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LOGGING RESIDUE RESULTING FROM AN INTERMEDIATE HARVEST OF A SECOND GROWTH REDWOOD STAND

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Figure 1. Logging residue remaining after an intermediate harvest in second-growth redwood. This area was logged using a running skyline yarding system.

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KEYWORDS

Intermediate harvest, Jackson Demonstration State Forest, line intercept, logging residue, redwood.

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METRIC CONVERSIONS

1 ft	=	0.305 m
1 in	=	2.54 cm
1 ac	=	0.405 ha
1 ft^2	=	0.093 m^2
1 ft^3	=	0.028 m^3
1°F	=	0.556°C
1 mi	=	1.609 km

ABSTRACT

Volumes of logging residue in pieces >1.5 inches diameter and >4 feet long produced from an intermediate harvest that removed 40% of the basal area of a mature second growth coast redwood stand were examined. Residue production from cable and tractor yarding sites was also compared. Cable logging produced 844 cubic feet of residue per acre while tractor logging produced 554 cubic feet per acre. This low residue volume is uneconomical for building material or fuel with present market prices.

INTRODUCTION

With building materials and energy sources at a premium, alternative sources are constantly in demand. Residue such as limbs, bark, tops, and broken pieces left in the forest after timber harvesting has recently been considered as possible material to meet some resource needs (Grantham and Howard 1980). Forest land managers are also interested in this residue because it affects wildlife habitat, restricts access to stands, increases wildfire potential, diminishes aesthetics, and influences nutrient cycling.

Estimates of the quantity of residue left after harvesting are varied (Howard 1981a, 1981b), because of differences among stands, harvest systems (clear or partial cut), and yarding methods. Residue research in redwood stands has been conducted following harvesting of old growth forests (Boe 1967), but in recent years the majority of harvesting has been in second-growth stands less than 100 years old. Residue volumes from an intermediate harvest in a second-growth stand are presented with emphasis on current utilization potential.

STUDY SITE

The study site is located on the Jackson Demonstration State Forest in Mendocino County, California. The area, 5 miles inland from the Pacific Ocean at an average elevation of about 800 feet, is part of the Hare Creek drainage and totals 346 acres. Precipitation averages 50 inches annually, falling almost entirely as rain from November to April. Coastal fog also provides additional moisture during the summer.

Soils on the upper slopes are Van Damme clay loams (clayey, vermiculitic, isomesic typic tropohumults) and Tramway or Irmulco series (fine-loamy, mixed, isomesic, ultic tropodalfs) on the steeper side slopes (Soil Survey 1986). The site is very good for redwood/Douglas-fir forest.

Historically the area was dominated by old growth coast redwood (Sequoia sempervirens [D. Don] Endl.) with some Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco), grand fir (Abies grandis [Dougl.] Lindl.), western hemlock (Tsuga heterophylla [Raf.] Sarg.), and an occasional Bishop pine (Pinus muricata D. Don). This drainage was first harvested about 90 years ago. The old growth forest was clearcut and logged with primitive equipment, then burned shortly afterward, leaving the site cleared of understory and smaller slash. Redwood regenerated naturally from sprouts and seed, while other conifers regenerated from seed alone. An occasional old growth tree, rejected by early loggers, also remained.

This second-growth stand was harvested in 1976. The harvest was designed to retain approximately 175 to 200 square feet per acre of basal area. This resulted in removing 45% of the 365 square feet per acre of conifer basal area in the unharvested stand. Part of the management objective was to increase redwood stocking so Douglas-fir was cut more intensively than redwood. Except for small but vigorous grand fir individuals, all other minor conifer species were completely removed.

Tanoak (Lithocarpus densiflora [H. & A.] Rehd.) was the most numerous and widespread hardwood species on the study area before logging. Although no preharvest tanoak data was collected on the harvested area, a similar unlogged adjacent stand had 36 square feet of tanoak basal area per acre. Hardwoods were not harvested in the 1976 operation.

