined from those machine rates and a time-weighted average of all production rates for each setting, and total costs were determined from those unit costs in a manner similar to that used to compute felling costs. Landing- and road-change costs also were determined from machine rates and the time required for each activity. Unit costs for yarding are summarized in Table 1.

### Roads and Landings

Data were collected for each road segment, and costs were estimated for each construction com-

ponent (e.g., survey and staking, clearing and grubbing, excavation) and then summed. This procedure was performed for each scenario. Cost estimates were based on information from USFS and BLM sources and from local rock suppliers.

From unit costs for road construction, average landing construction costs were determined to be \$1,555 and \$606 for the large and small yarders, respectively. These averages were used for computing total landing construction costs for all scenarios.

### Tractors, Loading, and Hauling

Tractor, loading, and hauling costs were determined from machine and production rates by the same method as that used for yarding costs. Unit tractor costs, estimated from USFS cost-appraisal information, were \$24.62 and \$13.52 for the 36- and 60-mbf/ac volumes, respectively. Loading production was assumed to be equal to the weighted average yarding production; haul production was computed on the basis of 5 mbf per truckload, 65-mile round trip, and average truck speed of 25 mph. Total costs were determined as a function of the total volume loaded and hauled. A profit-and-risk allowance equal to 10% of total harvesting costs was included for all scenarios.

### Timber and Loss Values

Mean annual increment (MAI) was used for evaluating the economic impact of roads and

landings as areas taken out of production. MAI for privately owned land in the central Coast Range was determined from the telephone survey to average 740 bf/ac/yr. The same MAI was used for both small and large timber because timber size was considered to be a function of age rather than site class.

When roads and landings were first built, right-of-way timber was credited as part of the harvest; acreage covered by roads and landings was then permanently removed from future harvest calculations. Because this economic analysis does not extend to the next rotation, the present worth of acreage removed from production was evaluated on the basis of MAI and summed over the next 25 years.

The economic impact of unharvested net conifer volumes, measured in million board feet (MMbf), was calculated with an assumed 1986 stumpage value of \$150/mbf. This is the value of the standing timber on the open market and does not include adjustments for the cost of growing the timber or for business taxes. Actual stumpage can vary according to production costs, timber market conditions, and profit and risk margins.

The entire site was assumed to be harvested over 25 years with total roading and harvesting costs spread evenly over that period. For this analysis, a real stumpage-price growth (above inflation) of 1.5% per year was assumed in order to determine real stumpage value for each year. (For example, real stumpage value after 25 years is  $\$150 \times (1.015)^{25} = \$218$ .)

## Results and Discussion

### Harvesting

Total harvesting costs include felling, ground-based and cable yarding, road (cable corridor) and landing changes, landing construction, and loading and hauling. These components were analyzed independently, and affect total harvesting costs in different ways. Total harvest for each scenario is listed in Table 3; harvesting costs for each scenario, and the difference from scenario I for each harvesting component in scenarios II and III, are shown in Table 4. These data are for comparison only; all costs are undiscounted and are directly applicable only if the entire 1336-acre area is harvested in one season.

Harvesting costs were not greatly affected by the imposed restrictions. Total felling costs

TABLE 3.

TOTAL HARVEST FOR EACH SCENARIO, BY YARDING METHOD AND TIMBER SIZE.

Yarding method	Scenario					
	I		II		III	
	Acres	mbf	Acres	mbf	Acres	mbf
Small timber						
Cable	1,221	43,221	1,215	42,353	1,193	37,600
Ground-based	112	4,032	112	4,032	129	4,644
Total	1,333	47,253	1,327	46,385	1,322	42,244
Large timber						
Cable	1,221	70,005	1,215	68,857	1,193	61,946
Ground-based	112	6,720	112	6,720	129	7,740
Total	1,333	76,725	1,327	75,577	1,322	69,686

TABLE 4.

