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Natural Abatement of Fire Hazard in Douglas-fir Blowdown and Thinning Fuelbeds

Abstract

Chronosequences of fuelbeds resulting from precommercial thinning and blowdown in Douglas-fir were measured using standard fuel inventory techniques. Non-linear least squares regressions were fitted to the resulting data. Results confirmed that precommercial thinning slash loses half its original loading and depth within two years. By comparison with published results, the same change in similar fuelbeds in ponderosa pine takes 15 years. Foliage retention on twigs and branches was nil after one year compared to ponderosa pine which retained fifty percent or more of its foliage for at least three years.

Changes in blowdown fuels mirror those in slash, except that more material is present initially. Fine fuels (less than three inches in diameter) fall to background levels within two to four years. Large fuels persist longer and decay more slowly but eventually melt away.

Sound logs become rotten after about 80 years. Findings of this study corroborate similar findings by others, namely that fire hazard in precommercial thinning slash is satisfactorily abated after three years; abatement is similar in blowdown but fuel depth and large fuel loadings decrease more slowly.

Introduction

Forest managers consider the slash left on-site following pre-commercial thinning and other harvesting operations a potential fire hazard. Likewise, these managers perceive that blowdown Douglas-fir (*Pseudotsuga menziesii*) stands constitute a similar but longer-lasting fire hazard. They do not, however, know how long this hazard persists. If they did, they could make more cost effective decisions concerning slash treatment, hazard assessment prior to harvest, fire behavior modelling and land management planning.

The objectives of this study were to develop estimates of the changes over time in fuelbed loading and depth in precommercially thinned and blown down low elevation Douglas-fir stands. The results provide estimates of the duration and decay of physical fuelbed characteristics in stands of this important commercial species. Because fuelbed characteristics strongly affect fire hazard, the results can be used to evaluate the changes in fire hazard over time.

Changes in fuelbed characteristics over time in thinning slash or blowdown can be examined either by series of periodic examinations of one area, or by studying a chronosequence of several areas. Ideally, one would establish permanent plots in a series of units, and return year after year to these same plots to gather fuelbed data and compute rates of decomposition. However, where time is limited, only the chronosequence method is practical. In this method, fuelbeds created at various times in the past are inventoried more or less simultaneously, and the results are interpreted as if the same unit was inventoried in successive years. Carlton (1980) used a similar approach to estimate changes in fuelbeds of ponderosa pine slash.

Much literature on precommercial thinning in Douglas-fir exists, but relatively few workers have explored precommercial thinning as a source of slash, and its expected duration as a fire hazard. Reukema (1964) in a study of litter fall in a young Douglas-fir stand concluded that litter fall in stands is proportional to basal area. Thinning, by removing a portion of the existing basal area, reduced litter fall.

Lawson (1978) studied thinning slash in coastal Douglas-fir in British Columbia. He observed that the falling of needles from their twigs after one winter reduces the expected fire spread almost in half. He concluded that the fire hazard in a thinned stand would, after three years, probably be satisfactorily abated for most situations of risk, weather severity, and fire suppression capability.

Fahnestock (1968) explored thinning slash in ponderosa pine in order to determine how fire behavior in the slash would change over time. He found that by thinning well-stocked stands of pine to a 3.7 by 3.7 m or wider spacing produces a fuel complex that rates high in rate of spread for at least five years after cutting, and it would burn with a relatively high intensity. Thus, in pine, thinning seriously increases fire hazard for about five years, but in the long run precommercial thinning greatly reduces the vulnerability of stands to fire.

Carlton (1980) studied a chronosequence in ponderosa pine precommercial thinning slash and found that fuel loading took 15 years to decrease by half, and that slash retained half its needles for at least three years.

Fahnestock (1960) studied the flammability of the logging slash of various species. He noted that Douglas-fir usually loses its foliage the first winter after cutting, but exceptions do occur. Fallen needles sometimes form noticeable concentrations on the ground, especially when supported by twigs. Twigs and branches lie increasingly flat with age. Bark disintegration is noticeable at the end of two to three years, but had not progressed far. He concluded that because slash loses most of its foliage in the first year following cutting, the flammability declines very slowly after the first year and is of little consequence by the end of the third year.

After five years, 75 percent of the twigs were retained in their original state, while the foliage lay in dense mats, bound together with fungal mycelia (Fahnestock and Dieterich 1962). Much of the bark on the residue was loose. The fuelbeds examined occupied 79 percent of their original volume and the rate of spread of fire in the fuels studied had declined by 82 percent.

