FOREST RESEARCH LABORATORY
RESEARCH NOTE 79

Damage to Regeneration during Shelterwood Overstory Removal on Steep Terrain: A Case Study

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Abstract

A case study was initiated in southwest Oregon to identify seedling characteristics and harvesting factors influencing seedling survival during removal of a shelterwood overstory. From a preharvest population of planted and natural Douglas-fir and ponderosa pine seedlings ranging from 5 to 400 cm in height, those between 40 and 100 cm high survived falling and yarding best. Most site disturbance and seedling mortality occurred within skyline corridors, which increased in width as skyline cross slope increased. However, even narrow (<2-m-wide) corridors on cross slopes <15 percent resulted in high mortality when they converged on a landing. Wide (10- to 12-m) corridors, occurring on skyline cross slopes >45 percent, also resulted in high mortality, but wide spacing between such corridors left many seedlings alive. Interplanting after logging would be necessary to ensure adequate stocking, with most of the seedlings required in areas where skyline corridors converge and in wide corridors on steep cross slopes.

Introduction

Over the last two decades, foresters in the western United States extensively prescribed the shelterwood regeneration system because clear-cutting had aroused public opposition and had frequently resulted in regeneration failure. In southwest Oregon, more than 80,000 ha received at least one shelterwood entry during this period. There have been, however, many regeneration problems locally with this silvicultural system: because of hot, dry summers and competing grass and sclerophyll brush, adequate natural regeneration has not been reliably obtained within 5 years. To remedy this problem, landowners have invested substantially in planting seedlings beneath shelterwood overstories, generally with success. Foresters are now concerned with protecting seedlings during overstory removal. There is, however, limited information on coordinating silvicultural objectives with cost-effective harvesting practices, especially on steep terrain where skyline logging is required.

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This case study was conducted to identify seedling characteristics and logging factors affecting seedling survival during such a harvesting operation. The effects of uphill and downhill logging, a variety of skyline cross slopes and corridor widths, and a range of seedling heights were observed. A skyline corridor is defined as the cleared strip of land through which logs are moved to a landing area by a skyline cable system, and skyline cross slope is the ground slope at right angles to the direction of the corridor.

Study Area and Methods

The study was on a 9-ha Bureau of Land Management (BLM) timber sale, about 8 km southwest of Medford, Oregon. Slopes within the unit were a nearly uniform 65 percent. The area had been logged by a combination of skyline and tractor systems in 1977. This entry constituted the shelterwood regeneration cut. Regeneration existing at the time of overstory removal was a combination of natural and planted Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] and ponderosa pine [Pinus ponderosa Laws.]. The Douglas-fir and ponderosa pine were underplanted in 1978 at a 1.8- by 1.8-m spacing. According to BLM stocking surveys, the area was satisfactorily stocked, but few excess seedlings were present. The overstory stand consisted of 434 trees over 19.0 cm d.b.h. and averaged 50 trees per hectare. Distribution of these trees was reasonably uniform throughout the unit (Fig. 1A). The merchantable volume averaged 145 m^3 per hectare.

Before logging, a 4.3- by 4.3-m grid was established over the study area. At each grid point, a 76-cm wire supporting a small plastic flag was inserted into the ground to mark the center of a circular plot with a 1-m radius. All plots were sampled prior to logging to determine seedling distribution (Fig. 1B) and height and to evaluate the condition and extent of understory vegetation. When present, one seedling on each plot was selected for observation of damage during logging. The intent was to examine possible relationships between seedling damage and skyline cross slope classes, seedling heights, and corridor widths for each yarding direction, rather than simply to provide a standard post-harvest stocking survey. The logging operation, which took place in July and August 1980, was representative of harvest practices on steep terrain for this area. Controlled falling techniques were not used (Fig. 1A). As a result, some trees were felled downhill and slid into the draw bottoms. Before yarding, trees were limbed and bucked to a maximum log length of 10.4 m. Nonmerchantable material was not yarded.

Two-thirds of the unit was logged uphill to two landings, with most of this timber being yarded with a fan-shaped setting to a landing on a small central ridge (Fig. 1C). The other one-third was logged downhill in two falling and yarding stages to landings on both sides of the main draw.

