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# Economic Implications for Management of Structural Retention on Harvest Units at the Blue River Ranger District, Willamette National Forest, Oregon

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## Abstract

Timber sales offered at the Blue River Ranger District since the 1988 introduction of management for stand structural retention were studied to describe and quantify, where possible, economic implications of that management. Values for the potential lumber from merchantable green trees ranged from \$102 to \$1114 per acre among the harvest units surveyed thus far. Protecting residual stand structure by not broadcast burning created an average savings of \$237 per unburned acre. When postsale snag creation was necessary to meet stand prescription requirements, average topping cost per tree was \$44.50 in 1989 but dropped to \$32.50 in 1990. Declines in revenues from future firewood sales may result from retention of stand slash and down wood. Administrative costs for the USDA Forest Service and logging costs for contractors have not been detailed. Response by bidders to sales with more than 2.0 million board feet of timber has not significantly changed since management for residual stand structure was introduced. Concerns that management for structural retention might reduce timber supplies for the wood products industry and timber revenues for the Forest Service have not been borne out thus far.

**Keywords:** Timber harvests, stand structure, retention, green trees, snags, down wood, Willamette National Forest.

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## **Introduction**

Since 1988, timber sales at the Blue River Ranger District (RD) in the Willamette National Forest (NF) have incorporated management practices for conservation of ecological values as outlined in the "Land and Resource Management Plan for the Willamette National Forest" (USDA Forest Service 1990). All current timber sale contracts include requirements for retaining structural features (green trees, snags, and down wood) from the previous stand. Stand structural features left after harvest (fig. 1, A and B) are designed to function as "biological legacies" that in turn are believed to maintain habitat and species diversity on National Forest timber lands (Swanson and Berg 1991). The number, size, and spatial arrangement of green trees, snags, and down wood used for these purposes have differed considerably with each timber sale contract. In some instances, otherwise merchantable timber must be left on the sale site in the form of green trees, snags, or pieces of down wood to meet the objectives of the specific stand prescription and the terms of the sale contract.

This paper examines existing knowledge of economic impacts and considers future economic implications and questions about management at the stand level for structural retention in the Blue River RD. We also characterize the economic outcomes for District-wide timber supply and revenues through calendar year 1990 as a function of management for structural retention, other concurrent policy decisions, and market behavior. The scope of this review is limited in that it draws on only the brief window of time when stand management has incorporated legacies of green trees, snags, and down wood in prescriptions for harvest sales. We had to use anecdotal information extensively because much needed information, particularly details on changes in harvesting costs under conditions of structural retention, does not exist in this initial period of transition, experimentation, and learning.

A sample of the range of minimum contract specifications for retention of green trees, snags, and down wood for representative sales is given in table 1. All timber sales originally projected timber volumes of 2.0 million board feet (mmbf) or greater.

Management objectives provide the basis for the silvicultural prescription for a particular stand. Harvest prescriptions are variable as a result of three factors: (1) sensitivity to site-specific ecological conditions; (2) adjustments needed for greater operational feasibility; and (3) the need to experiment with residual stand features in response to changing awareness of ecological management that promotes forest health and biological diversity. Knowledge of improved methods to achieve structural retention is growing. Recent timber sale contracts indicate trends toward (1) greater detail in specifications for retention of green trees, (2) increasing attention to retention of snags and down woody material, and (3) increasing use of clumping of retention trees into groups of 10 to 20 trees.

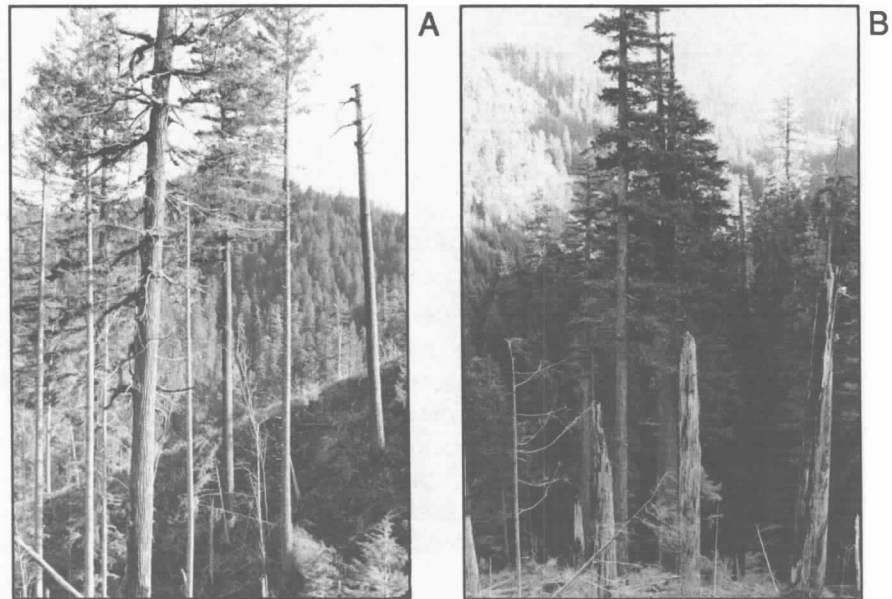


Figure 1—(A) Ennis unit no. 2. The management prescription required four trees per acre for retention: two live Douglas-fir trees >25 inches d.b.h., one hard snag, and one soft or decayed snag. (B) Slim Scout unit no. 2. The management prescription called for retaining per acre eight live Douglas-fir trees >24 inches d.b.h., all possible snags, and 300 lineal feet of down wood.