Olson and Fahnestock summarized slash deterioration (1955). For various species in locations from the northern tip of Idaho to the Clearwater River they observed that: fuelbeds compact about 20 to 36 percent during the first year, depending on whether they were lopped; this compaction hastens decay and reduces flammability; Douglas-fir slash loses all its needles after the first year; and finally that the finest fuels (needles and fine twigs) disappear after three years, but larger branchwood persists until brought into contact with the ground.

In summary, previous studies suggest that fine hazard resulting from precommercial thinning in Douglas-fir decreases significantly in two to three years. No quantitative descriptions of such fuels have been given, nor have studies of fuelbeds resulting from blowdown been reported. Quantitative measures of both types of fuels are necessary if fire hazard is to be evaluated using currently available models.

Methods

This study was conducted in the Bull Run Watershed, thirty miles northeast of Portland, Oregon. Elevation in the area varies from 230 m to 1250 m. Yearly precipitation in the area averages between 230 and 430 cm with most falling in the winter months. The area typically experiences a summer drought period during July and August.

Two sets of sampling sites were used. One set of fourteen areas had been precommercially thinned. The ages of thinning in this set ranged from zero years (thinned during the summer of 1987) to fifteen years (thinned during the summer of 1972). The second set of sites were four areas that had stands of large trees which had blown down at various times. Stands containing blowdown were found after extensive field reconnaissance, review of aerial photographs and maps, and personal interviews with local personnel. Age since blowdown ranged from four years (blown down in 1983) to eighty-one years (blown down in 1906). Blowdown ages were determined from U.S. Forest Service and City of Portland records for the area.

The selected precommercial thinning units were stocked primarily with Douglas-fir. Minor amounts of western hemlock and western redcedar were also encountered. Units selected showed relatively homogeneous expanses of untreated slash. Areas adjacent to roads that had been chipped were not sampled.

Twenty-four plots were systematically located within each unit in grid fashion. Plot centers were generally established 60 m apart, but were sometimes as little as 30 or as much as 140 m apart.

Two 7.6 m long transects were laid out perpendicular to each other at the plot center. The first was in the direction of main travel between plot centers. The second was at right angles to the first.

Duff depths were measured at 0.3 and 1.8 m from plot center. The high particle height was measured at 90, 120 and 150 cm from the plot center along each transect. The high log height (measured from ground to the top of the log or stem) was measured at 1.5, 3, 4.5, 6, and 7.5 m points on the transect. If foliage remained on any twig intersecting the transect, it was tallied. Generally, foliage intercepts were counted from zero to 7.3 m. However, if a large number of intersections were to be counted, then the length of the transect was shortened to 60 cm to facilitate tallying.

The fuel particle intercepts along the transect were counted into five diameter classes: 0 to 0.6 cm; 0.6 to 2.54 cm; 2.54 to 7.6 cm; and particles larger than 7.6 cm, sound or rotten particles counted separately. Particles in the 0 to 0.6 cm class were counted along the first meter of the transect. The intercepts for particles in the 2.54 to 7.62 cm class were counted along the first two meters of the transect, and intercepts for both sound and rotten material larger than 7.62 cm in diameter were measured along the transect out to 7.3 m. Logs and large limbs were counted as rotten if they "gave" or broke apart when kicked.

The fuel loading for each class was estimated by the arithmetic mean of the twenty-four plot estimates, for each of the units of that particular age that were sampled. Formulas for converting particle intercept counts to weight per unit area were taken from Brown (1974).

Similarly, in the blowdown fuelbed, the average loading by size class was computed by using the arithmetic mean of the plot estimates for each unit of a particular age that was sampled.

The average duff depth in both the thinning and blowdown slash was the arithmetic mean of the two depths taken along each transect. The average high particle intercept for both types of slash was the arithmetic mean of the three intercepts measured along each transect, and the average high log intercept for both types of slash was the arithmetic mean of the five intercepts measured along each transect.

Characteristics of Thinning and Blowdown Slash Fuelbeds

The ranges of data from the thinning slash units are given in Table 1. Ranges of data from the blowdown units are given in Table 2. A variety of regression models have been suggested in the literature on deterioration and decay of slash materials. Several such models and variants of them were applied to the data from this study. Because the agency that funded this study required the results to be given in English units, the regression statistics are so reported in the following tables. Tables 3 and 5 report the regression statistics for fuelbed loading for precommercial thinning slash and blowdown fuelbeds, respectively. Tables 4 and 6 report the corresponding statistics for fuelbed depth. Figures 1 through 6 show the trend lines for these equations. The axis labelling in these figures has been transformed to reflect the data in metric units.