A Skagit GT-3 running skyline yarder with a Danebo mechanical slack-pulling carriage was used to yard the unit. This system was capable of laterally yarding logs up to 37 m from the skyline. During lateral yarding, the entire log dragged the ground, but upon reaching the corridor, logs were typically yarded with the leading end suspended. Light turn weights permitted the use of a generally slack skyline, which may have reduced log control and increased corridor width. The use of stumps for skyline anchors resulted in low carriage clearance; thus, logs dragged the ground at the outer ends of the skyline corridors. Only twice during a sample of 32 yarding cycles were logs fully suspended over the two small draws below the upper fan-shaped setting.

Sample plots within the area yarded uphill were revisited after falling and again after yarding to determine the amount of seedling mortality (Fig. 1D) and site disturbance resulting from each of these phases of the logging operation. The logging contractor's operating schedule permitted plots in the area yarded downhill to be resampled only after both falling and yarding were completed.

Seedlings were classified as survivors if they suffered no observable aboveground damage or only minor damage such as broken lateral branches. Missing seedlings and those partially uprooted or with stems stripped of bark or with broken terminal leaders were classified as dead.

As an additional indication of logging-related disturbance, impacts to understory vegetation and to the ground surface were assessed throughout the study area. A plot was recorded as disturbed

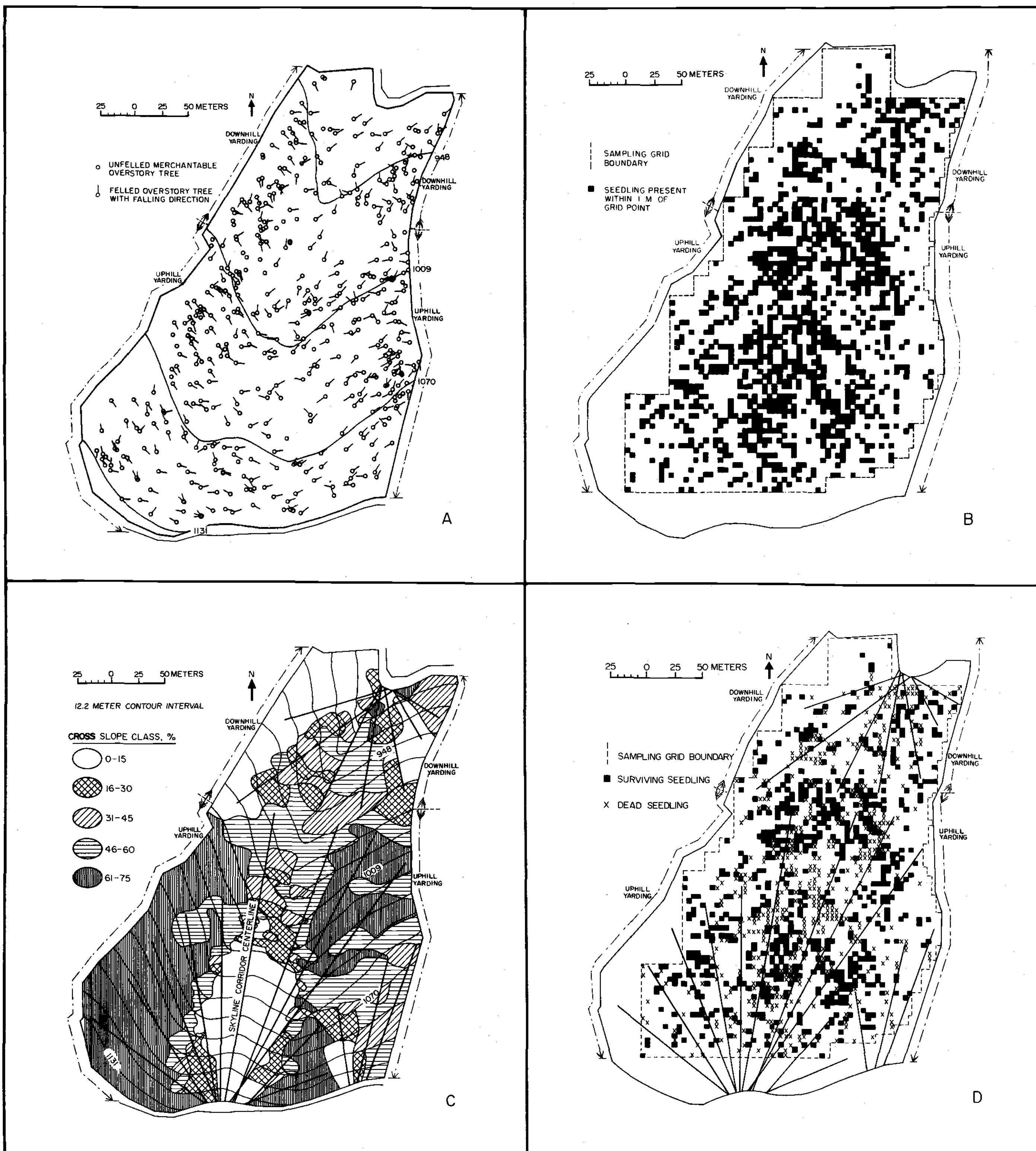

FIGURE 1.

(A) DISTRIBUTION AND FALLING DIRECTION OF OVERSTORY TREES. (B) DISTRIBUTION OF SAMPLE SEEDLINGS ON THE STUDY AREA BEFORE LOGGING. (C) SKYLINE CORRIDORS AND ASSOCIATED CROSS SLOPES. (D) DISTRIBUTION OF SURVIVING SAMPLE SEEDLINGS ON THE STUDY AREA AFTER LOGGING.

if understory vegetation had been destroyed and bare ground was present or if the plot had been buried under logging debris.

After logging, a theodolite and level rod were used to make an accurate contour map of the study area. Skyline corridors were traversed and located on this map. Their widths were measured as each corridor was traversed. Skyline cross slope was estimated for each plot from the topographic map (Fig. 1C).