**Table 1—Structural retention requirements for selected timber sales, Blue River Ranger District, Willamette National Forest, Oregon, 1988-90**

Sale name	Sale year	Green wildlife trees	Dead snags	Down wood
----- Number per acre -----				
Ennis	1988	Total of 4 residual stems with live trees preferred over snags	—	—
Sinne	1988	2 >25 inches d.b.h.	1 hard, 1 soft	—
Titan Too	1989	3 >20 inches d.b.h. and >25 feet tall	—	—
Paws	1989	3 >23 inches d.b.h.	—	—
Lookout/ Sentinel	1989	5 >20 inches d.b.h. and >25 feet tall	—	12 logs >16 inches top end and >8 feet long
O'Leary	1990	6 >22 inches d.b.h. and >40 feet tall	Leave all possible	12 logs >16 inches top end and >8 feet long
Slim Scout	1990	8 >24 inches d.b.h. and >60 feet tall	Leave all possible	300 lineal feet with logs >16 inches top end and >10 feet long with 75 percent of lineal length in logs >20 feet long

## Potential Timber Volume and Net Lumber Value

Most prescriptions identify Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) as the preferred species for green trees, snags, and down wood. Douglas-fir, the most valuable economic timber species in the Blue River RD, is preferred for structural retention because of its rooting strength and consequent hazard reduction, its resistance to fire damage, and the durability of its wood over time, which provide desired habitat characteristics (USDA 1986). Shallow-rooted species such as western red-cedar (*Thuja plicata* Donn ex D. Don) have been avoided as retention trees and snag trees wherever possible.

Timber sale contracts at the Blue River RD contain a clause allowing for selection by the purchaser of trees, snags, and down wood to be retained on the site. Selections by the purchaser must meet all the guidelines set forth in the contract clause. These guidelines reflect the objectives of the prescription. Benefits of purchaser selection include improved safety and operational feasibility and reduced logging costs. Purchasers also are more aware of tree grade (value) when they select the wildlife trees. Use of this contract clause has assisted Blue River RD in meeting site-specific objectives, and it has addressed some of the concerns raised by purchasers and operators about having to leave valuable timber trees standing.

Estimates per acre of retained timber volume and potential net value of lumber from four units systematically inventoried at the Blue River RD differed widely. Table 2 presents data from the inventoried units. Average per-acre volume of retained merchantable wood ranged from 0.20 to 4.05 thousand board feet (mbf). Between 0.2 and 8.5 percent of the total merchantable stand volume was retained. High amount of defect in retention trees and a low average number of retention trees per acre accounted for the low merchantable volumes on the Sinne Unit No. 5. These stands were part of the earliest efforts at structural retention and represent the low end of the spectrum of volumes of merchantable timber retained for structure. More recently cut units have had more complex prescriptions, which have resulted in higher volumes of merchantable timber retained. An inventory analysis conducted in conjunction with researchers at the H.J. Andrews Experimental Forest is currently underway to document the entire range of retention volumes to date at the Blue River RD.

Potential net lumber value<sup>1</sup> of merchantable trees retained on site represents an opportunity cost<sup>2</sup> incurred in terms of lumber income foregone to obtain benefits of management for the ecological values of structural retention. Average per-acre value of potential lumber retained on units ranged from \$102 to \$1114 (constant 1989 dollars for 1989 lumber prices). Value depends on the tree species retained, the average dimensions of the retention trees (height and diameter at breast height [d.b.h.]), their timber quality (for example, percentage of defect), the number of merchantable trees retained per acre, number of acres treated, and current lumber prices.

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<sup>1</sup> Potential net lumber value is defined as the market value of lumber minus the manufacturing cost. Transportation and yarding costs are not included.

<sup>2</sup> Opportunity cost is the value of the next best option that must be sacrificed when an economic choice is made.

**Table 2—Estimates of net potential merchantable volume and net potential lumber value from timber sales with structural retention, Blue River Ranger District, Willamette National Forest, Oregon**

Sale unit	Acres	No. of merch. trees retained	Merch. vol. retained	Merch. vol. sold	Percent vol. retained <sup>a</sup>	Value retained <sup>b</sup>
----- Thousand board feet -----						1989 \$
Ennis No. 1	18	23	53.5	1,010	5.0	9,000
Ennis No. 3	70	140	283.5	3,040	8.5	78,000
Sinne No. 5	82	17	16.7	6,840	.2	8,364
Sinne No. 7	48	44	59.2	3,770	1.6	17,952

<sup>a</sup> Timber sale planners adjust timber cruise tallies of merchantable timber volume downward to account for projected merchantable volume reductions to be used as green trees, snags, or down wood. The timber sale volume advertised to the public is listed in the table heading above as "Merch. vol. sold." Percentage of retained volume is figured by dividing the volume of actual retained merchantable timber in the sale unit by the sum of the advertised sale volume plus the volume of the merchantable timber retained in the sale unit.

<sup>b</sup> Priced according to 1989 lumber values.

Prescriptions for timber sale units with retention of snags, green trees, and down wood have emphasized retaining, wherever practical, trees that have little or no economic value as saw logs but that have considerable value as wildlife habitat and as a biological legacy. In three of the sale units shown in table 2, extensive tree, snag, or down wood retention often was not an appropriate option because the sites were infested with laminated root rot fungus (*Phellinus weirii*). Retention of the overstory for seed trees and for future economic harvest has not been practiced as a primary objective. More recent prescriptions are considering a broader mix of objectives, however.

All harvested stands have been of natural origin. Old-growth stands generally have sufficient cull trees, snags, and down wood so that little if any net merchantable timber volume needs to be retained on site for structural legacies. In existing mature natural stands and in future managed stands, value and volume of merchantable trees left for ecological values may be quite different. Because of reduced tree mortality and less cull material in these types of stands, it often will be necessary to leave more merchantable timber volume on site to meet prescription objectives for enough retention trees, snags, or down wood. The opportunity cost of retention management as valued by the timber volume foregone is expected to rise.