TABLE 1. Thinning Slash Fuelbed Data Ranges

		Minimum	Maximum
0-0.6 cm	(tonne/ha)	0.61	5.78
6-2.54 cm	”	1.21	8.51
2.54-7.6 cm	”	0.67	24.66
>7.6 cm sound	”	0.00	8.06
>7.6 cm rotten	”	0.00	2.29
Total fuel loading		4.20	46.97
Duff depth	(cm)	0.31	2.81
High particle height	”	7.36	67.84
High log height	”	1.64	26.02
Basal area removed	(sq. m/ha)	0.89	15.39

TABLE 2. Blowdown Fuelbed Data Ranges

		Minimum	Maximum
0-0.6 cm	(tonne/ha)	.79	2.25
0.6-2.54 cm	”	3.65	5.12
2.54-7.6 cm	”	4.31	16.62
>7.6 cm sound	”	6.35	583.6
>7.6 cm rotten	”	47.51	294.8
Total fuel loading	”	194.1	734.4
Duff depth	(cm)	51.3	29.0
High particle height	”	134.9	1620.0
High log height	”	169.9	727.5

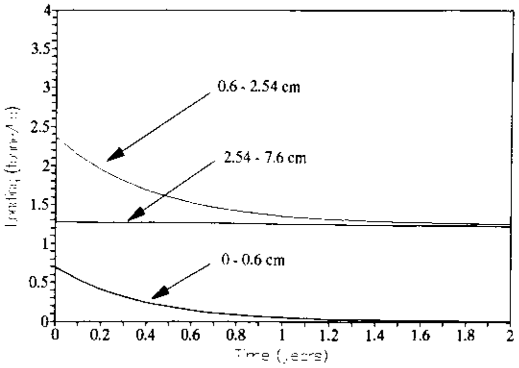

Figure 1. Trend line of plot averages for fine fuel loading in precommercial thinning slash fuelbeds, Bull Run study area, Oregon.

Fine fuel loading in precommercial thinning slash decreases with time since thinning. The initial rate of change is high, as one would expect, and approaches a steady-state value within a short time (Figure 1).

TABLE 3. Regression statistics from fuels inventory on precommercial thinning slash plots. Equation form is *Loading = a + EXP(b * Years).*

Diameter Class (mm)	Parameters a	Parameters b	MSE	*t*-value a	*t*-value b	Standard Error a	Standard Error b
0-0.6 cm	0.6210	−2.6462	0.511	2.77	0.39	0.22	6.76
0.6-2.54 cm	1.1072	−2.2958	1.148	3.24	0.32	0.34	7.20
2.54-7.6 cm	1.1418	−0.0228	7.947	1.15	0.10	0.99	0.22
>7.6 cm sound	0.1012	−0.0277	1.192	0.26	0.30	0.39	0.09
Equation: *Loading* = a + b * Time							
>7.6 cm rotten	−0.059	0.0424	0.177	0.99	4.33	0.06	0.01

Note: values based on 12 degrees of freedom.

TABLE 4. Regression statistics from fuels inventory on precommercial thinning slash plots, fuelbed depth. Equation form for duff is *Depth = a + EXP(b * Time).* Equation form for high particle and high log fuelbed depths is *Depth = a * EXP(b * Time).*

Depth Measure (in)	Parameter a	Parameter b	MSE	Standard Error a	Standard Error b
Duff	−0.362	0.027	0.064	0.081	0.009
High Particle	16.9	−0.56	48.8	2.567	0.039
High Log	8.01	−0.08	8.48	1.168	0.051

Note: values based on 12 degrees of freedom.

TABLE 5. Regression statistics for fuelbed inventory on blowdown slash plots. The equation form is *Loading = a + EXP(b * Years),* except for the >7.62 cm sound class, which is *Loading = a * EXP(b * years).*

Diameter Class (mm)	Parameter a	Parameter b	MSE	*t*-value a	*t*-value b	Standard Error a	Standard Error b
0-0.6 cm	−0.258	−0.0008	0.21	1.17	0.13	0.20	0.01
0.6-2.54 cm	0.626	−0.0047	0.22	2.88	0.54	0.22	0.01
2.54-7.62 cm	3.312	0.0396	3.45	1.34	0.08	2.47	0.52
>7.62 cm							
sound	146.9	−0.0551	0.73	15.4	5.89	0.32	0.01
rotten	35.90	−0.0568	328	5.14	23.3	6.99	0.01

Note: values based on 12 degrees of freedom.

