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Uphill Falling of Old-Growth Douglas-Fir

Douglas L. Hunt and John W. Henley

Authors

DOUGLAS L. HUNT is a forest products technologist with the Pacific Northwest Region, State and Private Forestry. JOHN W. HENLEY is assistant director for research planning and application at the Southern Forest Experiment Station. At the time this research was conducted, he was a forest products technologist with the Pacific Northwest Forest and Range Experiment Station.

Abstract

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Five timber sales were made in old-growth Douglas-fir with matched cutting units. On one unit of each sale uphill falling by either hydraulic jacks or tree-pulling machine was required; on the other unit free falling was required. Logging equipment and methods were the same in each unit. Uphill falling produced a larger volume of timber at less cost than free falling because breakage was less.

KEYWORDS: Felling operations, old-growth stands, Douglas-fir, *Pseudotsuga menziesii.*

Contents

Introduction

Two methods of falling timber uphill (directional falling) have become important tools for harvesting timber in the Pacific Northwest. The methods are tree pulling (line pulling) and hydraulic jacking.

In tree pulling, a crewmember climbs a tree and attaches a cable around the bole. The cable is then shackled to another line from a tree-pulling machine. This machine contains a powered drum set with a torque converter and is usually mounted on a truck. After the cable is attached and the climber has descended, the faller puts in an undercut and a backcut. Before the backcut severs all the holding wood (uncut portion of the stump), the crew moves to a safe location and signals the operator of the machine to pull the tree down.

In jacking, the cutter puts two backcuts in the tree, far enough apart to insert jacks. After sawing out the undercut and putting in the jacks, the cutter pumps the jacks by hand or power to tip the tree in the desired direction.

Directional falling is not new. Fallers have always used wedges and holding wood to control the direction in which trees fall when cut. New methods and equipment, however, enable timber cutters to fall trees where conditions are most likely to minimize breakage. Some loggers using tree pulling or jacking methods report that volumes of merchantable timber are higher because breakage is less. Data to substantiate these claims have been lacking. Reliable information on the costs and benefits of directional falling is needed by land managers and timber harvesters making decisions on which method to use. This paper reports results of a study comparing uphill falling with free (conventional) falling.

Procedure

Five timber sales, each containing two or three matched cutting units, were selected from old-growth Douglas-fir timber stands in western Oregon and Washington. Purchasers were required to use tree-pulling or hydraulic jacking methods and equipment to fall trees uphill on one or two of the matched units and to use free fall methods, in the sidehill direction (parallel to the contours), on the other unit.

In the units felled uphill, the lead (falling pattern) was established and maintained by pulling trees or hydraulically jacking them. Usually the falling direction was established at an angle somewhat less than "straight up" or perpendicular to the land contours. Exceptions were made when a change in the falling direction would prevent or minimize breakage—near roads, rock outcrops, and sharp ridges—or to take advantage of draws and ridges.

In the free felled units, the lead was usually established and maintained in a sidehill direction. The cutters used only wedges, holding wood, and special undercuts to maintain the established direction.

The purchaser was required to use the same cutting crew and insure that they felled all units with equal competence, The same logging equipment and procedures were also required for each unit. The objective was to obtain unbiased information on the effects of falling method on breakage and costs.

Units in each sale were as identical in timber characteristics and terrain conditions as possible. Characteristics of the units are summarized in table 1, to show their similarity. Each timber sale is identified by name and project number.

Table 1—Characteristics of cutting units in 5 timber sales of old-growth Douglas-fir

Project No.	Location	Sale name	Cutting unitiy	Size	Slope	Average d.b.h.	Average tree height to a 6-inch top	Defect	Gross volume per acre	Gross volume per tree 1/
				Acres	Percent	Inches	Feet	Percent	Thousand board feet. Scribner scale	
03	Illinois Valley Ranger District Siskiyou National Forest	Loop Hope	FF	7	35	39	148	4	117	3.5
			HJ	8	35	38	164	4	104	3.9
04	Powers Ranger District Siskiyou National Forest	Three Way	FF	13	70	38	162	11	100	3.5
			TP	13	70	38	157	7	102	3.1
			HJ	16	70	38	154	14	99	3.3
05	Lowell Ranger District Willamette National Forest	Hobbit	FF	33	65	45	148	39	108	4.4
			TP	25	60	48	166	46	116	6.6
06	Wind River Ranger District Gifford Pinchot National Forest	Trout Creek Hill	FF	16	45	38	122	14	130	3.5
			HJ	18	50	38	114	14	130	2.6
12	Coos River Area Coos Bay District, Bureau of Land Management	South Susan Ridge	FF	29	75	42	163	18	106	4.0
			HJ	25	75	42	148	20	113	4.3

1/FF = free or conventional falling; HJ = hydraulic jacking; TP = tree pulling.

2/Stump diameter > 24 inches inside bark.

Percent slope is the average slope from top to bottom of each cutting unit.

Average diameter at breast height (d.b.h.), percent defect, and gross volume (Scribner scale) per acre were taken from cruise data provided by the local administration unit for each sale. The average gross volume (Scribner scale) per tree and the average tree height to a 6-inch top were calculated from cutters' records made when trees were felled.

Figure 1, a view of the Three Way sale shortly after falling was begun, illustrates the preferred layout. Here, three adjacent cutting units are separated only by flagged lines. The Loop Hope and Trout Creek Hill sales were also arranged this way. The cutting units in the Hobbit and South Susan Ridge sales were geographically separated. This arrangement was not ideal but was necessary because no accessible timber stand large enough to be divided into similar cutting units could be found.


Figure 1.—Three Way sale after falling was begun.


Figure 2.—Trout Creek Hill sale timber.

Figure 2 shows the type of old-growth Douglas-fir included in the sales.