## **Postharvest Economic Implications Fuels Management**

Implementation of retention management in timber stands often has coincided with a substantial reduction of broadcast burning. Broadcast burning frequently reduces the fitness of retained green trees, snags, and down wood for intended ecological benefits. Fire also may destroy the natural advance regeneration of shade-tolerant species, such as western redcedar and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), which contribute to retaining biological diversity in commercial timber stands. The single contract at Blue River RD for burning postharvest slash amounted to \$255/acre in 1991 vs. \$247/acre in 1990. Of the 23 units in 5 completed timber sales examined, 10 units (206 of 588 acres) were not burned (except for piles at landings). This represented a 35-percent savings in fuels management costs, or \$50,882 in 1990.

The most recent timber sales prescribe some type of burning on all units but emphasize light burns and hand piling. Blue River RD has been increasing the use of various techniques, including jackpot burning and the use of piling equipment, to carry out site-specific fuels management prescriptions. These burns are more labor intensive than broadcast burning as they require greater control and must be confined to restricted areas. Fuels management costs therefore may not decrease overall, although expenditures for broadcast burning are decreasing. The workload for fuels management per acre managed is becoming increasingly complex as a result of the increased necessity to control fuel loads to satisfy diverse management goals.

Air quality may improve locally and regionally as broadcast burning and burning of hand-piled debris decline. Economic benefits of improved air quality are difficult to quantify.

## **Planting and Stand Development**

Because the Willamette NF must guarantee stand regeneration within 5 years of harvest, planting of seedlings remains the dominant way to regenerate stands. Planting costs for stands that have slash retained on the site without burning amounted to \$159/acre in 1990 (five units) and \$138-142.50/acre in 1991 (seven units) as compared to \$135/acre as the 5-year district average for burned units.<sup>3</sup> Planting costs differ greatly among harvest units owing to accessibility, economic conditions, and contractor skill and experience. There is no clear indication as yet that planting costs are affected by stand conditions created by management for structural retention.

Evidence of either economic benefits or drawbacks from increased slash retention based on changes in browsing levels in young stands has not been gathered yet. Long-term impacts of various densities of residual overstories on the growth, density control, yield, and ultimately value of regenerating stands on specific types of sites also are not well understood.

## **Snag Creation**

Topping of trees has been carried out to create and hasten the development of snag trees in stands where not enough snag trees were available to meet management objectives. The number of snags created per acre can differ greatly. At Ennis Unit No. 3, for example, no snags were created artificially because many trees already had broken tops. By contrast, 80 percent of merchantable retention trees were blasted to create snags at Sinne Unit No. 7.

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<sup>3</sup> Dollar figures are not adjusted for inflation.

**Table 3—Firewood cordage from commercial and personal use permits, Blue River Ranger District, Willamette National Forest, Oregon**

Fiscal year	Commercial cordage	Change since 1984	Personal use cordage	Change since 1984	Total cordage
		<i>Percent</i>		<i>Percent</i>	
1984	1425	0	1869	0	3294
1985	781	-45.2	1619	-13.4	2400
1986	376	-73.6	2144	+14.7	2520
1987	680	-52.3	4913	+162.9	5593
1988	252	-82.3	3512	+87.9	3764
1989	169	-88.1	4009	+114.5	4178
1990	202	-85.8	2691	+44.0	2893

Cost of creating snags is a function of tree height or d.b.h. class, the method by which snags are created (dynamite blasting or sawing), terrain, and labor availability. Average topping cost per tree at Blue River RD was \$44.49 in 1989 with 100 trees topped. The contractor charged \$34.93/tree for the smallest category of trees (<24 inches d.b.h.) and \$57.52/tree for the largest trees (>36.0 inches and 170 to 205 feet tall). At other Forest Service districts, as much as \$100/tree has been charged for snag creation in old-growth trees. In 1990, average topping cost at Blue River RD was \$32.50/tree for 125 trees. Costs for snag creation are decreasing as more people become involved and compete with each other for contracts from the Ranger District.

## Firewood Sales

Table 3 presents data for firewood cordage for commercial and personal use taken by permit from Blue River RD from FY 1984 to FY 1990. The number of commercial firewood sales on the Blue River RD has steadily declined since 1984; however, sales of firewood for personal use generally have increased over the same period. Total available cordage sold each year has fluctuated widely between 2400 and 5593 cords per year since 1984. Additional effects of retention of green trees, snags, and down wood on firewood supplies are not yet apparent. Use requirements, structural retention, and fewer timber sales have combined to reduce the amount of firewood currently available.

Contributions from regeneration harvest units to firewood supplies for personal use may decline as a result of requirements for retaining down wood and slash on sites after harvest. Recent sales of firewood for personal use have been limited to areas around landing decks. As a result of structural retention and requirements for harvest utilization, generally less potential firewood remains at landing decks after timber harvests. Consequently, there are tradeoffs between the local fuelwood supplies for personal use and ecological benefits of structural retention; however, a probable continued reduction in volume of timber for sale in the future may be a much more significant factor on firewood volume.

Alternative sources for firewood supplies may come from precommercial and commercial stand thinnings, salvage from blowdown, and careful use of hardwood resources. When chip prices are low, stumpage sold as firewood may have a higher value than it would as chips.

**Administrative  
Costs for the  
Ranger District  
Timber Sale Planning**

The scope of timber sale planning evolved as a complex process before stand management for retention of green trees, snags, and down wood began. Many other considerations, such as requirements of the National Environmental Policy Act of 1969, increasing levels of knowledge, and increasing involvement of varied public constituencies, play a central role in planning. Changes in management practices have not added any measurable additional cost to the planning process.

