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SOIL SURFACE CONDITIONS FOLLOWING SKYLINE LOGGING

by

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In the Douglas-fir region of the Pacific Northwest, most timber harvesting involves one of three methods: tractor, high-lead, or skyline. Tractor and high-lead methods are now used much more frequently than the skyline. Recently, however, interest in skyline logging has increased, especially in areas where the timber ready for harvest is located on steep terrain with difficult access. Because skyline yarding distances may range up to a mile, road requirements are substantially less than those for other methods. Wooldridge,[1] in comparing skyline and tractor logging near Twisp, Wash., estimated that skyline logging required only 10 percent of the road area necessary for tractor yarding.

Skyline logging has been advocated not only for its effect in decreasing soil disturbance due to road construction, but also because of its potential for minimizing soil disturbance during yarding. Typically, a skyline system involves yarding logs to a fixed overhead cable where they are raised then transported to a downhill landing. Theoretically, the logs should be off the ground over most of the yarding distance; therefore, it has been assumed that skyline logging results in substantially reduced soil disturbance compared with that resulting from a conventional high-lead operation.

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[1] Wooldridge, David D. Watershed disturbance from tractor and skyline crane logging. J. Forest. 58: 369-372, illus. 1960.

THE STUDY

This paper reports on the results of a portion of a study designed to assess and compare soil disturbance caused by tractor, high-lead, and skyline logging. The effects of high-lead and tractor logging on soil surface conditions have been described previously.[2/] The study was conducted in the H. J. Andrews Experimental Forest, which is located on the west side of the Cascade Range, approximately 40 miles east of Eugene, Oreg.

The effects of skyline logging were studied in experimental watershed 1. This entire 237-acre watershed was clearcut between the fall of 1962 and the fall of 1966. Logs were yarded to a single landing near the mouth of the watershed by means of a 10-ton Wyssen Skyline Crane.

The timber stand was largely old-growth Douglas-fir mixed with western hemlock. Slopes in watershed 1 are steep, averaging about 63 percent. There are several nearly vertical rock outcrop areas, as well as steep downward trending ridges between tributary drainages. Soils tend to be shallow and stony. The Frissell series,[3/] a Regosol derived from reddish tuffs and breccias, is the most common soil in the area.

Four soil surface disturbance classes were used to determine the extent of soil disturbance after yarding:

1. Undisturbed--litter still in place and no evidence of compaction.
2. Slightly disturbed--three conditions fit this class:
   a. litter removed and mineral soil exposed;
   b. mineral soil and litter intimately mixed, with about 50 percent of each; and
   c. pure mineral soil deposited on top of litter and slash.

[2/] Dyrness, C. T. Soil surface condition following tractor and high-lead logging in the Oregon Cascades. J. Forest. 63: 272-275, illus. 1965.

[3/] Provisional series, not yet correlated.

3. Deeply disturbed--surface soil removed and the subsoil exposed.
4. Compacted--obvious compaction due to passage of a log. The soil surface directly under large cull logs was assumed to be in this condition.

The percentage of the total clearcut area in each of the four disturbance classes was determined from conditions observed at 10-foot intervals along eight randomly located transects.

Slash density observations were also made within 1 square foot centered at each observation point. The four slash density classes were as follows:

1. Heavy--entire square foot covered with slash at least 1 foot deep.
2. Light--10 percent or more of the area covered with slash less than 1 foot deep.
3. Absent--total slash cover is less than 10 percent.
4. Cull log--log 12 inches or more in diameter present.

To determine the extent to which surface soil physical properties were altered by logging disturbance, 80 bulk-density samples were collected from the surface 2 inches of soil. Sampling was carried out in a representative area of Frissell soil near the mouth of the watershed. Twenty bulk-density samples were collected in 1962 before logging, and 20 samples were taken from areas representative of each of three disturbance classes after logging--undisturbed, slightly disturbed, and deeply disturbed. The compacted class was not sampled for bulk density because much of it was located directly beneath cull logs.

RESULTS

Soil surface disturbance and slash density were observed at about 1,750 points in watershed 1. Values for high-lead logging in three nearby cutting units are included in the summary for comparison (table 1).

Perhaps the most surprising aspect of the soil surface disturbance data is that values for skyline and high-lead logging are, in most respects, similar. Largest differences between skyline and high-lead logging are in the proportion of logged area within the deeply disturbed and compacted classes. Skyline logging resulted in some decrease in both the proportion of area classified as deeply disturbed (4.7 percent vs. 9.7 percent for high-lead) and compacted (3.4 percent vs. 9.1 percent for high-lead). Although skyline logging resulted in slightly more area within the undisturbed class as compared with high-lead logging, there was also a small increase in area within the slightly disturbed class (table 1).

Table 1.--*Percent of total cutting unit area by soil surface disturbance and slash density classes for two logging methods; H. J. Andrews Experimental Forest*

Classes	Skyline	High-lead[1/]
Soil surface disturbance:		
Undisturbed	63.6	57.2
Slightly disturbed	24.4	21.5
Deeply disturbed	4.7	9.7
Compacted	3.4	9.1
Nonsoil areas[2/]	3.9	2.5
Total	100.0	100.0
Slash density:		
Heavy	10.8	26.9
Light	53.8	37.7
Absent	32.2	25.9
Cull log	6.4	9.9
Total	[3/] 103.2	100.4

[1/] Averages for three cutting units located in watershed 3 in the H. J. Andrews Experimental Forest (see text footnote 2).