Two harvest methods were employed: cable, using a yarder with a running skyline; and tractor, using crawler and rubber-tired machines (Figures 1 and 2). No whole tree skidding was done with either harvest method. Limbing was conducted along the entire tree length in the yarder area and to a 6-inch top in the tractor area. Yarder corridors were no wider than 20 feet and were usually only 10 to 15 feet wide.

The cable and tractor areas were essentially equally harvested. Post-harvest basal areas are shown in Table 1. Board foot volumes and changes in species composition for comparison are in Table 2.

Table 1. Basal area remaining after intermediate harvesting using a tractor and cable system. Values are means in square feet per acre (plus or minus one standard deviation). Pre-harvest basal area was 365 square feet per acre.

	Redwood	Douglas-fir	Other Conifer	Conifer Total	Tanoak
Cable	158.0 (88.2)	41.9 (37.0)	0	199.0	13.0 (20.8)
Tractor	164.1 (74.7)	48.3 (44.9)	0.7 (3.7)	213.1	6.9 (21.6)

Table 2. Species composition and board feet of timber harvested from a 346-acre intermediate harvest in a second-growth coast redwood stand.

	Species Composition (%) Pre-Harvest	Species Composition (%) Post-Harvest	Board Feet (millions)
Redwood	69	89	5.909
Douglas-fir	26	11	6.127
Other Conifers	5	0	.929
Total	100	100	12.965

Figure 2. This second growth redwood stand was logged by tractors and rubber-tired skidders.

Figure 3. An example of logging residue that remained from earlier harvests some 90 years ago.

METHODS

Logging residue was sampled in 1982, six years after harvesting, using a line intercept method (Pickford and Hazard 1978). A random starting point was chosen on the road around the harvest area. From this point, a random compass point directed into the harvest area was selected. A straight transect was walked from this point, continuing until it had crossed the harvest area. Transects did not cross any roads used since the harvest ended. Because the area is topographically diverse, any one transect had some lines perpendicular and others parallel to the slope. Lines were not allowed to approach within 100 feet of currently used roads, as some residue next to roads had been removed by firewood cutters.

The sampling procedure involved stretching a 100-foot tape across the forest floor and recording any intercepts made by qualified residue pieces. These lines were segments of the straight transect, the beginning of each line being a random distance of up to 50 feet from the end of the previous line on the same transect. Each transect usually had about five 100-foot lines. A residue piece qualified if it was at least 4 feet long and greater than 1.5 inches in diameter at the point of intercept with the line. Residue pieces counted were placed into 1-inch diameter categories. Residue encountered was segregated into three types of material: second-growth logging residue, remnant residue of the original old growth forest harvest (Figure 3), or recent wind-fall material. No separation of fragments by species was attempted.

Slash piles on landings were burned immediately following the harvest, so were not sampled in this study. Results from other partial cuts (Howard 1981a) have shown that slash piles contain less than 3% of the volume of wood removed, on average.

Forty intercept lines were placed in each harvest area. This sample was determined adequate at the 95% level plus or minus 19%, using variation in volume of logging residue to determine adequacy (Howard 1981a). Change in sample standard deviation was negligible after about 25 lines had been placed in each area.

The data was converted to cubic feet per acre using the formula:

$$V = \frac{\pi^2 \Sigma d^2}{8L} \cdot \frac{43560}{144}$$

where V = volume in cubic feet per acre, L = length of the sample line, and d = diameter of residue pieces (Hazard and Pickford 1980, Howard 1981a). Volumes were determined for different size classes of residue as well as total volume.

The percent of bole length containing some living foliage was estimated for trees in the cable area and the tractor area. Ocular estimates were made to the nearest percent of height. Trees were selected randomly from several harvest areas adjacent to and including the study site to get a fair comparison between hilltop and sidehill trees.

RESULTS AND DISCUSSION

Tractor-logged areas tend to be near hilltops and cable areas on hillsides, so a difference in the percent of live crown might exist because of supposed environmental differences between the two areas. If the trees in one area had more crown to begin with, then a difference in residue following logging would be expected. However, comparisons of percent live crown between tractor and cable logged areas showed no apparent difference. The sidehill cable sites averaged 20.6% crown (+-10.8, N=104 trees) and hilltop tractor sites averaged 21.3% (+-10.7, N=108 trees). Consequently, there is no reason to believe that any differences in logging residue between tractor and cable areas resulted from a difference in the types of trees harvested.