**Timber Sale Preparation**

The cost for timber sale layout and timber sale appraisals has increased over the past several years. These increases are due in part to timber sale appraisals and layout (including timber cruises), increased log accountability, changes in personnel, and changes in management practices. Appraisal costs rose 44 percent per hour from 1987 to 1990 (from \$18.53 to \$26.70 as measured in 1989 dollars), and appraisal time increased 30 percent (from 31.33 hours to 40.85 hours per mmbf) in the same period. Layout, marking, and cruising time rose by 86 percent (from 72.4 hours to 135 hours per mmbf). How much these increases are specifically due to implementing practices for retention management is uncertain because of a lack of documentation.

**Timber Sale  
Administration**

The number and duration of visits by timber sale administrators to logging sites to check harvesting progress and compliance with the timber sale contract have both increased. Records of increases in time and labor currently are not kept, but we know that the time required to ensure that timber purchasers follow contract stipulations for requirements per acre for down wood has increased. The potential is great for misunderstanding increasingly complex contract stipulations that are the result of management for structural retention. Additional costs frequently are incurred to sample harvest units to ensure that the sale purchaser is complying with contract requirements for down wood and for timber utilization.

The earliest timber sale contracts with provisions for retention of down wood required a certain range or number of pieces of material to be left on site. The definition of a piece was vague, however; for example, if a 40-foot log were left on site and if the minimum length required were 10 feet per piece, the log could be interpreted as representing from one to four pieces. An interdisciplinary committee reviewed the situation and recommended adjustments to standards established by the Willamette National Forest Land and Resource Management Plan to develop prescriptions and contracts. These changes describe the requirements more fully. Prescriptions now provide greater flexibility for the purchaser's operations while still accomplishing management objectives. Contracts may now specify an average minimum lineal length per acre for logs, minimum top diameter, minimum log length, and a minimum percentage of logs in a specific decay stage.

**Costs to  
Purchasers and  
Logging Operators  
Marking Retention Trees**

Cost of marking retention trees by the purchaser or purchaser's agent is added into harvest cost appraisals for each timber sale. The appraised cost ranges from \$0.18 to \$0.26/mbf. The bid price of a prospective purchaser should generally reflect the added cost of marking retention trees.



**Table 4—Cut-to-cruise comparisons for completed timber sales with retention of green trees, snags, or down wood, or a combination, at Blue River Ranger District, Willamette National Forest, Oregon**

Sale name	Appraised cut	Actual cut	Fulfillment
	<i>Thousand board feet</i>	<i>Percent</i>	
Ennis	7,200	6,562	91
Lookout	4,500	4,108	91
Lookup TBV	10,600	8,756	83
Roar East	7,200	6,999	97
Sinne	12,200	12,227	100
Stockstill	5,700	3,971	70
Three Bears	9,200	7,419	81

#### **Actual Cut Compared to Appraised Cruise**

For the completed timber harvests with retention of wildlife trees, snags, and down wood in excess of 2.0 mmbf of sales, the actual timber volumes from scale tickets as compared to appraised timber volumes before sale are listed in table 4.

The average percentage of fulfillment of these timber harvests was 87.6 percent of cruised volume, which compares with the average volume fulfillment for the Willamette NF from 1983 through 1988 of 93.4 percent. The wide range of cut to cruise percentages and the small sample size available make a statistically valid trend difficult to detect. As Blue River RD staff gain experience dealing with volume requirements for retained trees, snags, and down wood, prediction of actual timber harvest volumes with deductions for retention of merchantable volume likely will become more accurate.

Appraisal overestimations by the USDA Forest Service of actual timber harvest volumes is particularly important to purchasers, because the predominant type of payment for timber sales has changed since 1987, when virtually all sales were scale sales. In FY 1990, about 80 percent of timber sales sold at Blue River RD were premeasurement sales whereby the purchaser pays the bid amount regardless of the amount of timber actually harvested. This method for offering timber sales once again underscores the necessity that timber sale bidders conduct their own cruises and appraisals in advance of bidding on a timber sale.

#### **Felling and Yarding**

The timber appraisal method currently in use may not accurately reflect the true costs of log yarding in timber sales with retention of wildlife trees. But, appraisal for yarding in sale units with green tree (shelterwood) retention may be no less accurate than the appraisal figures given for standard clearcut harvests.

Yarding costs probably constitute the greatest and most variable change in costs in National Forest timber sales with management for structural retention. Practices such as green tree, snag, and down wood retention create physical impediments to logging operations. As a result, more complicated, and usually more costly, harvest systems are needed.

Obstacles created by down wood result in an added, but as yet unquantified, time cost through lower production rates. In addition, movement of down wood on steep slopes is unpredictable; there is potential for increased danger to workers and increased damage to remaining standing trees. Costs of rising insurance rates, added equipment for safety and protection, and damage to merchantable timber have not been systematically researched or calculated. Another significant cost of yarding in stands managed for structural retention is the cost of labor needed for appropriate distribution of down woody material across the unit.

Another major change is the frequent use of skyline equipment with slack-pulling carriages.<sup>4</sup> Use of this equipment has been increasing for other management reasons as well; that is, reduction of damage to soils, creation of narrower corridors in leave stands, and so forth. This type of system is being appraised for use in most timber sales with management for structural retention. This is thought to add 5 to 10 percent to the cost. Initially, some logging operators chose to use a logging system without lateral yarding capability, even though allowance for lateral yarding was included in the sale appraisal. These operators experienced a greater decrease in productivity as a result.

Total costs for felling and yarding are estimated to be roughly 15 to 35 percent greater for sales with green tree and snag retention as compared to conventional clearcuts.<sup>5</sup> The need for more exact cost information is acute.