HARVESTING COST SUMMARY (1336-acre basis).<sup>1</sup>

Activity	Scenario I		Scenario II		Scenario III	
	Unit cost/mbf	Total cost	Unit cost/mbf	Total cost	Unit cost/mbf	Total cost
<u>Small timber (36 mbf/acre)</u>						
Felling	15.47	735,917	16.27 (1.20;7.5%)	754,498 (18,581)	17.88 (2.31;15%)	755,281 (19,364)
Loading	20.31	959,708	20.31	942,097 (17,611)	20.31	857,976 (-101,732)
Hauling	28.93	1,367,029	28.93	1,341,918 (25,111)	28.93	1,222,119 (-144,910)
Yarding						
Cable	58.70	2,537,072	60.48 (1.78;3%)	2,561,513 (24,441)	60.12 (1.42;2.5%)	2,260,334 (-276,738)
Tractor	24.62	99,268	24.62	99,268	24.62	114,335 (15,067)
Road change	3.16	136,734	3.06 (-0.10;-3%)	129,438 (-7,296)	3.01 (-0.15;-5%)	113,159 (-23,575)
Tower move & rig	0.40	17,086	0.40	17,086 (0)	0.62 (0.22;55%)	23,299 (6,213)
Landing construction	0.62	26,664	0.63 (0.01;1%)	26,664 (0)	0.97 (0.35;56%)	36,360 (9,696)
Subtotal	124.43	5,879,478	126.60 (2.17;1.7%)	5,872,482 (-7,014)	127.42 (2.99;2.4%)	5,382,863 (-496,615)
Total with profit- and-risk allowance	136.87	6,467,426	139.26 (2.39;1.7%)	6,459,724 (-7,702)	140.17 (3.30;2.4%)	5,921,149 (-546,277)
<u>Large timber (60 mbf/acre)</u>						
Felling	11.15	885,367	12.28 (1.13;10%)	928,032 (72,665)	14.50 (3.35;30%)	1,010,424 (-155,057)
Loading	8.32	638,352	8.32	628,801 (-9,551)	8.32	572,819 (-65,533)
Hauling	27.59	2,116,843	27.59	2,085,169 (-31,674)	27.59	1,922,637 (-194,206)
Yarding						
Cable	29.55	2,068,812	31.56 (2.01;7%)	2,173,409 (104,597)	33.33 (3.78;13%)	2,064,543 (-4,269)
Tractor	13.52	90,854	13.52	90,854	13.52	104,645 (13,791)
Road change	1.64	114,513	1.57 (-0.07;-4%)	107,847 (-6,666)	1.50 (-0.14;-8.5%)	93,075 (-21,438)
Tower move & rig	0.75	52,553	0.76 (0.01;1%)	52,553 (0)	1.16 (0.41;55)	71,664 (19,111)
Landing construction	0.98	68,420	0.99 (0.01;1%)	68,420 (0)	1.51 (0.53;54%)	93,300 (24,880)
Subtotal	78.67	6,035,714	81.18 (2.51;3.2%)	6,135,085 (99,371)	85.14 (6.47;8.2%)	5,933,107 (-102,607)
Total with profit- and-risk allowance	86.49	6,636,285	89.29 (2.80;3.2%)	6,748,594 (112,309)	93.65 (7.16;8.3%)	6,526,418 (-109,867)

<sup>1</sup> All unit costs are given in dollars/mbf. Changes relative to scenario I are shown in parentheses.

increased in progressively restrictive scenarios even though less timber was cut, but total yarding costs increased only slightly or decreased because (a) less volume was harvested in more restrictive scenarios and (b) yarding distances shortened and productivity increased in scenario III because more roads were required. The cost of additional roads and landings exceeded the savings gained from increased yarding production, so these roads normally would not be built except in response to the buffer requirements.

Harvestable volume decreased from scenario II to scenario III, primarily because of requirements for conifer retention in buffers but also because the amount of inaccessible timber increased as greater stream-protection requirements caused blind leads and reduced payloads. Although all scenarios permitted some yarding through stream buffers, the more restrictive scenarios required corridors through buffers to be at least 150 feet apart. These protective measures reduced payload capacity on some settings and severely restricted logging access in some areas.