Graphical displays, chi-square tests of independence, and regression analysis were used to assess plot disturbance and seedling mortality as functions of logging phase (falling or yarding), skyline cross slope, and yarding direction. Seedling survival was also assessed as a function of seedling height.

Damage to Uphill—Yarded Area

Site Disturbance

Fifteen percent of the plots were disturbed by tree falling (Table 1). Of the remaining undisturbed plots, 28 percent were disturbed by log yarding. After both logging phases were completed, a total of 35 percent of the plots had been disturbed by either falling or yarding.

TABLE 1.

SITE DISTURBANCE AND SEEDLING MORTALITY INCURRED DURING FALLING AND YARDING.

Yarding direction and logging phase	Site disturbance[a]	Seedling mortality[b]
	Percent	
Uphill		
Falling	15	22
Yarding	28	28
Falling & yarding combined[c]	35	41
Downhill		
Falling & yarding combined	30	42

[a] Percentage of plots on which disturbance to understory vegetation or ground surface occurred.
[b] Percentage of surviving seedling population killed by indicated logging activities.
[c] Total disturbance does not equal sum of falling and yarding disturbance because some plots buried by large amounts of slash during falling were uncovered during yarding.

Plot disturbance from yarding logs was not functionally related to skyline cross slope (Table 2). However, width of skyline corridors was greatest on areas of steeper cross slope (Fig. 2). Skyline corridors averaged less than 2 m wide in areas with cross slopes less than 15 percent; in areas with cross slopes greater than 45 percent, they averaged 10 to 12 m wide.

TABLE 2.

PERCENTAGE OF PLOTS DISTURBED DURING LOGGING PHASES, BY SKYLINE CROSS SLOPE CLASS.

Yarding direction and logging phase	Skyline cross slope class (percent) 0–15	16–30	31–45	46–60	61–75
	Percent disturbed (and total number of) plots				
Uphill					
Yarding	33.3 (378)	28.0 (161)	31.5 (178)	28.1 (698)	25.5 (926)
Falling & yarding combined	38.9 (450)	38.6 (202)	41.8 (225)	34.3 (823)	31.3 (1,057)
Downhill					
Falling & yarding combined	23.2 (498)	26.9 (253)	32.6 (215)	41.8 (263)	55.0 (20)