Cutters and loggers were required to record data according to instructions from personnel of the Pacific Northwest Forest and Range Experiment Station. Information recorded each day by the logging crew included listing workers by occupation, hours worked, equipment used, and delay time.

Information for each tree recorded daily by the cutters included:

1. Type; i.e., merchantable, cull, standing snag, or windfall.

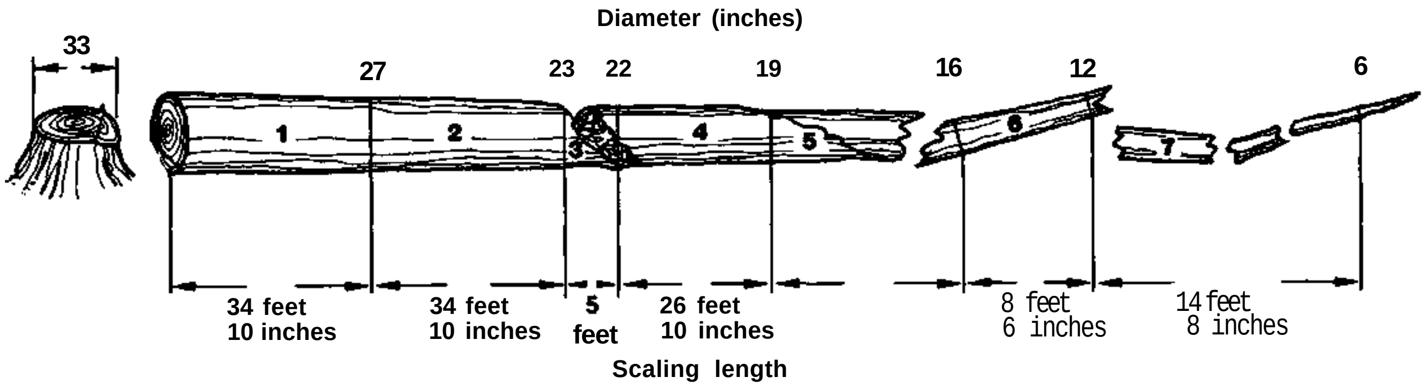
2. Diameter and length of each segment.

3. Segment type; i.e., log, sound break, cull break, or top break.

4. Falling method used.

5. Species.

Log volumes were computed from scaling diameters and lengths. Breakage volumes were computed by scaling diameter and length to the nearest foot. Figure 3 illustrates falling and bucking measurements and codes.



Segment 1: Coded 1, bucked log
Segment 2: Coded 1, bucked log
Segment 3: Coded 3, cull break
Segment 4: Coded 1, bucked log
Segment 5: Coded 2, sound break
Segment 6: Coded 1, bucked log
Segment 7: Coded 4, top break
The remaining segment is beyond the 6-inch top and was not measured.

Figure 3.—Codes by segment.

After these records were keypunched, a computer-edit program identified coding and recording errors which were then corrected. Other computer programs produced lists by tree, log, and breakage. Further analysis of variables was made possible by separating tree type, segment type, falling method, and species.

For statistical analysis, a randomized complete block design was used in which blocks were the entire sale areas and falling methods were the treatments within blocks. Because only one sale area provided three cutting units, four of the five blocks used only two falling methods.

Analysis of variance was used to test the one important contrast among falling methods. This compared uphill falling (both jacking and pulling) with free falling. Results showed uphill falling differed significantly from free falling in all variables tested, except loading productivity.

Results

Breakage Data

All breakage data in this report are from Douglas-fir trees 24 inches or more d.i.b. (diameter inside bark) at the stump. Data for the small understory trees were not included because initial analysis indicated that data from these trees distorted the results. Including data from hundreds of small trees reduced average tree height and length to the first break but contributed nothing to the breakage volume. Deleting small trees provided a more accurate picture of breakage in trees of sizes that concern both timber sellers and purchasers.

Total breakage (including sound, cull, and top) was reduced in units felled uphill compared with free-felled units in all sales except the South Susan Ridge (project 12). The difference in volume lost to breakage ranged from 2 percent to over 5 percent (table 2 and fig. 4). The average reduction in breakage for the five units felled uphill was 3 percent.

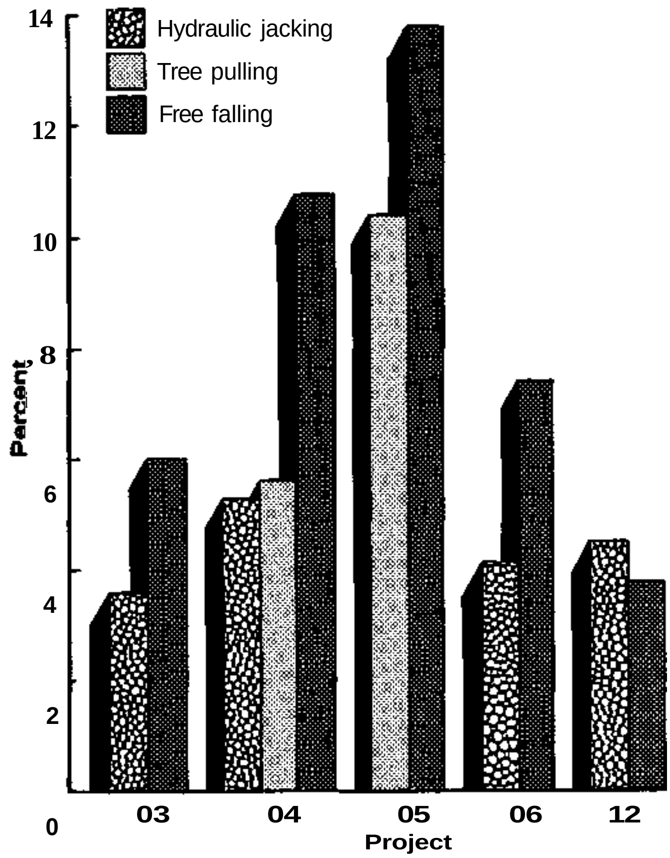


Figure 4.—Percent of cubic volume of tree lost in breakage.