## Felling

Total felling costs increased as restrictions intensified, even though the volume cut decreased. The shift to a higher percentage of directional felling, both jacking and line-pulling, caused this increase. The relatively small total cost jump from scenario II to scenario III in small timber illustrates how harvesting less timber (25% rather than 60% of conifers within buffers) can offset the substantial cost increases that result from the use of more expensive felling techniques.

## Yarding

Cable yarding is by far the largest harvesting-cost component, and also the most complex in terms of the interaction between costs and management requirements. As with felling, the decrease in timber harvested tended to reduce total cable yarding costs, even though unit costs increased because of the shift to more expensive, lower-production logging systems. Systems with

lateral yarding ability were required for protection of buffer areas and to attain 150-foot corridor spacing along buffers. This requirement reduced production rates and increased unit costs compared to nonlateral systems because of (a) the added production components of lateral outhaul and inhaul, (b) the higher cost for slackpulling carriages, and (c) the need for more tailtrees in order to minimize live lines through buffers. Production rates can also decrease if tailtrees are not rigged in advance of yarding operations.

When the management requirements of scenario III were imposed, a completely new logging layout resulted. More roads and landings were needed in order to access the timber while maintaining the required stream protection. As more landings are used, landing construction and tower moving and rigging costs increase, and unit costs increase because more landings are used to access less timber. Scenarios I and II required 44 landings; scenario III required 60. As a result, average yarding distance was reduced from 842 feet in scenarios I and II to 765 feet in scenario III. Also, the external yarding distance for many units in scenarios I and II required a skyline tag for yarding with the small tower, whereas skyline tags were less often necessary in scenario III. These factors increase production rates and explain the relatively small increase in scenario III for cable production unit costs for small timber (Table 4). Even a small percentage increase in production costs (due, for example, to shorter yarding distance) greatly outweighs larger percentage increases in proportionally small operations such as road changes and tower moving and rigging.

Because the same landings were used in scenarios I and II, yarding distances (and therefore production rates) were the same for both. However, the overall production rate for scenario II was less because conditions required that a greater percentage of the yarding be done with less efficient systems, as shown below.

Yarding method	Scenario		
	I	II	III
	(%)		
Skyline			
Lateral	35	50	62
Nonlateral	35	22	18
Total	70	72	80
Hi-Lead	30	28	20

Ground-based skidding was greatest in scenario III because there were more roads, and right-of-way logging was included in the ground-based area computation. In this case study, unit costs for ground-based systems were not affected by changes in riparian-zone management requirements because ground-based logging occurred only on ridgetops or in other areas away from buffered streams (except where the road right-of-way crossed a buffered stream). This might not be true for another area, and unit costs could increase as management schemes change.

## Road Changes and Landing Construction

Road-change costs for cable yarding were lower, in total and on a unit basis, in the more restrictive scenarios. As more buffers are required, the distance between road changes is more likely to be 150 feet instead of 50-60 feet due to the shift toward more lateral yarding. More volume is harvested per road change, so, even though actual road-change time may be longer for more complicated systems with lines running through standing timber, fewer road changes are required. And, although there are fairly large changes in costs for items such as moving the tower and constructing landings (scenario III), these changes have little effect on overall harvest costs because the total costs for these operations are comparatively small.

## Loading and Hauling

Loading and hauling costs are functions of volume harvested only. Therefore, unit costs were the same for all scenarios, but total costs differed substantially because of differences in the volume loaded and hauled. These combined costs account for up to 42% of total harvesting costs, and thus tend to mute the effect of cost differences in other harvesting components. Loading and hauling costs are the main reason that total harvesting costs are lower in scenario III than in scenario I.