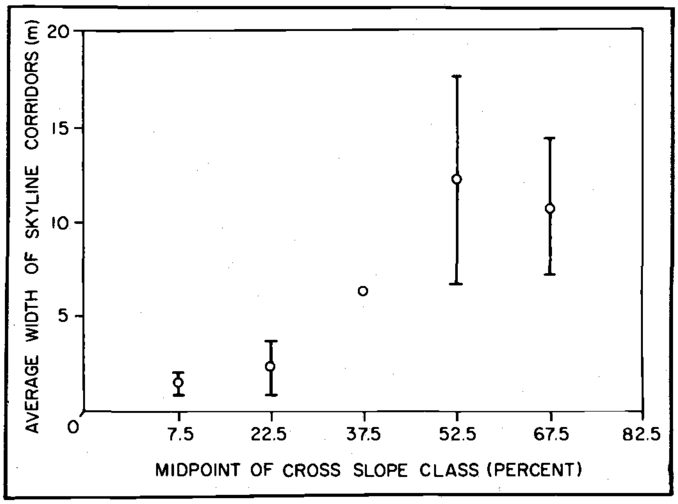

FIGURE 2.

AVERAGE WIDTH OF SKYLINE CORRIDORS (±1 S.D.) AS A FUNCTION OF CROSS SLOPE. THE MIDPOINT AT 37.5 PERCENT REPRESENTS ONLY ONE OBSERVATION.

Seedling Mortality

Prior to logging, seedlings were found within 35 percent of the sample plots (966/2,757) and ranged in height from 5 to 400 cm. Those in the 21- to 40-cm height class were by far the most common (Fig. 3).

Tree falling killed 22 percent of the sample seedlings (Table 1). Mortality in the various height classes ranged from 15 to 28 percent and was not functionally related to seedling height.

Twenty-eight percent of the sample seedlings that survived falling were killed by log yarding (Table 1). When the entire range of seedling heights was analyzed by linear and simple curvilinear regressions, seedling height did not explain much of the variation in seedling mortality. However, in the range from 0 to 100 cm, yarding mortality was linearly related to height ($r = -0.98$) (Fig. 3). Mortality was least in the 61- to 100-cm height classes. Above 100 cm, seedling mortality generally increased, but there was a large amount of variation in survival.

We were unable to find a meaningful statistical relationship between skyline cross slope class and seedling mortality resulting from yarding. However, mortality was somewhat less for cross slope classes in excess of 45 percent (Table 3). On steep cross slopes, few seedlings survived within the wider skyline corridors; however, tailholds were 50 m apart, and substantial numbers of seedlings survived between corridors.

TABLE 3.

SEEDLING MORTALITY INCURRED DURING LOGGING PHASES, BY SKYLINE CROSS SLOPE.

Yarding direction and logging phase	Skyline cross slope class (percent) 0–15	16–30	31–45	46–60	61–75
	Percent seedlings killed (and total number before logging activities)				
Uphill					
Yarding	36 (137)	46 (48)	23 (56)	25 (199)	25 (222)
Falling & yarding combined	48 (176)	54 (69)	44 (78)	38 (260)	36 (277)
Downhill					
Falling & yarding combined	37 (78)	36 (66)	43 (74)	45 (89)	100 (9)