TABLE 6. Regression statistics from fuels inventory on blowdown slash plots, fuelbed depth. Equation form for high particle and high log fuelbed depths is *Depth = a * EXP(b * Time).*

Depth Measure (in)	Parameter a	Parameter b	MSE	Standard Error a	Standard Error b
High Particle	24.05	−0.0157	0.64	0.28	0.01
High Log	19.49	−0.0127	0.41	0.18	0.01

Note: values based on 12 degrees of freedom.

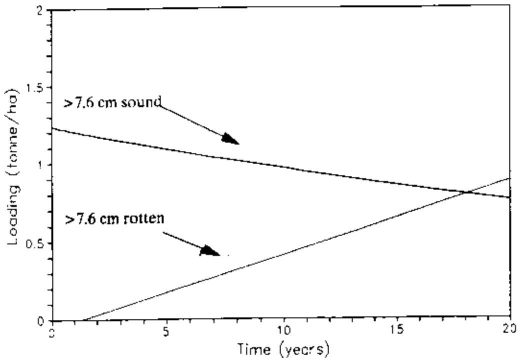

Figure 2. Trend line of plot averages for large fuel loading in precommercial thinning slash fuelbeds, Bull Run study area, Oregon.

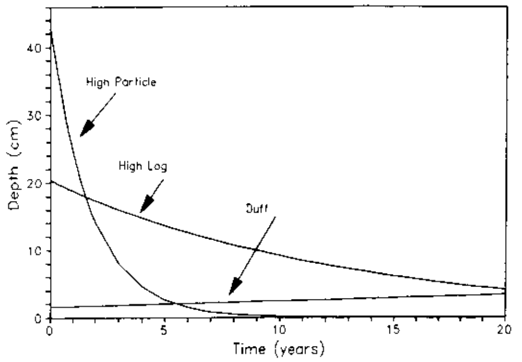

Figure 3. Trend line of plot averages for fuelbed depth in precommercial thinning slash, Bull Run study area, Oregon.

Fuels in the >7.6 cm rotten category were uniformly sparse over all units surveyed (Figure 2). Only four of fourteen units had any fuels in this category at all, and these were in older units. Thus, trends for this size class may be questionable. But overall, the trends for fuel loading in all size classes of precommercial thinning slash seem reasonable.

Needle persistence in precommercial thinning slash was measured as the number of twigs counted along sampling intercepts which retained at least three needles per meter of transect. For current season slash, needle persistence averaged 13 twigs per meter; for 1-yr old slash, it averaged 0.53 twigs per meter. No needles were observed in slash older than 1 year. For all practical purposes, needle loading can be assumed to fall to zero by the start of the second season after thinning.

Duff depth increases gradually over time, as one would expect (Figure 3). Because the data range stops at 15 years, the flattening of the duff accumulation curve observed repeatedly in biomass studies is not represented by this model. Had the data included older sites, this flattening would no doubt have been included.

Both the high particle and high log heights decrease over time, with greatest rate of change early on, again as one would expect (Figure 3). The high particle height drops much more quickly than the high log height. Fuelbed depth, as measured by high particle height, falls to fifty percent of its original value in less than two years. By contrast, depth as measured by high log height does not decrease to fifty percent of the original depth for nearly nine years. This probably reflects the rapid breakage of the twigs and small branches supporting the thinned stems in the first few seasons after thinning, and the much slower process of stem decay and failure of the larger branches which support the heavier thinned stems.

Figures 4 and 5 show the changes in fuelbed loading in blowdown fuels. In these models, the trends of loading over time for the fine fuels (0-0.6 cm through 2.54-7.6 cm classes) do not fall off as rapidly as those for precommercial thinning slash, probably because fine materials in these species on the west slope of the Cascades decay rapidly and are essentially gone from the surface litter within three years. Since the first data point for the blowdown chronosequence was four years since the disturbance event, the period of most rapid decay had already passed, and is therefore not reflected in the resulting models.

The large material (>7.6 cm sound and >7.6 cm rotten) behaves as one would expect within the range of the data. Loading of sound material larger than 7.6 cm starts high and decreases to a low value. Loading for rotten material larger than 7.6 cm starts low and stays low for nearly 50 years, then begins to increase. At the limit of the data range, this increase nearly accounts for the entire loss of sound material in the >7.6 cm size class.

Fuelbed depth as measured both by high particle height and high log height gradually decreases (Figure 6). Initially, depth as measured by high particle height exceeds that measured by high log height by about 12.7 cm. At the limit of the data (81 years), the two measures of fuelbed depth converge. This reflects what typically happens; as time passes even the largest branches decay and fall, leaving the logs themselves as the highest particles in the original fuelbed.