Table 2—Percent of cubic volume lost, by type of breakage

Project	Sale name	Cutting unit*	Sound	Cull	Top	Total	Difference
			Breakage				
			- - Percent - - -				
03	Loop Hope	FF	3.9	0.3	1.8	6.0	
		HJ	2.5	.1	1.0	3.6	2.4
04	Three Way	FF	7.4	1.3	2.1	10.8	
		TP	3.4	.4	1.8	5.6	5.2
		HJ	3.0	.9	1.4	5.3	5.5
05	Hobbit	FF	5.1	6.1	2.6	13.8	
		TP	3.7	6.1	.6	10.4	3.4
06	Trout Creek Hill	FF	2.7	2.0	1.7	6.4	
		HJ	2.2	.4	1.5	4.1	2.3
12	South Susan Ridge	FF	2.2	.3	1.3	3.8	
		HJ	3.1	.4	1.0	4.5	-.7

*FF = free or conventional falling; HJ = hydraulic jacking; TP = tree pulling.

This reduction in breakage appears small compared with some previous reports on uphill falling. Experienced foresters using jacks or tree-pulling machines have assumed that the reduction was much higher. Groben (1976) and Kjosness[1] estimated 10 to 15 percent less loss from breakage; Burwell (1971) stated that 10 percent could be expected but that results appeared better; and Shook[2] mentioned 5 percent less loss. None of these sources provided data, and Burwell (1971) mentioned that there was no statistical proof available. McGreer (1973) reported savings in breakage from 1.17 to 1.70 percent. The procedures used to measure breakage in this study were those used by McGreer.

The reduction in breakage, though small, was statistically significant and represents a real saving.

1/Kjosness, John D. 1977. Up the hill - the benefits of using jacks. Report presented at the 1977 Sierra Cascade Logging Conference, Redding, Calif.

2/shook, Paul. 1974. How to save timber on steep ground. Paper presented at the 1974 Oregon Logging Conference, Eugene.

Contrary to the belief of most cutters and loggers, table 2 shows that not all the savings in breakage or even most of it occurred in the tops of trees. For this study, top breakage was defined as loss of merchantable wood from the last bucking point to a 6-inch, or existing top. A top that was rotten or for any reason unmerchantable, was coded as "cull break." Savings in top breakage were found in the six units felled uphill, but they ranged from only 0.2 to 2.0 percent, with an average of 0.7 percent. Savings in sound breakage occurred in five of the six uphill units and ranged from 0.5 to 4.4 percent, averaging 2.3 percent. This indicates that although some volume from the top is saved in uphill falling, more is saved in the lower, more valuable portion of the tree.

The average length of all logs cut, divided by the average length of all trees to a 6-inch top, gave the portion of the average tree recovered in logs (fig. 5). For example, if the length of logs cut from all trees averages 75 feet and the length of all trees averages 100 feet, then 75 percent of the average tree is recovered in logs.

In all five sales, the proportion of trees cut into logs was greater in units felled uphill than in free-felled units. The increase ranged from 1 percent to 9 percent and averaged 5 percent. Statistical analysis of this variable indicates that this increase is significant.

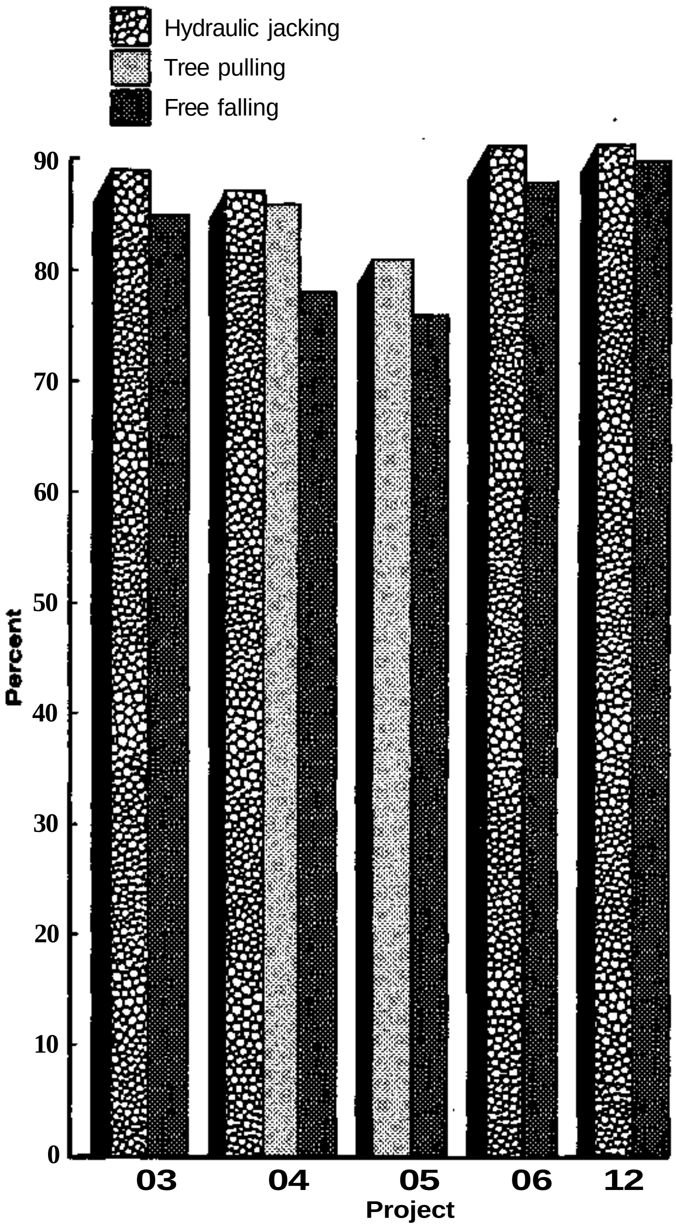


Figure 5.—Percent of merchantable tree length recovered in logs.