Table 3. Volume of residue remaining on the forest floor following an intermediate harvest with two types of log removal. Volumes statistically different between cable and tractor areas are indicated with an asterisk (P<.05).

DIAMETER CLASS inches	CABLE cu. ft./acre	TRACTOR cu. ft./acre
2	183.6*	104.5
3	92.4*	64.7*
4	103.0	79.1
5	79.3	46.7
6	97.4	100.8
7	18.3	32.0
8	47.8	65.7
>8	222.2*	60.3*
TOTAL (current harvest)	844.0*	553.8*
OLD RESIDUE	460.8	860.1
TOTAL (all residue)	1304.8	1413.9

Results of the line intercept estimate of residue are presented in Table 3. The cable-logged area had 52% more residue from the 1976 harvest than the tractor area, a difference significant at the .05 level. Small limb-sized pieces accounted for much of the total difference, possibly because of differences in limbing requirements between the yarder and tractor areas. It is also possible that fewer qualified pieces at least four feet long existed in the tractor area because of crushing and breakage by the tractors during skidding.

The cable logged area also had nearly four times the volume of pieces more than eight inches in diameter, probably due to breakage during timber felling and bucking because of the steeper ground. None of the 8-inch and greater-sized residue pieces encountered were merchantable sawlogs.

The majority of slash material is from harvested conifers, but some is also from hardwoods. The hardwoods are not harvested but some are knocked down or broken off during timber felling and skidding and generally left lying intact. Tanoak decreased from a basal area of about 36 square feet per acre before harvest to 9.2 square feet per acre following the harvest.

Decay rates vary between conifer residues. The Wood Handbook (1974) classifies redwood as the most resistant to decay, Douglas-fir as moderately resistant, and true firs, such as grand fir, as having slight resistance. Tanoak is also only slightly resistant to decay. All of the remnant material from the original harvest was redwood, much of it greater than 20 inches in diameter; consequently we feel that few, if any, residue pieces had decayed appreciably, although the area was sampled six years after the harvest.

Our results show residue volumes much lower than those reported for other selection harvests in the Northwest. Howard (1981a) showed partial cuts in Oregon and Washington yielding an average of 124 cubic feet of residue per 1000 board feet harvested, though he does not state the intensity of the partial harvest. For the entire harvest area, our data showed only 17.1 cubic feet of residue per 1000 board feet harvested.

These low residue volumes combined with current poor markets and high cost of reentry harvests would make salvage operations economically marginal at best. Hardwood close to roads will be removed by individual firewood gatherers, but this is a small part of the residue volume. Most of the tractor area skid roads were closed after the harvest to prevent erosion, and there is no vehicular access into the cable area. Preliminary attempts to remove downed hardwoods for firewood on a commercial basis following conifer harvest on the State Forest have not been very successful.

The long-term market for chipped material has not been sufficient to interest industry in developing a commitment to residue salvage. Because much of the residue volume is in small pieces it will be some time before technology will allow this material to be used in quantities such as those from this harvest.

The potential for energy production from logging residue exists. Considering that the total harvest volume from the study area was 12,965,000 board feet, an estimated 221,505 cubic feet of residue remains. However, this material is economically unobtainable using present harvest methods. A whole-tree harvesting system seems feasible, but much work remains to investigate this possibility.

Removing residue as a step in timber stand maintenance, especially coupled with present markets for residue material, is not economically justified. The residue volumes remaining following this intermediate harvest do not sufficiently increase the wildfire potential in these stands near the coast to warrant removal. Access by foot to the stand is somewhat impeded by the small limbs, but this material will decompose during the next few years.

The timber site may actually benefit by leaving the residue in place. Nutrient cycling is certainly improved by natural decay of slash (Stark 1980, among others) and erosion is reduced. The effect of slash on understory plant species or conifer regeneration is not clear, but such small volumes as encountered here are probably innocuous. Proper inventory of residue derived from harvesting conifers will help forest land managers understand the importance and potential of this resource.

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