[2/] Stumps, rock outcrops, and streambeds.

[3/] Totals more than 100 percent because "cull log" plus "heavy" or "light" slash were sometimes recorded at a single point.

Slash distribution figures indicate that skyline logging caused fewer accumulations of heavy slash than did high-lead (table 1). As a result, there was a corresponding increase in the proportion of the area falling within the light slash class in the skyline unit (53.8 percent vs. 37.7 percent for high-lead).

Bulk density of the surface 2 inches of soil in both the skyline and high-lead logged areas was similar for the before-logging class and for the undisturbed and slightly disturbed classes after logging (table 2). Light disturbance apparently results in very little alteration of the mineral soil, involving mainly the removal of surface litter. Deep disturbance caused an appreciable increase in bulk density for both skyline and high-lead logging methods. This greater bulk density may be attributed largely to the exposure of more dense subsoil material.

Table 2.--*Mean surface-soil bulk-density values*[1] *before and after two methods of logging; H. J. Andrews Experimental Forest*

(In grams per cubic centimeter)

Disturbance	Skyline	High-lead[2]
Before logging	0.677 ± 0.023	0.712 ± 0.016
After logging:		
Undisturbed	.730 ± .032	.753 ± .019
Slightly disturbed	.668 ± .030	.785 ± .032
Deeply disturbed	.858 ± .025	.990 ± .026

[1] Standard error of the mean.

[2] The high-lead samples were collected in an area of the McKenzie River soil (tentative series) which, like the Frissell, is derived from reddish tuffs and breccias. The Frissell and McKenzie River series have almost identical surface soil properties.

DISCUSSION

The potential for erosion following logging is largely a function of the area of exposed mineral soil. Therefore, a protective layer of slash over disturbed soil will probably prevent any substantial amount of surface erosion for at least a year or two. In this study of skyline logging, the presence or absence of slash was noted along with the degree of soil disturbance. The proportion of the logged area in which bare mineral soil was exposed was 12.1 percent of the total area of this skyline-logged unit. This value is compared with values for percent of bare mineral soil exposed, determined in another study comparing skyline and high-lead logging on the Oregon coast:[4]

	Skyline	High-lead
	(percent)	(percent)
This study	12.1	14.8
Oregon coast	6.4	15.8

In this study, about twice as much bare mineral soil was exposed by skyline logging as that determined by Ruth on the Oregon coast. The greater incidence of soil disturbance in the present study is probably due largely to the unfavorable topographic characteristics of watershed 1 for skyline logging. The canyonlike terrain and intervening ridges often made it impossible to hold the logs off the ground during the entire yarding distance, resulting in considerable soil disturbance on ridgetops directly under the skyline. The site for the coast study was much more favorable for skyline operations, having generally smooth, uniform side slopes. As a result, it was possible to keep logs free of the ground, minimizing contact between logs and soil during yarding.

Soil surface disturbance data collected for this study indicate very little difference between the skyline and high-lead logging methods. This agrees substantially with Ruth's findings on the Oregon coast. His study was replicated on four areas where half of each area was logged

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[4] Ruth, Robert H. Silvicultural effects of skyline crane and high-lead yarding. J. Forest. 65: 251-255, illus. 1967.

by the skyline method and the other half by high-lead. At two of these sites, the skyline-logged area showed considerably less disturbance than did the high-lead. However, at the other two locations both logging methods resulted in approximately equal amounts of soil disturbance. Because of this variance, the difference between the two treatments was not statistically significant.

Soil surface conditions immediately after logging are subject to rapid change, especially if the slash is burned. The amount of bare soil exposed to the erosive action of precipitation after burning may actually be controlled more by severity of the slash burn than by the original logging disturbance. It is also important to consider the rapidity with which vegetation restores protection against erosion. Despite regeneration problems that sometimes arise, we are fortunate in western Oregon that regrowth of native vegetation in cutting units occurs rapidly. Present plans call for study of soil surface conditions following slash burning in watershed 1, as well as a yearly inventory of plant cover and species composition.

Since results of this study, along with Ruth's findings, indicate very little difference in yarding-caused disturbance when skyline logging is compared with high-lead, it may be concluded that the main advantage of the skyline method lies in the fact that it requires far less road construction than does high-lead. Binkley[5/] calculated that road requirements for skyline yarding are only about one-third of those necessary for high-lead logging. This reduction is extremely important to good watershed management. Many studies have shown roads, especially those newly constructed, are often the primary source of stream sediment coming from forested uplands. For example, Fredriksen[6/] reported that road construction in watershed 3 resulted in a 250-fold increase in stream sediment during the first storms after the roads were built. In addition to surface erosion

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[5/] Binkley, Virgil W. Economics and design of a radio-controlled skyline yarding system. U.S. Forest Serv. Res. Pap. PNW-25, 30 pp., illus. 1965.

[6/] Fredriksen, R. L. Sedimentation after logging road construction in a small western Oregon watershed. In Proc. Fed. Inter-Agency Sedimentation Conf., 1963. U.S. Dep. Agr. Res. Serv. Misc. Pub. 970, pp. 56-59, illus. 1965.

from raw, roadside slopes, roads are also the source of many mass soil movements, some of which have far-reaching downslope effects. Therefore, any means of reducing road mileage in steep, mountainous areas of western Oregon and Washington is a goal well worth pursuing. The possibilities of skyline logging in this connection certainly deserve serious consideration

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