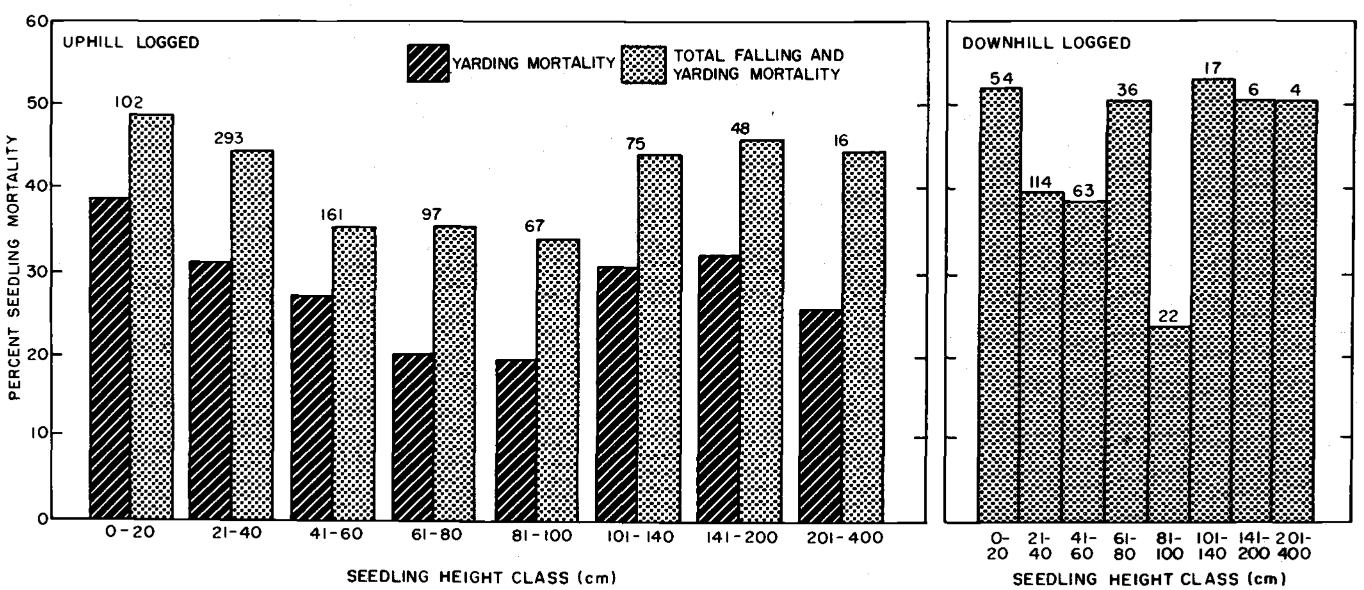

FIGURE 3.

SEEDLING MORTALITY AFTER UPHILL AND DOWNHILL LOGGING, BY SEEDLING HEIGHT CLASS. NUMBER OF LIVING SEEDLINGS PRIOR TO LOGGING INDICATED ABOVE THE BARS.

Damage to Downhill—Yarded Area

Site Disturbance

The combined effects of falling and yarding resulted in disturbance to 30 percent of the plots in the area yarded downhill (Table 1). In contrast to the area yarded uphill, disturbance of plots in the area yarded downhill was strongly associated with skyline cross slope (P = 0.05), with plot disturbance increasing from 23.3 percent to 55.0 percent as cross slope increased (Table 2).

Seedling Mortality

Before logging, seedlings were found on 29 percent of the plots in the downhill-yarded area (356/1,249). Forty-two percent of these seedlings were killed during logging (Table 1). Seedling mortality was not functionally related to seedling height, but the 81- to 100-cm height class had the lowest mortality—22 percent (Fig. 3). Seedling mortality increased with increasing skyline cross slope (Table 3).

Because tree falling patterns were similar in both yarded areas and the ground slope was uniform (Fig. 1A,C), it was assumed that any differences in overall seedling survival on the areas yarded uphill and downhill could be attributed to differences in log control associated with yarding direction. However, total mortality was similar for both yarding directions (Table 1), and a chi-square test indicated that seedling mortality was independent of yarding direction (P = 0.05). Distribution of surviving sample seedlings is shown in Figure 1D.

Do Our Results Make Sense?

Seedlings in the study area were subjected to a variety of disturbances normally associated with skyline logging of a shelterwood overstory. When heavy timber is removed from steep terrain by a skyline logging system with many converging corridors and steep skyline cross slopes, ground disturbance can be severe. Such disturbance can be especially detrimental to young seedlings. In the present study, in which 30 to 35 percent of the site was disturbed, seedlings less than 20 cm in height did not survive well. Such seedlings are easily pulled from the ground or, when damaged, have a limited ability to survive. Their greater flexibility, however, enables them to survive some of the disturbance resulting from timber falling, including logs that roll downhill after bucking.

Larger seedlings, from 40 to 100 cm in height, survived best under the conditions of this study. Such seedlings have a better-established root system and larger crown, yet they remain quite flexible. These characteristics help prevent seedlings of this size from being dislodged from the soil or from suffering breakage. Seedlings taller than 100 cm are more rigid and may suffer increasing amounts of breakage or uprooting, as was borne out in this study.

Other researchers have also identified size classes of seedlings that survive logging operations better than others (Gaas 1974, Benson and Gonsior 1981). However, optimum size classes vary as terrain features, stand characteristics, harvesting equipment, and layout of the timber sale change; consequently, only broad generalizations are possible.