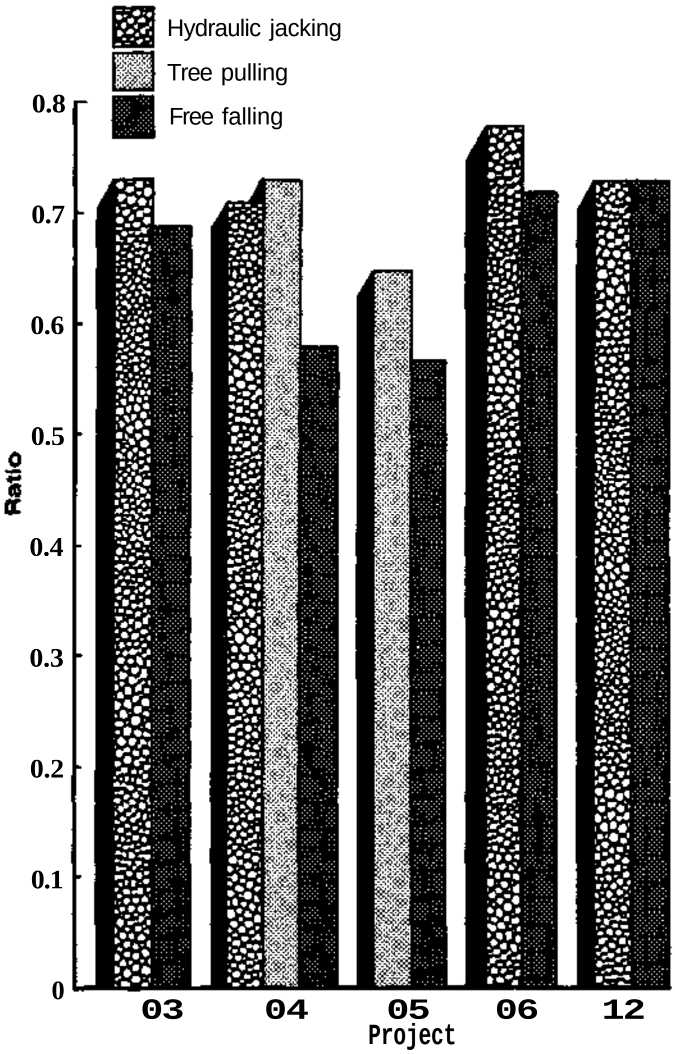


Figure 6.—Length of tree to the first break expressed as a ratio.

The location of the first break is important to the timber purchaser because it determines the number of logs of preferred length that can be cut (lengths and diameters that best fit manufacturing and marketing needs). Length to the first break is shown in figure 6 as a ratio of average length (height) to the first break over average tree height to a 6-inch top. Average length to the first break was determined by totaling lengths of all logs to the first break, and dividing this total by the number of trees. Average tree height was determined the same way.

In one sale, the first break occurred at the same point for both units. In the other sales, length to the first break occurred farther up the tree for units felled uphill. The increase in length ranged from 0 to 15 percent of average tree height, and averaged slightly under 8. In feet, the improvement ranged from 2 to 22 and averaged 12. Statistically analyzed, these values indicate that the differences are significant.

For scaled sales, where the purchaser pays only for logs brought out of the woods/ there is no great incentive to reduce breakage. What a purchaser really wants are preferred log lengths,

Figure 7 indicates that more logs of preferred length were cut in the units felled uphill than in free-felled units. The fifth sale was omitted from this analysis because the operator changed log length requirements in one unit. This change prevented a comparison of preferred log lengths between units. For sales shown, the number of logs of preferred length increased from 5 to 17 percent and averaged slightly over 9 percent for the five units felled uphill. This increase in number of logs of preferred length is probably the most tangible benefit a purchaser receives from uphill falling. Again, analysis indicates the increase in logs of preferred length is real and not a chance occurrence.