## Roads

Road requirements for scenarios I and II were identical except that a bridge accessing a landing in scenario I was eliminated in scenario II to avoid crossing the creek. This change required 0.11 miles of additional road construction at a cost of \$13,000. (No additional endhaul was needed.) Scenario III, however, represents an

entirely different logging plan. Headwall areas and steep sideslopes could be avoided when roads were located for scenarios I and II, but the management requirements for scenario III (i.e., reclassification of 80% of Class II streams into Class I) necessitated location of some roads in difficult terrain. This resulted in increases of 46.7% in road miles and 105% in road construction costs relative to scenario I (Table 5). Total road construction costs per mile for scenario III increased 39.8% over that for scenario I. However, 30% of this increase results from the requirement for 100% endhaul on 0.81 miles of road (12.7% of total miles), a construction practice involving about three times the cost of normal road construction.

These roads not only are expensive, but also are located in areas where the risk of road failure and resulting stream sedimentation is high. The increased buffer requirements for scenario III are intended to provide additional protection of water quality and of fish and wildlife habitat. However, part of the price of this additional protection appears to be increased chance of stream sedimentation because roads must be built in high-risk areas.

TABLE 5.  
TOTAL ROAD CONSTRUCTION REQUIREMENTS AND COSTS.<sup>1</sup>

Cost factor	Scenario		
	I	II	III
Miles of new construction	4.35	4.46 (2.5%)	6.38 (46.7%)
Number of landings	44	44	60
Acreage in roads and landings			
Small timber	22.7	23.2	33.2
Large timber	24.5	25.0	35.7
Total cost (\$1000's) <sup>2</sup>	200	213 (6.5%)	410 (105%)
Average cost/acre <sup>2</sup>	149	160	307
Average cost/mile <sup>2</sup>	45,977	47,758 (3.9%)	64,263 (39.8%)

<sup>1</sup> Changes relative to scenario I are shown in parentheses.

<sup>2</sup> Includes 10% profit-and-risk allowance.

## Value per Acre

Our results indicate that an increase in riparian-zone management requirements, as represented by scenarios II and III, would have a strong impact on landowners' costs.

Requirements for retention of conifers in stream buffers created the highest cost in the form of foregone revenue. From 70 to 92% of foregone timber volume is merchantable volume either left in buffers or inaccessible under the given conditions (Table 6). The remainder consists of future yield foregone because land is taken out of production for roads and landings (Table 7).

Because of the interaction among restrictions, it is difficult to isolate which factor (buffer width, buffer length, or conifer retention in buffers) has the greatest impact on foregone timber value. The combined effect of two independent changes in restrictions is different from that of the two changes imposed simultaneously. Obviously, even if all other costs are constant, market fluctuations can have substantial impacts on value per acre, particularly in scenario III.

Table 6 presents a cost comparison between the more restrictive scenarios and scenario I. The analysis was performed for both small and large timber in order to show the influence of that variable.

Instead of developing a harvest schedule that designated the year in which each acre in the study area would be cut, a present-value approach was used to account for management of the timber land over time. The total cost of cutting the entire 1336 acres was calculated in 1986 dollars; that cost was spread out equally over 25 years (a period during which the rules could reasonably be expected to apply and during which harvesting technology would likely remain stable); and the present value of the resulting 25-year cash flow was then discounted at a 4% rate, which represents the real compounding potential above the effects of general inflation.

With this present-value method, total impact is computed by simply multiplying total acres to be harvested in the next 25 years by the present-value cost/acre. For example, if a landowner harvests 1000 acres in the next 25 years and the present-value cost/acre is \$269, then the total impact is \$269,000.

Implementing Forest Practices Rules similar to those modeled in scenario II would result in discounted present-value costs to the landowner of \$75/acre for small timber and \$168/acre for large timber (Table 6). The cost for large timber is higher mainly because of the greater volume left in buffers. Implementing rules as modeled in scenario III would result in discounted present-value costs of \$269/acre for small timber and

TABLE 6.