A major factor is reduced daily productivity in harvest quantities. Productivity depends on the complexity of the sale layout and of contract requirements. The presence of retained trees, snags, and down wood pose greater risks and require added planning and attention to safety. For an average complete clearcut with no retention trees, 50 to 60 mbf can be yarded per day with a skyline system. When two to three trees per acre are retained, production declines by as much as 15 mbf per day. On one site in the Blue River RD where 16 trees per acres have been retained for visual considerations, total daily productivity was 35 mbf. These results infer that loss of productivity due to tree retention is not necessarily correlated to the actual number of retained trees per acre. Generalities about production rates due to levels of structural retention are difficult to make because slope, standing volume per acre, equipment in use, and experience of operators also come into play.

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<sup>4</sup> A slack-pulling carriage allows line to be pulled to the side of the skyline corridor. This increases the capability for lateral yarding. This line is pulled to the logs to be removed from the area. An increase in the distance that one line can laterally yard logs reduces the number of skyline corridors needed to log an area. A reduction can be beneficial when several trees are required to be left standing in a unit. There are a variety of slack-pulling carriages ranging from line pulled totally by hand to carriages with an internal motor that feeds out the line. The latter type of carriage requires a yarder with three drums. For more information on slack-pulling carriages, consult Studier and Binkley (1985) and Conway (1976).

<sup>5</sup> Personal communication. M. Wilson, timber management assistant and Forest Service representative, Willamette NF, Blue River RD, P.O. Box 119, Blue River, OR 97413-0119.

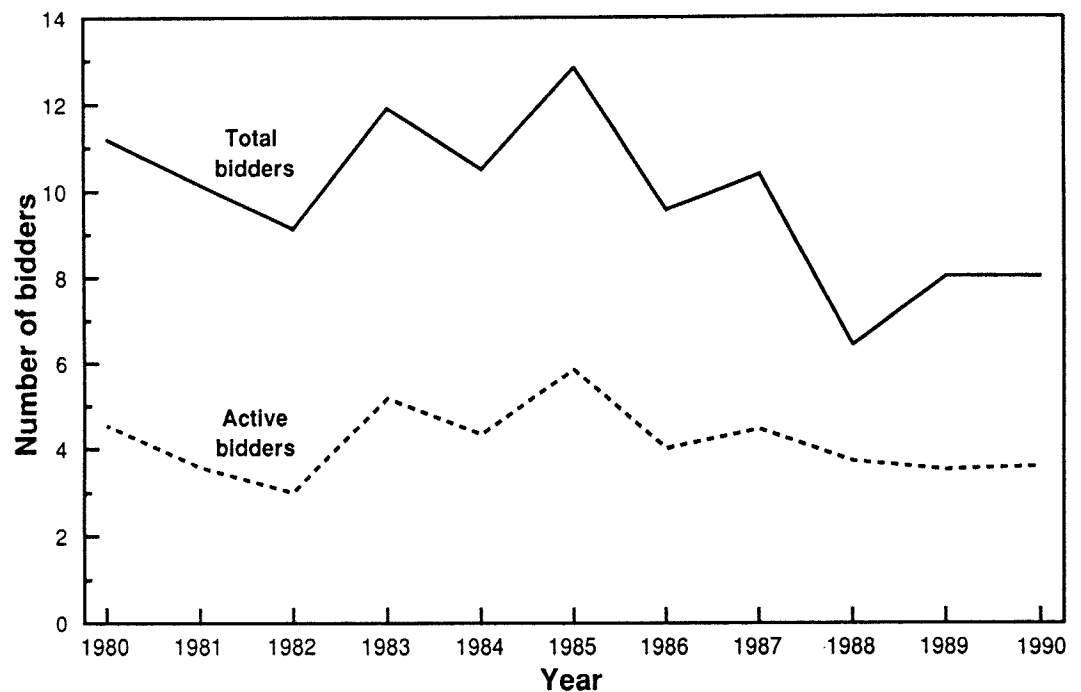


Figure 2—Average number of bidders per timber sale, 1980-90, for sales with more than 2 million board feet, Blue River Ranger District, Willamette National Forest.

## Purchaser Response

Perceptions by timber purchasers of the results of management for retention of green trees, snags, and down wood may be changing response by purchasers to Forest Service timber sales. Sentiments of timber purchasers toward timber sales with retention are almost uniformly negative. Reasons identified for disaffection include rigid contractual stipulations, difficulties in harvest engineering, and dubious profitability.

Bidding behavior provides a quantitative indicator of purchaser response. The number of total bidders for timber sales greater than 2 mmbf statistically has declined very significantly. The average number of total bidders for sales in this category was 10.60 between 1980 and 1987 ( $n=62$  sales,  $SE=0.38$ ); during the period of initiation of retention trees, snags, and down wood (1988 to 1990), the number of total bidders dropped to 7.43 ( $n=28$ ,  $SE=0.46$ ) ( $p<0.001$ ). Comparison of average active bidders, those bidders who actually bid higher than the minimum bid offer, declined significantly but less steeply from 4.31 between 1980 and 1987 ( $n=65$  sales,  $SE=0.05$ ) to 3.61 from 1988 to 1990 ( $n=28$  sales,  $SE=0.03$ ) ( $p<0.05$ ). From 1985 to 1990, the number of active purchasers has remained virtually constant (see fig. 2). The constancy since 1985 indicates that the decrease in number of active bidders occurred before timber sales included management for structural retention. Decline of total bidders is probably due to industry effects unrelated to purchaser reactions to stand management for structural retention.