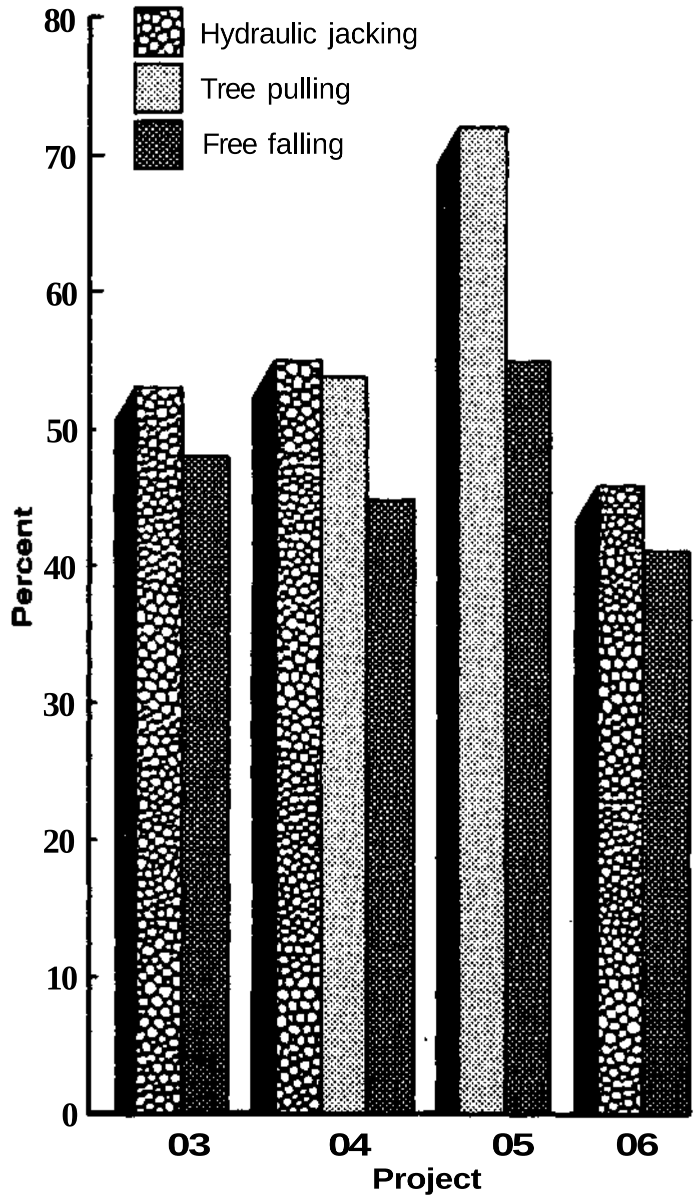


Figure 7.—Percent of logs in the preferred length.

Production Data

Palling and bucking costs were initially computed in dollars per thousand board feet. Data presented on this basis become obsolete when basic wage rates and fringe benefits increase. To keep the data as relevant as possible, we computed productivity in terms of the number of person-hours required to fall and buck 1,000 board feet. Since it was not possible to relate hours worked to species cut, production data are based on volume from all species in each unit.

Figure 8 shows that production rates on the free-felled units were invariably higher than on the units felled uphill.

Lower production in the jacked units was due to two factors—the requirement to fall uphill and to use jacks. A first reaction might be that these two factors are the same. Observations and data indicate, however, that falling uphill, even without jacking, is likely to be less productive than sidehill falling. Trees standing straight will rarely fall uphill without wedging, which takes time. Trees leaning out of the falling pattern must be jacked, and making the extra cuts needed for the jack seat and pumping the jacks takes time. Also, falling trees uphill requires cutters to spend more time moving their equipment up and down the hill. Bucking trees lying uphill is also more difficult and slower than bucking trees lying on the sidehill. Not only must the bucker continually move up and down the hill, but as a tree is being cut into logs, the uphill portion has a tendency to slip down and pinch the saw bar. This situation requires the bucker to spend more time using wedges to prevent pinching. All this adds up to lower production per person-hour and correspondingly higher costs per thousand board feet.

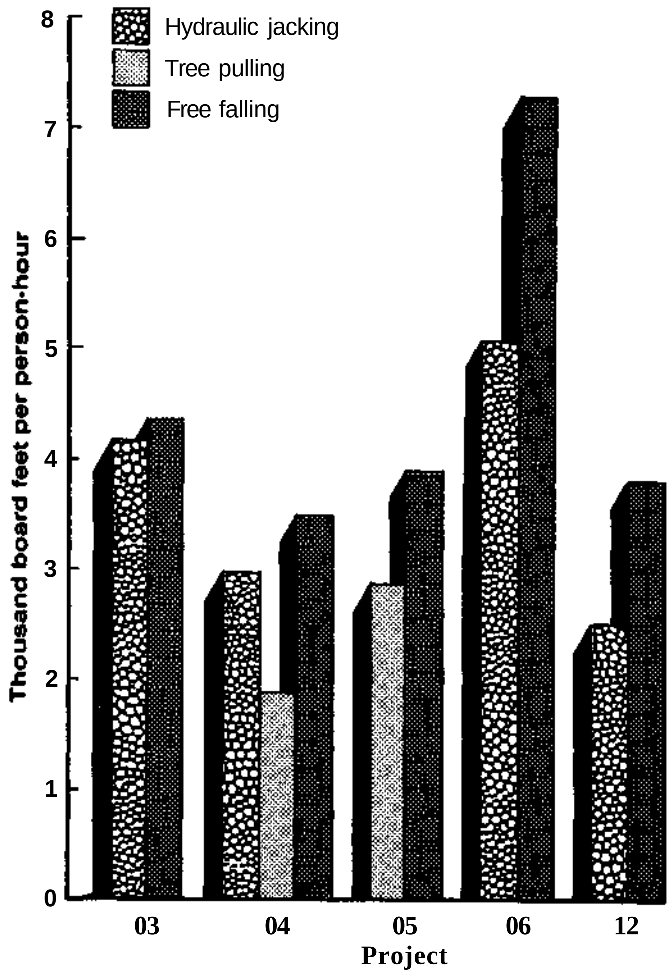


Figure 8.—Falling and bucking production by logging units.

Productivity is also lower in the tree-pulled units because additional crewmembers are needed to climb trees and operate machines. The project 04 crew averaged more volume cut per day in the tree-pulled and jacked units than they did in the free-fall unit. But dividing that volume by the person-hours required to produce it resulted in a lower volume per person-hour. Minor causes of lower productivity are changing the pulling line blocks and pulling the line down the hill. As for jacked trees, bucking trees after pulling is slower than free felling.

Comparisons of productivity cannot be made among the five sales because of differences in timber size and topography; however, some general observations about production rates may be made. Four of the five sales, projects 03, 04, 05, and 12, show productivity rates in the free-fall units that are reasonably close. Project 06 shows a rate for free falling that is more than twice that of project 04, and considerably higher than the others.

We believe the main reason for this high production rate on project 06 was the amount of single jacking (one person both falling and bucking). Ground, timber conditions, and cutters[1] abilities were not considered responsible for the differences between project 06 and the other projects. The slight loss in productivity from uphill falling in project 03 was probably because the unit had good timber on a relatively flat slope with little brush cover. The cutters could move freely on most of the ground and carry jacks more easily on the 35-percent slope than would have been possible on steep, brushy slopes; bucking was less of a problem too.