SUMMARY OF REQUIREMENTS AND COSTS PER SQUARE MILE (640 ACRES).<sup>1</sup>

Description	Scenario I		Scenario II		Scenario III	
	Small timber	Large timber	Small timber	Large timber	Small timber	Large timber
Road construction						
New miles	2.09	2.09	2.14	2.14	3.06	3.06
Acres in roads and landings	10.9	10.9	11.1	11.1	15.9	15.9
Total cost (\$1000's)	96	96	102	102	197	197
Cost/acre	149	149	160	160	307	307
Harvesting						
MMbf <sup>2</sup> harvested	22.681	36.828	22.265	36.277	20.277	33.449
Acres harvested	638.3	638.3	635.5	635.5	633.1	633.1
Total cost (\$1000's)	3,104	3,171	3,101	3,239	2,842	3,133
Cost/acre	4,841	4,943	4,835	5,049	4,432	4,883
Cost/mbf	136.87	86.10	139.26	89.29	140.17	93.65
Inaccessible area and volume						
Inaccessible area in buffers (%)	1.3	1.3	3.9	3.9	14.0	14.0
MMbf left in buffers	0.000	0.000	0.313	0.378	2.214	3.062
Unloggable acres <sup>3</sup>	1.44	1.44	4.32	4.32	6.72	6.72
MMbf lost to roads and landings	0.202	0.202	0.205	0.205	0.295	0.295
Undiscounted costs						
Roads (\$1000's)	96	96	102	102	197	197
Harvesting (\$1000's)	3,104	3,185	3,101	3,239	2,842	3,133
Foregone volume (\$1000's) <sup>4</sup>	38	43	101	127	413	564
Total cost (\$1000's)	3,238	3,324	3,304	3,468	3,451	3,893
Cost/acre	5,060	5,172	5,163 (103)	5,419 (247)	5,393 (323)	6,083 (912)
Discounted costs (4% rate)						
Total cost (\$1000's)	2,023	2,069	2,071	2,176	2,195	2,487
Cost/acre	3,162	3,232	3,237 (75)	3,400 (168)	3,431 (269)	3,886 (653)

<sup>1</sup> Present-value costs (changes relative to scenario I) are shown in parentheses, and apply not only to acres in buffers, but to all acres.

<sup>2</sup> MMbf = million board feet.

<sup>3</sup> Inaccessible with conventional systems as determined by payload analysis.

<sup>4</sup> Foregone volume x assumed stumpage value (\$150/mbf).

TABLE 7.

## TOTAL ACRES TAKEN OUT OF PRODUCTION OR UNLOGGABLE, BY SCENARIO.

Characteristic	Scenario		
	I	II	III
Road right of way	17.8	18.3	26.6
Landings			
Small tower	4.9	4.9	6.6
Large tower	6.7	6.7	9.1
Unloggable area	3.0	9.0	14.0
Total area out of production <sup>1</sup>			
Small tower	25.7	32.2	47.2
Large tower	27.5	34.0	49.7
Area in buffers	17.4	52.1	187.3

<sup>1</sup> Area for the small tower corresponds with the volume assumption for small timber; that for the large tower corresponds with the volume assumption for large timber.

\$653/acre for large timber (Table 6). This increase (also due primarily to restrictions on harvesting merchantable conifers in buffers) is proportionally greater in scenario III because a larger percentage of Class II streams require buffers, and average conifer density in buffers is higher in these than in Class I stream buffers (Figure 3). In scenario II, the present-value cost/acre for large timber is 124% of that for small timber; in scenario III, that difference is 147%.

Table 8 shows present-value cost/acre for the more restrictive scenarios when (1) timber is harvested over a period other than 25 years and (2) a 6% instead of a 4% discount rate is applied. If an area is to be harvested immediately, the undiscounted present-value cost/acre from Table 6 will apply.

Total revenue was estimated by multiplying total volume harvested in each scenario by \$150/mbf (the assumed stumpage revenue). Relative cost impact as a percent of total revenue

could then be computed by comparing total revenues to the present-value costs associated with scenarios II and III. For scenario II, the added costs represented 2% and 3% of the revenue generated from harvesting operations for small and large timber, respectively. For scenario III, the respective added costs are 7% and 12% of the timber revenue.