Although falling and yarding in this study caused almost equal seedling mortality in the area yarded uphill, Studier and Binkley (1974) contend that falling should cause limited mortality if logs do not slide or roll after hitting the ground. They indicate that directional falling should minimize log movement after the tree hits the ground and may also reduce seedling mortality during yarding by reducing the angle through which the logs must be turned as they are moved into the skyline corridor. Perhaps if the trees in this study had been felled uphill or toward the skyline corridor by using wedges, hydraulic jacks, or tree-lining techniques (Hunt and Henley 1981), they would have rolled and slid downhill less frequently and mortality from both falling and yarding might have been reduced.

Studier and Binkley (1974) also contend that the width of the skyline corridor will increase with increasing skyline cross slope, regardless of yarding direction. Our observations support this contention but not the logical corollary that, as skyline cross slope and corridor width increase during uphill logging, seedling mortality will also increase. This apparent contradiction in our results is largely explained by the layout of the skyline corridors in this unit. On the area yarded uphill, 11 corridors converged through the flatter cross slopes below the main landing. This pattern resulted in concentrated site disturbance and seedling mortality even though individual corridors were generally less than 2 m wide. The converging corridors disturbed a large proportion of the area on the flatter cross slopes. In comparison, almost complete seedling mortality was observed within the wide corridors associated with steep cross slopes, but these areas were generally at the outer yarding limits of the fan-shaped corridor pattern where individual corridors were up to 50 m apart. The ground between the corridors remained relatively undisturbed and seedling survival was high. Here, the large amount of disturbed ground in the corridors represented a relatively smaller proportion of the total area mapped in the steep cross slope classes. We hypothesize that this is the reason why our results do not show mortality to increase as skyline cross slope increases.

Binkley and Lysons (1968) and Conway (1976) report that downhill logging will cause more damage to seedlings than uphill logging because the former allows less log control. During downhill yarding, the trailing end of a log is free to move laterally under the influence of gravity and may not track well in a corridor, particularly as skyline cross slope increases. In this study, mortality was independent of yarding direction. Comparison of the two yarding directions may be invalid, however, because downhill yarding involved shorter skyline lengths, greater carriage clearances, and fewer converging corridors. Nevertheless, it is clear that for downhill logging under the study conditions, minimizing skyline cross slope reduces site disturbance and seeding mortality.

What Can We Conclude from a Case Study?

Results of this single case study must be applied cautiously to other areas and conditions, although they do provide a basis from which to plan additional research under more controlled conditions. Some generalizations, however, can be made from our data. In areas where logging-related ground disturbance during overstory removal is extensive, seedlings between 40 and 100 cm in height may survive best. Furthermore, the layout of skyline corridors can have an effect on the amount of site disturbance and seedling mortality. Numerous corridors converging on a single landing result in extensive site disturbance and mortality, regardless of corridor width. A layout that minimizes both corridor width and the number of corridors converging on a single landing will provide the best possible distribution of seedlings after overstory removal. In evaluating the post-harvest seeding population, it may be useful to keep in mind future tree spacing goals. Surviving seedlings on either side of a 3-m-wide corridor may easily meet the targeted spacing for young stands, but 15-m-wide corridors probably create unacceptable holes in the stand, regardless of corridor pattern.

Literature Cited

BENSON, R.E., and M.J. GONSIOR. 1981. Tree damage from skyline logging in a western larch/ Douglas-fir stand. USDA Forest Service Research Paper INT-268, 15 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

BINKLEY, V.W., and H.H. LYSONS. 1968. Planning single-span skylines. USDA Forest Service Research Paper PNW-66, 10 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

CONWAY, S. 1976. Logging Practices. Miller Freeman Publications, Inc., San Francisco, California. 416 p.

GAAS, A.A. 1974. Rational logging technology with preservation of advance growth. Lasnoye Khozyaistvo (1):28-32.

HUNT, D.L., and J.W. HENLEY. 1981. Uphill felling of old-growth Douglas-fir. USDA Forest Service Research Paper PNW-122, 18 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

STUDIER, D.D., and V.W. BINKLEY. 1974. Cable logging systems. USDA Forest Service, Region 6, Division of Timber Management, Portland, Oregon. 211 p.

Note

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Conversion Table

1 cm = 0.4 inch
1 m = 3.3 ft
1 ha = 2.5 acre

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