Project 04 illustrates the difference in falling and bucking productivity between jacking, tree pulling, and free falling similar timber on similar ground conditions. Figure 8 shows that the production rate for free falling is close to all other sales except project 06. Productivity in the jacked unit of project 04 dropped only slightly from the free-felled unit despite problems encountered in falling with jacks and bucking on steep slopes. Again, some single jacking was done in this unit, which probably helped maintain a good production rate. As expected, the tree-pulled unit showed a large drop in production. The four-person crew, although new to tree-pulling procedures, worked efficiently and usually had one or two trees rigged for pulling ahead of the cutters. Even so, the loss in productivity was almost half (46 percent) of the free-fall rate.

When depreciation, maintenance, and costs of operating tree-pulling equipment are added to the 46-percent loss in production, the costs of pulling trees in project 04 ($10.46 per thousand board feet) were double those for the free felled-unit ($5.22). Although high, this cost is considerably less than the rule-of-thumb cost of three times that of free falling.

In project 05, the difference in productivity between the tree-pulled and free-felled units is not great (fig. 8). Table 1 (page 2>, however, shows that trees in the free-felled unit had an average d.b.h. of 45 inches compared with 48 inches in the pulled unit. This difference in d.b.h. resulted in an average gross volume per tree of 2,060 board feet in the free-fall unit and 3,750 board feet in the pulled unit. The larger tree volume in the pulled unit resulted in production only 24 percent less than the free-felled unit although only about half as many trees were cut per day in the pulled unit. To provide some insight to what the production loss might have been had tree sizes been comparable, the following adjustment was made.

The average gross tree volume in the pulled unit was adjusted down to the same level as in the free-felled unit. This tree volume was expanded (by the actual number of trees cut) to a new but smaller total volume. Dividing this total volume by the person-hours required to cut all the trees gave an adjusted productivity rate for the pulled unit. This new rate was 1,700 board feet per person-hour instead of the 2,900 shown in figure 8 and would result in 56 percent less production than the rate for free falling. Since only half the number of trees were cut per day in the pulled unit, this lower productivity appears reasonable. Although it may be questionable if the same number of hours would be required to cut smaller trees, we believe the adjusted rate based on trees of the same size more fairly represents tree-pulling productivity. Averaging the tree-pulling production rates from projects 04 and 05 results in a 51-percent loss.

Yarding productivity was also computed on the basis of volume per person-hour and is illustrated in figure 9. Only four projects are shown because project 05 required two landings in the free-fall unit for efficient logging. This, of course, reduced the average yarding distance in that unit and made comparison with other units impossible.

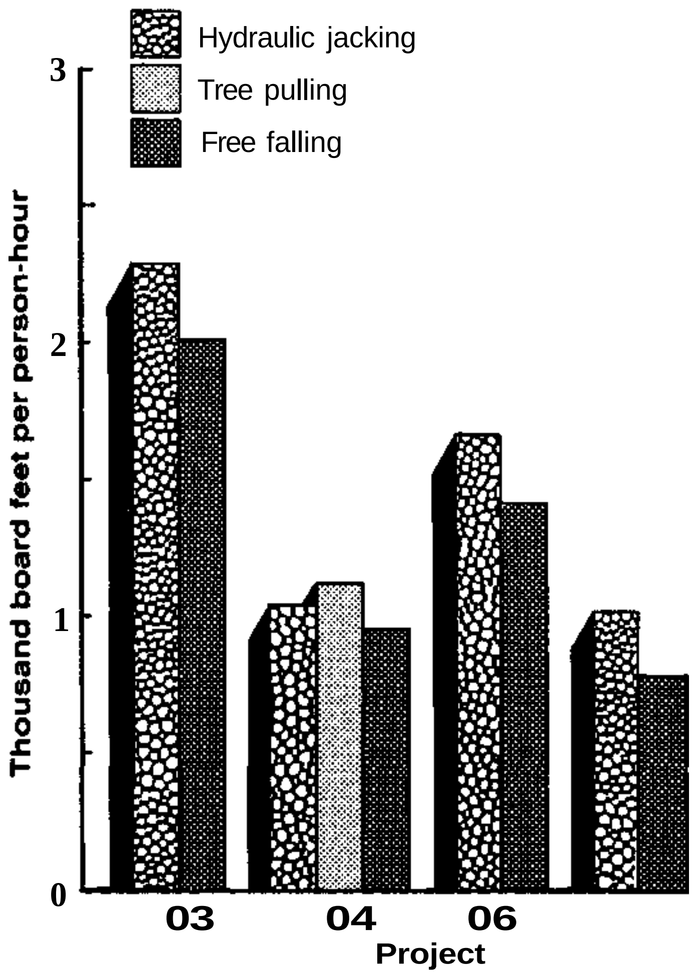


Figure 9.—Yarding production by falling units.

The hours worked by crews were recorded by occupation. This record was usually kept by the yarder engineer or the loader operator. Any delay time caused by yarder breakdown, line splicing, etc., was subtracted from total time on the job. Thus, the person-hours used for calculating productivity represent only time the yarder and crew were actually working.

Yarding productivity in the five units felled uphill was higher than in free-felled units. Data did not permit determining the factors responsible. But many loggers with experience on jacked or tree-pulled units claim that costs of YUM (yarding unmerchantable material) and clearing streams are lower when these methods are used. Any decrease in time required for YUM and stream cleanout would increase yarding production. In another sale, not included in these data but where stream cleanout time was recorded separately, considerably more time was spent clearing streams in the free-fall unit than in a unit felled uphill.

Statistical analyses of yarding productivity indicate that production per person-hour for the uphill-felled units was significantly higher than for free-felled units.