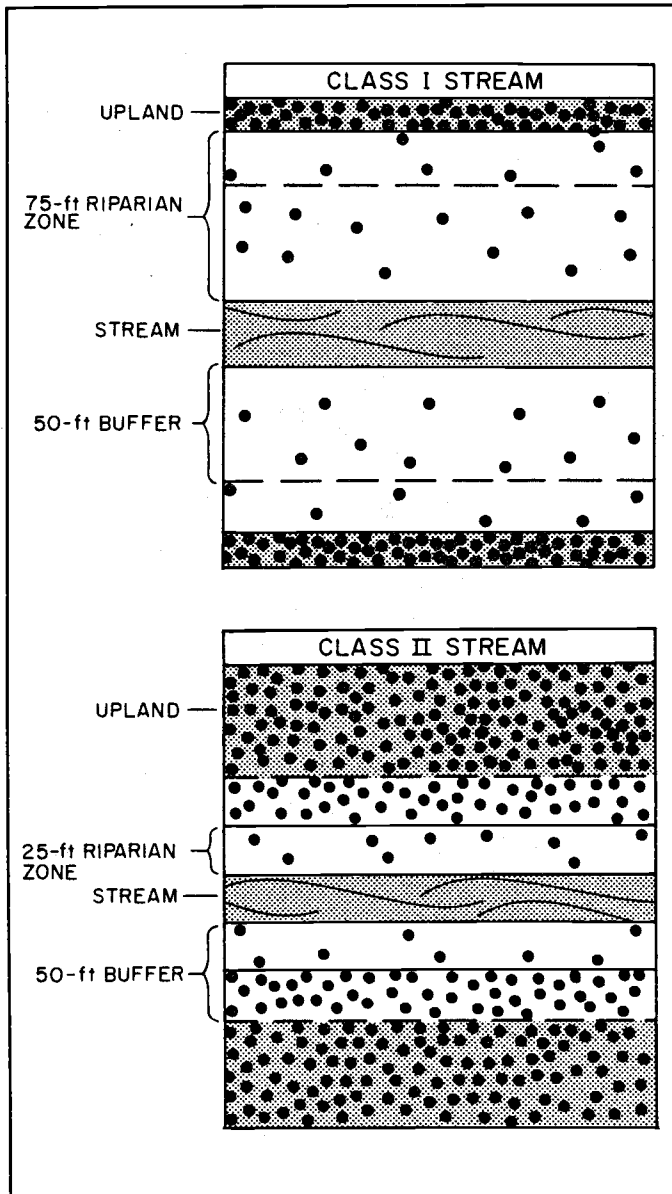


FIGURE 3. Relative conifer densities in riparian zones on Class I and Class II streams.

TABLE 8.

PRESENT-VALUE COST PER ACRE, IN DOLLARS, FOR THE MORE RESTRICTIVE SCENARIOS RELATIVE TO SCENARIO I, FOR VARIOUS HARVEST PERIODS AND TWO DISCOUNT RATES.

Harvest period (years)	Scenario II		Scenario III	
	4% disc.	6% disc.	4% disc.	6% disc.
Small timber				
5	94	89	312	295
10	89	80	301	272
15	84	73	291	252
20	79	66	280	233
25	75	60	269	216
30	71	55	259	200
40	64	47	239	173
50	57	40	221	151
60	52	35	205	133
100	37	22	1525	86
Large timber				
5	223	211	833	788
10	207	188	782	708
15	193	168	736	640
20	180	151	694	581
25	168	136	653	529
30	157	124	618	484
40	139	104	555	409
50	124	88	500	351
60	111	76	453	305
100	76	48	321	195

### Sensitivity to Stumpage Value

Table 6 also summarizes inaccessible and un-logging volume, the value of which was also computed with the assumed stumpage value of \$150/mbf. This value varies with timber market conditions, production costs, and profit-and-risk margins. The tabulation below shows that, even if all other costs are constant, fluctuations in stumpage value can have substantial impacts on value per acre, particularly in scenario III.