Although purchasers state their aversion to sales having retention management, the aversion does not seem strong enough to change bidding behavior. Perceptions of timber scarcity may be the principal factor in overcoming the aversion to sales with green tree, snag, and down wood retention. At present there is too brief a time from which to judge the long-term trends of bidder interest in sales with structural retention.

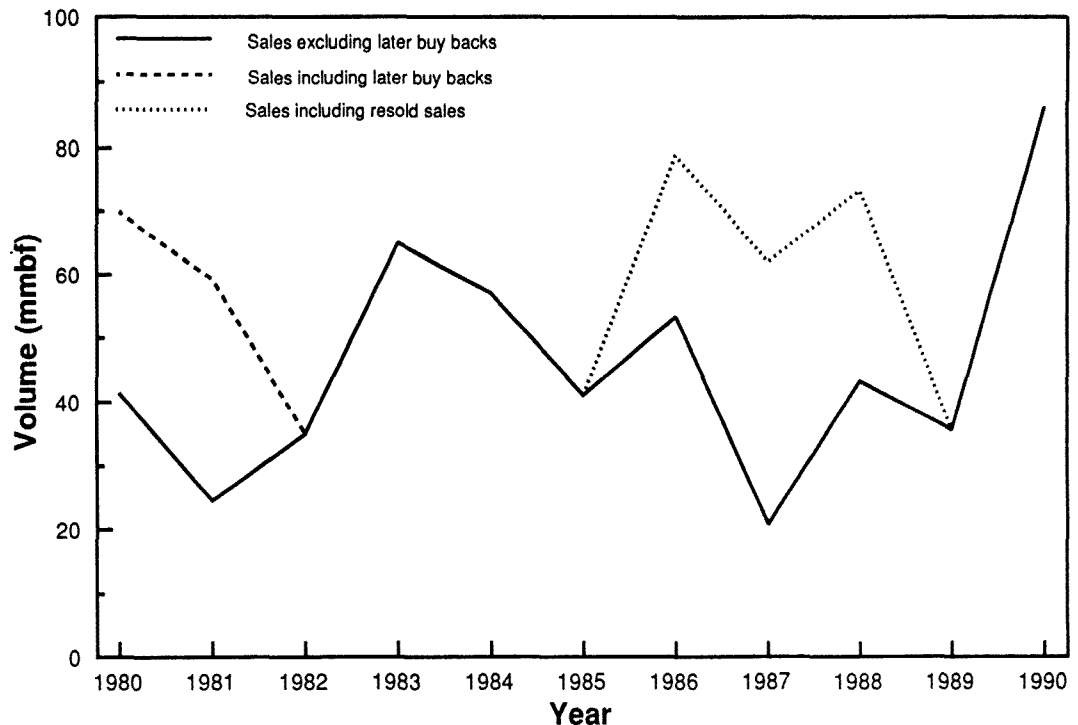


Figure 3—Total timber volume sold, 1980-90, for sales with more than 2 million board feet, Blue River Ranger District, Willamette National Forest.

## Changes in Timber Sale Volume and Value

Management practices in the Pacific Northwest that carry over green trees, snags, and down wood as residual stand components may reduce regional timber supply and adversely affect the forest products sector in the future. Effects extend beyond the industry. Revenues to counties from Forest Service timber sales may be reduced as a result of shifts in stand management practices. A retrospective look at all timber sales from Blue River RD appraised in excess of 2 mmbf from 1980 to 1990 suggests that the role of management for structural retention may not be decisive in determining timber supply when it is viewed in context with other Forest Service policies and with macroeconomic events. Since 1988, when green tree retention was first introduced, the total annual volume of stumpage and sale bid amounts (expressed in constant 1989 dollars) has equaled or exceeded levels earlier in the 1980s (figs. 3 and 4). The initial phase of timber sales with retention has coincided with a period of high stumpage prices so that total district timber sale receipts have not fallen.

How long the high level of stumpage prices will continue is uncertain. An additional element to cushion the economic impact during the first 3 years of retention practices has been the historically high acreages offered for timber sales (fig. 5). Recent court injunctions preclude the possibility, at least in the near term, of allowable sale quantities (ASQs) being based on large numbers of acres available for timber harvest. Negative outcomes for timber supply and revenue that stem from management for structural retention could be compounded when either timber prices decline as the result of low demand or availability of timber from Ranger Districts is legally restricted (for example, moratoriums on timber cutting).