Loading efficiency was determined by the same procedure used for yarding. Figure 10 shows rates for the paired units. There seems to be little relationship between loading production and falling methods. In two of the uphill units, rates of loading were higher than in free-felled units; four uphill units had lower rates. Of the latter four, only one shows a large difference. Statistical analysis on loading production indicated that the differences in productivity were not significant. Therefore, we conclude that there is no improvement in loading productivity from uphill falling techniques.

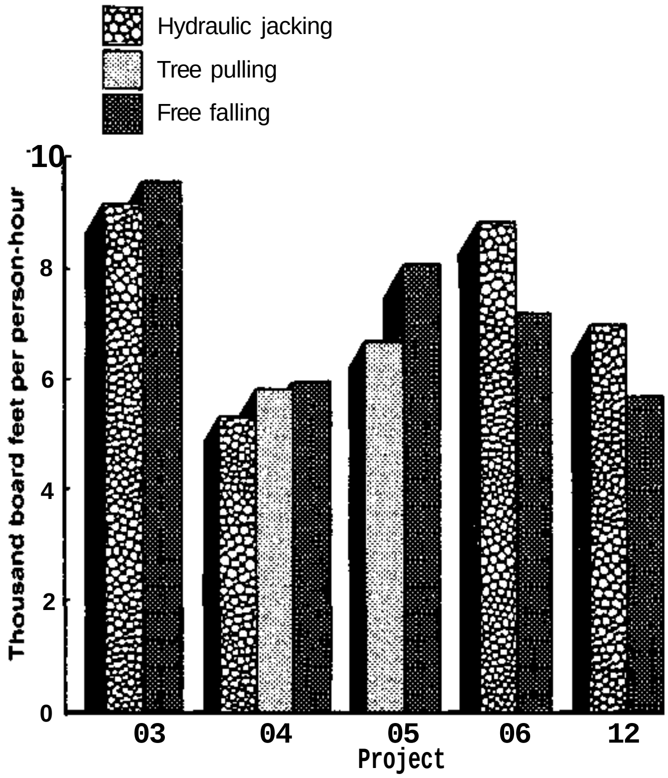


Figure 10.—Loading production.

Logging contractors and foresters who participated in the sales agreed with this conclusion. They failed to see how different falling methods could influence loading efficiency. The advantages of having slightly longer logs, slightly less log breakage, and perhaps fewer chunks were believed to be too small to affect loading productivity.

Application of Results

Expressing the costs of logging and truck-loading in thousands of board feet per person-hour provides a convenient method to compare costs but does not quantify monetary advantages of uphill falling. Two examples show that money could be saved through uphill falling under certain assumed but realistic conditions.

Costs for free falling and bucking were developed by applying an hourly wage rate to the person-hours.[3] Dividing total dollars spent for this work by the gross log volume from the cutters' records gave costs in dollars per thousand board feet. Costs for tree jacking were computed the same way, except that an additional $0.23 per thousand board feet was added for operation and depreciation of the jacks. Labor costs for tree pulling were calculated by the same rates, but estimating costs of the tree-pulling machine required a more detailed procedure. Based on estimates from reliable logging systems specialists, we assumed an initial cost of $15,000 for a pulling machine constructed of good used equipment. Calculating the depreciation of this machine with its rigging and operating costs gave a machine cost of $8.05 per hour. This rate was applied to the hours the machine was used to give total costs for the machine. Labor and machine costs were added, then divided by the cutters' volume to get a dollar cost per thousand board feet.

3/cutters' hourly wage rate from the U.S. Department of the Interior, Bureau of Land Management, Timber Production Costs Schedule 20, 1977.

To pay for saws, $1.33 per hour was added to labor and equipment costs for all falling methods.

Costs for yarding and loading were developed the same way as for cutting. For each occupation, the appropriate hourly wage rate was applied to the hours worked and added to the hourly machine charges appropriate to the yarders and loaders used (see footnote 3). Before total costs were calculated, delay and breakdown times were subtracted so costs reflected only the time loader, yarder, and crew were actually productive. Labor and machine costs were totaled and the total divided by gross log scale volumes. This gave costs in dollars per thousand board feet, gross Scribner scale, for yarding and loading.

Value Comparisons

To illustrate how increased costs for uphill falling are more than offset by increased yarding productivity and increased timber volume, we compared costs and benefits under prescribed conditions.

We assumed a cruise volume of 60,000 board feet per acre, a stumpage value of $300 per thousand board feet, and a recovery volume 3 percent higher for tree jacking and 4 percent higher for tree pulling. Costs used for falling, bucking, and yarding are averages from the four paired units of this study. Since loading costs were not significantly different for units felled uphill or free felled, these were combined and averaged for all units.

Costs for falling, bucking, yarding, and loading a jacked unit and a free-felled unit show the following:

	Jacked unit	Free-felled unit
	(Dollars per thousand board feet, Scribner log scale)	
Falling and bucking	5.52	4.18
Yarding	14.68	16.51
Loading	4.15	4.15
Total	24.35	24.84

A unit jacked uphill produced a value higher than a comparable free-felled unit because greater volume was recovered. The difference was 1,800 board feet per acre, or 3 percent more than the cruise estimate of 60,000 feet

	Jacked unit, 61,800 board feet per acre	Free-felled unit, 60,000 board feet per acre
	(Dollars per acre)	
Logging costs	1,504.83	1,490.40
Value at $300 per 1,000 board feet	18,540.00	18,000.00
Net value	17,035.17	16,509.60
Additional value	4/525.57	0

4/$8.50 per 1,000 board feet.

We used the same method, assumptions, and costs to compare tree pulling with free falling.

Costs for falling, bucking, yarding, and loading in a pulled unit compare with costs for a free-felled unit as follows:

	Pulled unit	Free-felled unit
	(Dollars per thousand board feet, Scribner log scale)	
Falling and bucking	10.93	4.97
Yarding	14.68	16.51
Loading	4.15	4.15
Total	29.76	25.63

A pulled unit produced additional value over a free-felled unit because volume recovered was 2,400 board feet per acre, or 4 percent more than the cruise estimate of 60,000 board feet.