Stumpage value (\$/mbf)	Scenario			
	II		III	
	Small timber	Large timber	Small timber	Large timber
— (Present-value cost/acre) —				
100	51	136	127	456
150	75	168	269	653
200	99	199	411	851



## Sensitivity to Buffer Design

Two additional scenarios were developed to isolate the effects of changing either (1) buffer width or (2) buffer length (i.e., percentage of Class II streams reclassified), all other variables being identical to those in scenario II. Changing buffer length (the second of these scenarios) affected the proportional use of each logging system. The proportions employed for that scenario were, therefore, an average of those for scenarios I and II.

The tabulation below demonstrates that cost changes are not directly proportional to changes in buffer dimension.

The results show that, for the specific conditions modeled, upgrading streams from Class II affects present-value cost/acre about twice as

much as increasing buffer width on Class I streams. The primary reason is that the riparian zone is narrower, and average conifer density in buffers is therefore higher, on Class II than on Class I streams (Figure 3).

Percent Class II streams reclassified	Average buffer width			
	40 feet		50 feet	
	Small timber	Large timber	Small timber	Large timber
	(Present-value cost/acre)			
10 (0.5 mi/mi <sup>2</sup> )	—**	—**	51	120
20 (1.0 mi/mi <sup>2</sup> )	63	149	75*	168*

\* Values from Table 6.  
\*\* Not determined.

## Areas for Further Study

This study addresses only the timber-related costs and foregone revenues that would result from implementing the proposed rules. The following factors could affect the actual costs of implementation but are not considered in this study.

- Administrative cost of applying the rules.
- Costs associated with establishing a new stand. These include the construction cost of fire trails adjacent to stream buffers, animal damage to regeneration because of proximity to buffer habitat, and restrictions on burning, use of chemicals, and other site-preparation and silvicultural operations as they relate to stream buffers. All of these factors could cause productivity losses in or adjacent to buffer strips.
- Taxes and overhead. These issues would complicate the analysis and often would not significantly affect the results.
- Road maintenance costs. We assumed that constructed roads would be closed after logging. This assumption may not be appropriate in some cases.
- Cost of replanning and layout of previously planned logging units in order to comply with rules changes.
- Stream density. This study was conducted in the central Coast Range, and it reports economic impacts associated with that stream density. Because average stream density is lower and the species and volumes in the drainages are different in Cascade-Range watersheds, economic impacts of proposed riparian-zone management rules will differ in that area. Extrapolation to other situations is therefore inappropriate, and even a Coast-Range landowner may be affected more or less severely under conditions different from those imposed in the model. For example, because drainages in southwest Oregon often contain relatively high densities of mature conifers, a greater percentage of merchantable timber volume would be left to provide shade and woody debris. Economic impacts also would be greatly magnified for property that is concentrated along streams.
- Engineering capability. The logging costs represented in this study can be achieved only by companies that use state-of-the-art engineer-

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ing in planning and operations. Companies without this level of engineering skill would incur higher costs, especially in scenario III.

To complete the economic picture, the value of improved water quality, fish and wildlife habitat, and slope stability should be assessed and compared with the total costs. However, evaluating

these benefits is difficult, often requiring analytical tools not available to us. Such direct cost-benefit comparison may also be inappropriate because the net benefits represent a gain to society, whereas the timber landowner bears the costs of implementation; those incurring the costs do not reap the benefits directly.

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## Appendix: Oregon Forest Practices Rules

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At the time this study was done (August 1986), the Oregon Forest Practices, Northwest Oregon Region, General Rules were being changed. The study used the following tentative updated rules as the basis for the study.

### RULE #629-24-101: DEFINITIONS

(2) "Class I streams" means waters which are valuable for domestic use, are important for angling or other recreation, are used by significant numbers of fish for spawning, rearing, or migration routes, and/or have substantial influence on downstream water quality. Stream flows may be either perennial or intermittent.

(3) "Class II streams" means any headwater streams or minor drainages that generally have limited or no direct value for angling or other recreation. Stream flow may be either perennial or intermittent.