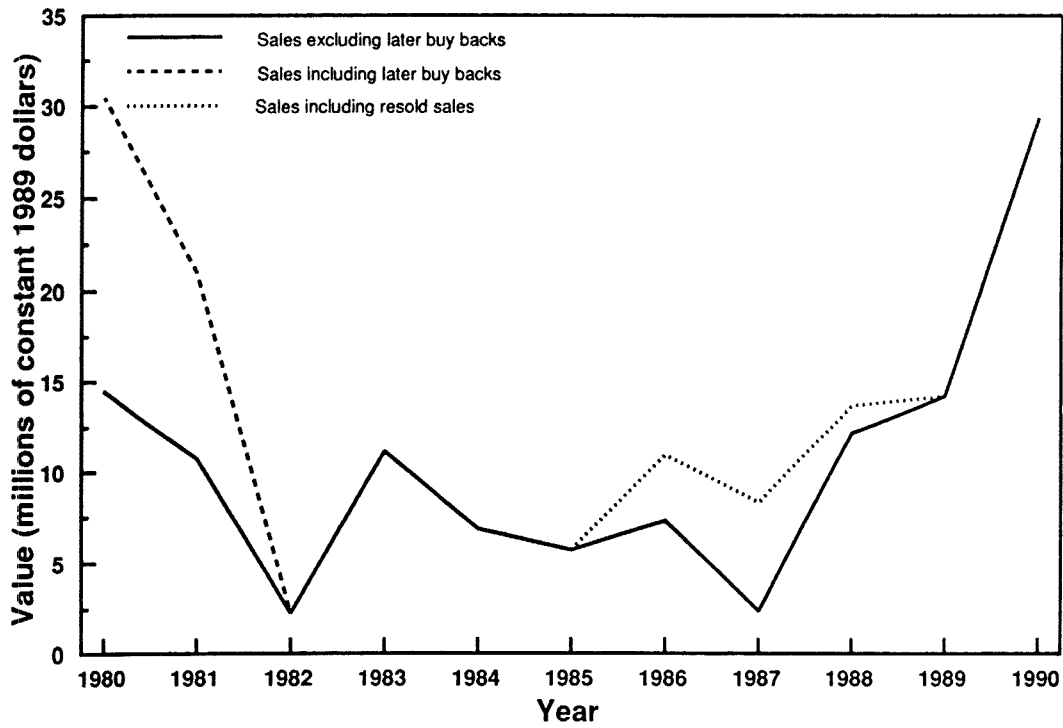


Figure 4—Timber sale final bid totals, 1980-90, for sales with more than 2 million board feet, Blue River Ranger District, Willamette National Forest.



Figure 5—Acres of timberland offered for bid, 1980-90, for sales with more than 2 million board feet, Blue River Ranger District, Willamette National Forest.

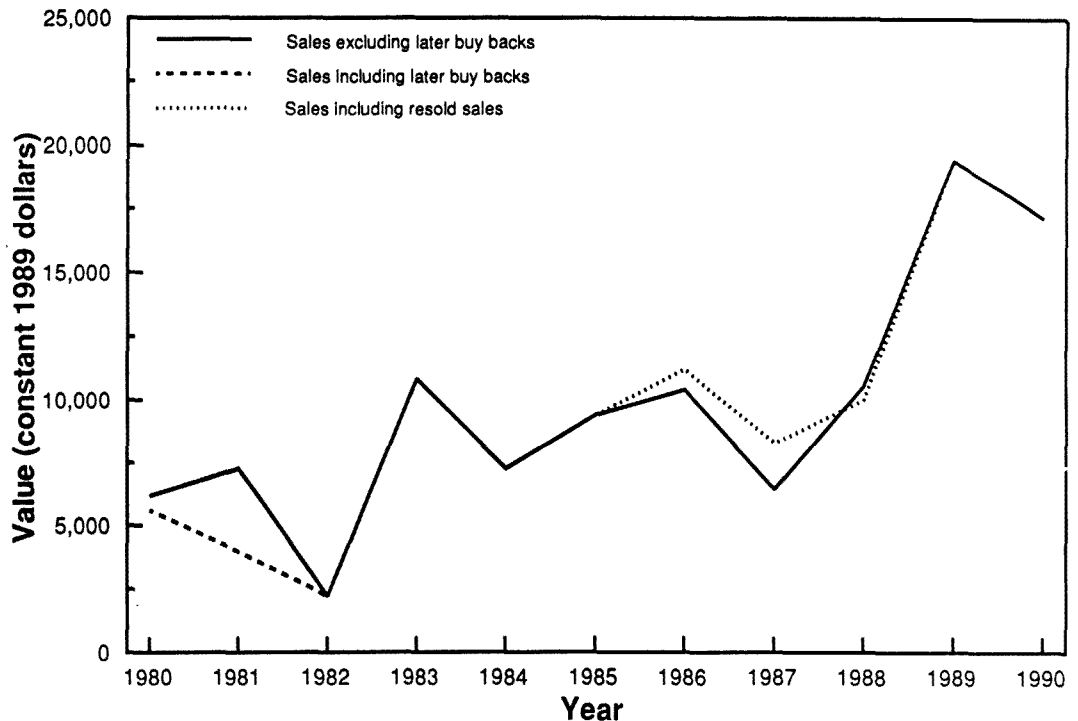


Figure 6—Average stumpage value per acre sold, 1980-90, for sales with more than 2 million board feet, Blue River Ranger District, Willamette National Forest.

Reduced economic returns resulting from a shift in management toward structural retention are most apparent for an individual acre. Overall, timber value in real dollars per acre has recovered from the 1982 recession (fig. 6); however, per-acre timber yields for major timber sales, as projected from Forest Service cruise surveys, show that production per acre has been declining since the mid-1980s (fig. 7). This trend may be partly due to the amount of timber foregone as the result of green tree retention, snag retention, and creation of down woody material. Other factors also may be at work though. Harvesting stands from less productive sites or sites without high volumes of old-growth trees may be contributing the major portion of decline in timber yield per acre because the decline began in 1987, before timber sales that included structural retention were initiated.

## Conclusions

In the short time that management for retention of green trees, snags, and down wood at harvest has been implemented at the Blue River RD, considerable, but in many respects poorly defined, changes have begun to alter costs and benefits of Forest Service timber sales for individual forest stands and the District as a whole (see table 5). Some of these changes are due to costs of management for structural retention; other changes can be ascribed to concurrent events. Greatest short-term changes brought about by structural retention involve increased costs for logging operations, increased costs for timber sale administration by Forest Service personnel, and the currently foregone value in residual trees.