	Pulled unit, 62,400 board feet per acre	Free-felled unit, 60,000 board feet per acre
	(Dollars per acre)	
Logging costs	1,857.02	1,527.80
Value at $300 per 1,000 board feet	18,720.00	18,000.00
Net value	16,862.98	16,462.20
Additional value	5/400.78	0

5/$6.42 per 1,000 board feet.

Observed Benefits

At the outset of the study, operators actively engaged in jacking or tree pulling stated that they found both methods had numerous advantages over free falling. Published reports in trade journals have claimed such advantages as less damage to roads, lower costs for clearing streams, lower yarding costs, greater production at mills, safer working conditions, and less tree breakage.

Not all these advantages were directly measured in the study, but some were observed and are described below.

Breakage on Roads

Roads, particularly at the bottom of cutting units, can cause substantial breakage during free falling. Since the larger limbs of most trees grow on the downhill or sunlit side of the slope, the trees usually lean in that direction. If the cutting unit has a road and the cutters start from it, many of the first trees cut fall either on the road or the bank (fig. 11).

Figure 12 shows a jacked unit with a road at the bottom. Here, the trees at the edge of the road have been felled uphill and away from the road by use of jacks. Breakage in this area of the unit was almost nonexistent. In addition to savings on breakage, road maintenance costs are substantially lower since heavy equipment is not required to remove chunks and tops from the road as in a free-fall unit.

Figure 11.—Trees free felled beside a road.

Figure 12.—Trees jacked beside a road.

Costs of Clearing Streams

A large amount of breakage can accumulate in a steep-sided stream after free falling; much of it is too big to remove by hand and must be pulled out by a yarder. In another study with two similar cutting units, each having about the same length of stream, the logger recorded time spent in clearing the streams. Hours of labor were 41 percent less in the unit felled uphill. Although these data are not part of this report, they are indications of savings that can be achieved in clearing streams and probably in reducing yarding costs.

Safety

Safety of workers falling trees uphill is a controversial subject, even among fallers. Pulling trees uphill with a cable should be one of the safest ways to fall timber because the cutters have time to retreat to a safe place before signaling the machine operator to pull a tree over. In the jacking method, if jacks are provided with long hoses (100 feet, for instance), cutters could be a considerable distance from a tree when it falls. With either procedure, the workers have time to avoid the falling tree and falling limbs. Unfortunately, in actual practice these procedures are not regularly used, especially in jacking. Most hydraulic jacks have a 10-foot hose as standard equipment. Rarely does a cutter purchase additional lengths of hose to allow working a greater distance from the tree. Many cutters prefer to stay close to the stump because, by moving around it, they can more easily avoid a tree that does not fall in the planned direction. Also, many cutters are concerned about production and sometimes are still cutting on a tree while final jacking is in progress. Cutters in a tree-pulling operation, too, sometimes will cut wood as the tree is pulled over.

Cutters who have not jacked or pulled trees on a regular basis often express fear of working beneath felled or bucked timber and cite safety laws. Timber felled uphill, however, is not as prone to roll downhill as is timber felled across a hillside. It lies in an uphill direction (fig. 13) and is not aligned parallel to the contours. Observations during this study indicated that uphill tree pulling or jacking, properly practiced, should be as safe as free falling. Fallers who regularly fall trees uphill say they feel as safe or safer than when they were free falling trees.

Figure 13.—Trees felled uphill.

Summary and Conclusion

On five timber sales in west-side old-growth Douglas-fir, contract specifications required one cutting unit to be felled uphill, using, when necessary, hydraulic jacks or a tree-pulling machine. Timber on the other unit was to be felled by the conventional or free-fall method. Yarding and loading equipment, methods, and crew were to be the same in both units. Records were kept on the falling and bucking, yarding, and loading operations for each unit in each sale.

Data compiled from the falling and bucking phase indicated that total breakage was less, and tree utilization, log length to the first break, and percent of preferred log lengths were increased on units logged uphill. Productivity in terms of thousand board feet felled and bucked per person-hour, however, was decreased by about 18 percent when trees were jacked and 51 percent when they were pulled. When this loss of productivity was converted to dollars per thousand board feet, falling and bucking costs were increased 32 percent for jacking and 120 percent for pulling.

On these same uphill units, yarding productivity increased about 10 percent on the basis of a thousand board feet per person-hour; costs, in dollars per thousand board feet, decreased about 11 percent. Loading production and costs were not affected by falling methods.

Data from this study applied to representative timber values and volumes indicate that jacking or pulling trees uphill instead of free falling them can result in an additional value of $8.50 and $6.42 per thousand board feet, respectively. This increase in value can be achieved despite an increase in costs of falling and bucking uphill. Increased cutting costs are offset by reduced yarding costs plus a saving of timber through reduced breakage.

Other advantages of uphill falling, which either are impossible to measure or were omitted from this particular study, include protection of water quality and fish habitat, being able to harvest in environmentally sensitive areas, reduced costs of maintaining roads, and increased production and values of end products at mills.

From these five timber sales, we conclude that falling old-growth Douglas-fir uphill benefits the public agencies that sell timber and the industry that harvests and processes that timber.

Metric Equivalents

When you know	multiply by	to find
inches	2.540	centimeters
feet	0.305	meters
acres	0.4	hectares

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Five timber sales were made in old-growth Douglas-fir with matched cutting units. On one unit of each sale uphill falling by either hydraulic jacks or tree-pulling machine was required; on the other unit free falling was required. Logging equipment and methods were the same in each unit. Uphill falling produced a larger volume of timber at less cost than free falling because breakage was less.

KEYWORDS: Felling operations, old-growth stands, Douglas-fir, *Pseudotsuga menziesii*.

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