(28) "Streamside Management Area" means the combination of the aquatic zone, the riparian zone, and the riparian zone of influence in or along waters of the state. The streamside management area on each side of the stream shall be an average of three times the stream width, but not less than an average of 25 feet nor more than an average of 100 feet. Stream width is an average of the stream width during normal winter flow where the stream flows in a single channel.

(29) "Aquatic Zone" means the wetted area of streams, lakes, and wetlands up to the average high water level. Oxbows and side channels are included if they are part of the flow channel or contain freshwater ponds.

(30) "Riparian Zone" means the terrestrial area where the vegetation and microclimate are influenced by perennial or intermittent water, associated high water tables, and soils which exhibit some wetness characteristics.

(31) "The Riparian Zone of Influence" means the transition area within the riparian ecosystem between the riparian zone and the upland cover type. This zone is characterized by trees and shrubs that form the outer edge of the riparian ecosystem as identified by a change in plant composition, relative plant abundance, and the end of high soil moisture. This zone contains trees which may provide shade or contribute fine or large woody material or terrestrial insects to a stream. It also contains trees that provide habitat for wildlife associated with the riparian ecosystem.

#### RULE #629-24-546: STREAM PROTECTION

(2) Avoid cable yarding through any Class I stream. When yarding across such streams is necessary, it shall be done by swinging the yarded material free of the ground in the aquatic and riparian zones and in a manner to minimize disturbance to the zone of influence.

(3) Prior to skidding, yarding, or operating machinery in or through any Class I stream, obtain approval from the State Forester.

(5) The operator shall provide for shade, wildlife habitat, soil stabilization, and water-filtering effects of forest vegetation in streamside management areas adjacent to Class I streams.

Apply the following practices:

(a) Maintain 75 percent of the overstory canopy in the aquatic and riparian zones on both sides of the stream.

(b) Leave all snags, down unmerchantable logs, and shrubs in the aquatic and riparian zones. Snags determined to be a safety hazard by Workers' Compensation Department, Accident Prevention Division, OAR Chapter 437, Division 80, Logging are an exception to this rule.

(c) Retain a minimum average of nine conifers over 14 inches dbh per acre of streamside management area on each side of the stream where a sufficient number of conifers exist before harvest to do so. Cull or low-value conifers are satisfactory to meet this requirement.

(d) Limit machine and yarding activity in the riparian zone to the minimum required to remove timber harvested from the zone.

(e) Limit machine and yarding activity in the riparian zone of influence so that no more than one third of the ground surface is disturbed.

(f) Avoid cable yarding through Class I streams. When cable yarding across any Class I stream, use full suspension system lifting the material clear of the vegetative cover or through well-spaced corridors to minimize disturbance to the buffer.

(g) Timber felled in the streamside management area shall be directionally felled away from the stream.

(h) Residual trees and plants may be removed from the streamside management area where necessary to improve future wildlife and aquatic habitat upon prior approval of the State Forester.

Olsen, E.D., D.S. Keough, and D.K. LaCourse. 1987. ECONOMIC IMPACT OF PROPOSED OREGON FOREST PRACTICES RULES ON INDUSTRIAL FOREST LANDS IN THE OREGON COAST RANGE: A CASE STUDY. Forest Research Laboratory, Oregon State University, Corvallis. Research Bulletin 61. 15 pp.

A case study was performed on a 1336-acre drainage in the Oregon Coast Range to determine the harvesting and transportation requirements of three alternative prescriptions for riparian management areas (buffers) on industry land. Timber-related activities were modeled and the associated costs estimated for each prescription in order to demonstrate the economic impact of changing buffer width and length and increasing harvesting constraints. The results indicate that landowners' costs would be significantly greater than present costs if new Forest Practices Rules similar to those modeled in the more restrictive scenarios are implemented. In this study, cost increases ranged from \$75 to \$653 per acre, a large component of which is attributable to restrictions on conifer harvest in buffers.

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