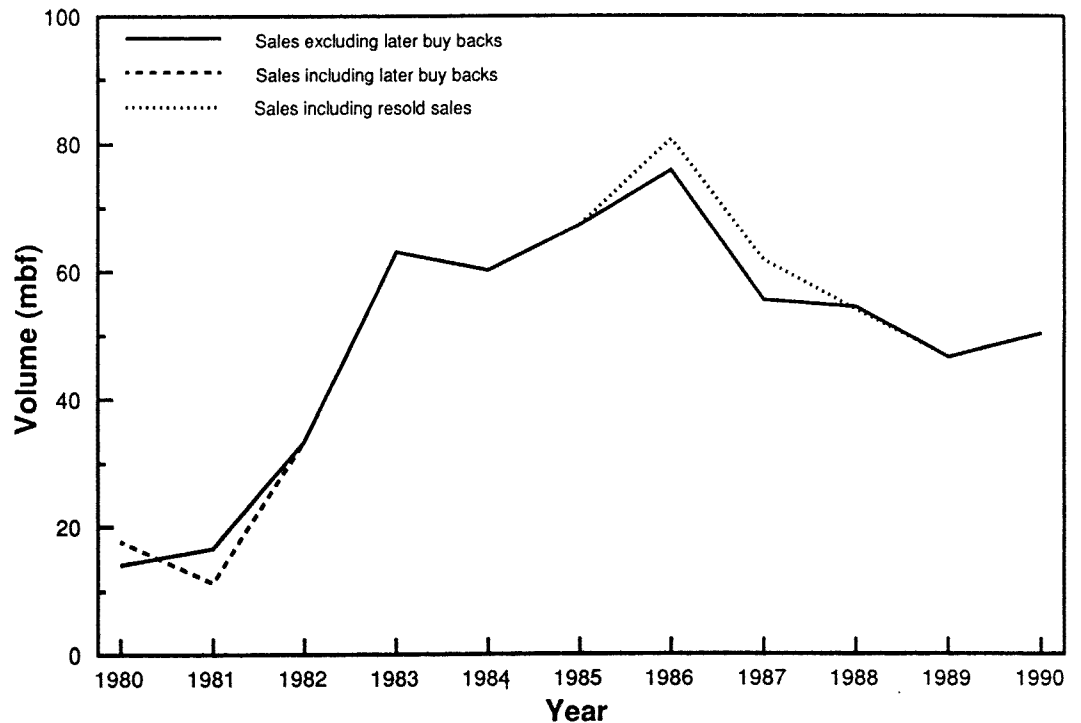


Figure 7—Average appraised stumpage volume per acre sold, 1980-90, for sales with more than 2 million board feet, Blue River Ranger District, Willamette National Forest.

Potential factors in long-term economic changes in timber sales can be identified as well. Economic and ecological benefits may be improved sustainability of long-term site productivity; reduction of some aspects of stand management and costs, especially with regard to treatments to control fuel loads; and increased capacity for future production of a diverse portfolio of market and nonmarket values for the public. No specific definition covers many types and magnitudes of output values because research on management for structural retention is in the early stages and a long tradition of practice does not exist. Production relations between quantities of retained stand elements (number of green trees, volume of down wood, and so forth) and specific output amounts of specific resources (levels of targeted economic or ecological outputs) are not known in most cases. Without defined output goals, a tradeoff analysis is difficult to carry out.

Potential negative effects could result as well in the long term with management for structural retention; for example, increased operational costs for loggers, greater risks to purchasers of payment unit sales, decreases in timber revenues to counties, increased safety hazards, decreases in growth and yield of timber, and reduction of the timber supply from the Ranger District.

**Table 5—Types, magnitudes, and directions of the costs of timber harvests and subsequent management for stands with requirements for structural retention, Blue River Ranger District, Willamette National Forest, Oregon**

Management practice	Per acre cost	Per tree cost	Trend of cost
----- 1989 dollars -----			
Retention/ merchantable lumber	102-1120 <sup>a</sup>	391-557	Increasing with rising stumpage prices and harvest of younger stands
Snag creation	0-34	45	Per-tree cost declining; per-acre cost rising with increased management
Broadcast burning	(237) <sup>b</sup>	N.A.	Savings decreasing as management of slash requires more complex prescriptions
Other fuels management	Unknown	N.A.	Rising
Added planting costs	Unknown	N.A.	Stable or declining
Animal Control	Unknown	N.A.	Unknown
Fertilization	Unknown	N.A.	Unknown
Firewood sales	Unknown	N.A.	Opportunity cost rising
Timber sale planning	Negligible	N.A.	Stable
Timber sale preparation	Unknown	N.A.	Stable
Timber sale administration	Unknown	N.A.	Unknown
Felling	Variable	N.A.	Unknown
Yarding	Variable	N.A.	Unknown

N.A. = not applicable.

<sup>a</sup> In cases where there is an average of less than 1 merchantable tree per acre left on site, the value of the potential lumber may be less than the value of a single merchantable tree.

<sup>b</sup> Number in parentheses represents savings in management costs.

The following proposals can assist the Forest Service in better defining and controlling the economic outcomes brought about by implementation of management for structural retention:

1. Keep systematic, uniform, and detailed records of costs and desired benefits (or values) from retention management associated with each timber sale unit.
2. Monitor in detail to what degree economic changes are attributable directly to management of structural retention and to what degree these changes are caused by concurrent events unrelated to management of structural retention.
3. Monitor and evaluate the resources (both market and nonmarket) intended to benefit from management for structural retention to ensure that desired levels of resource production are being attained and that resources not benefiting from management for structural retention are not unacceptably impaired.



4. Develop appraisals of Forest Service timber sales that rely on empirical evidence to realistically reflect economic impacts of retention management.
5. Rely on natural processes as a means to reduce management costs of capital and labor for implementing structural retention and subsequent stand regeneration under retention conditions.
6. Establish an ongoing task force that includes timber management personnel from the Forest Service, representatives from the Occupational Safety and Health Division (OR-OSHA) of the Oregon State Insurance and Finance Department, loggers, and logging systems engineers who together will develop an equitable policy of safety regulations and enforcement to promote public and occupational safety and to foster economically efficient and ecologically sound innovations in harvesting technology.

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