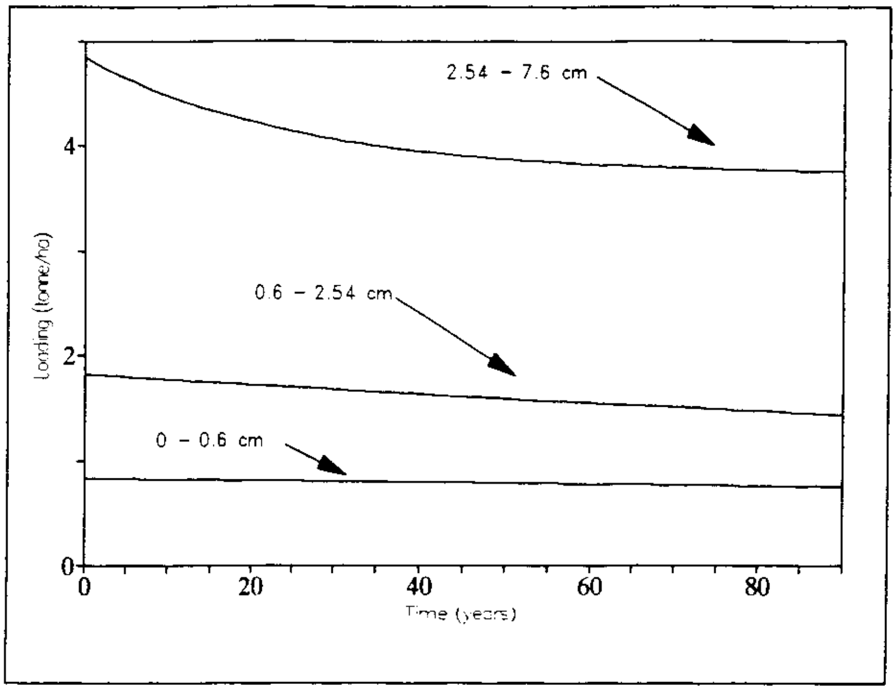

Figure 4. Trend line of plot averages for fine fuel loading in blowdown fuelbeds, Bull Run study area, Oregon.

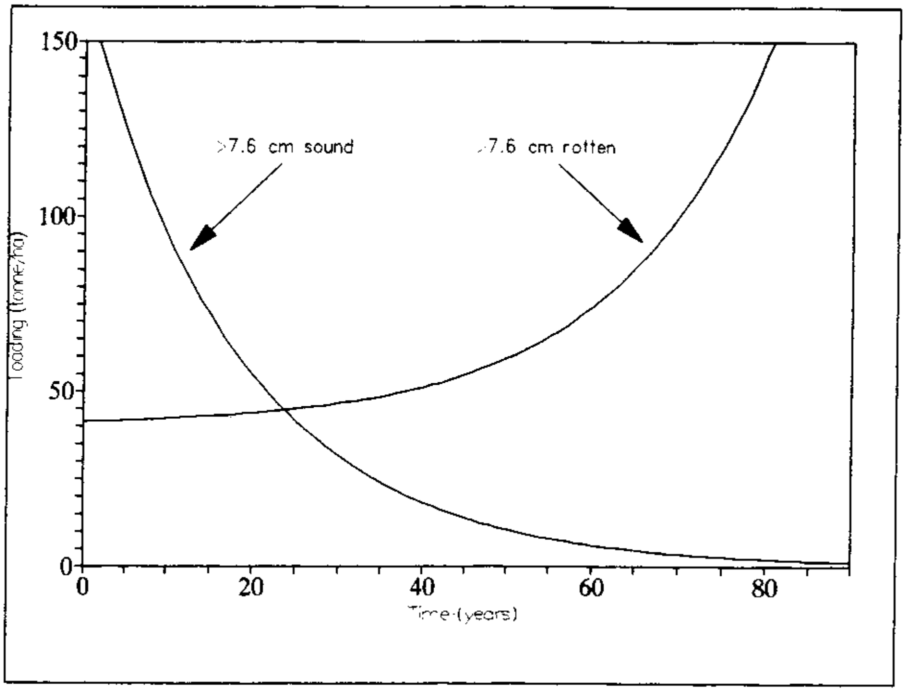

Figure 5. Trend line of plot averages for large fuel loading in blowdown fuelbeds, Bull Run study area, Oregon.

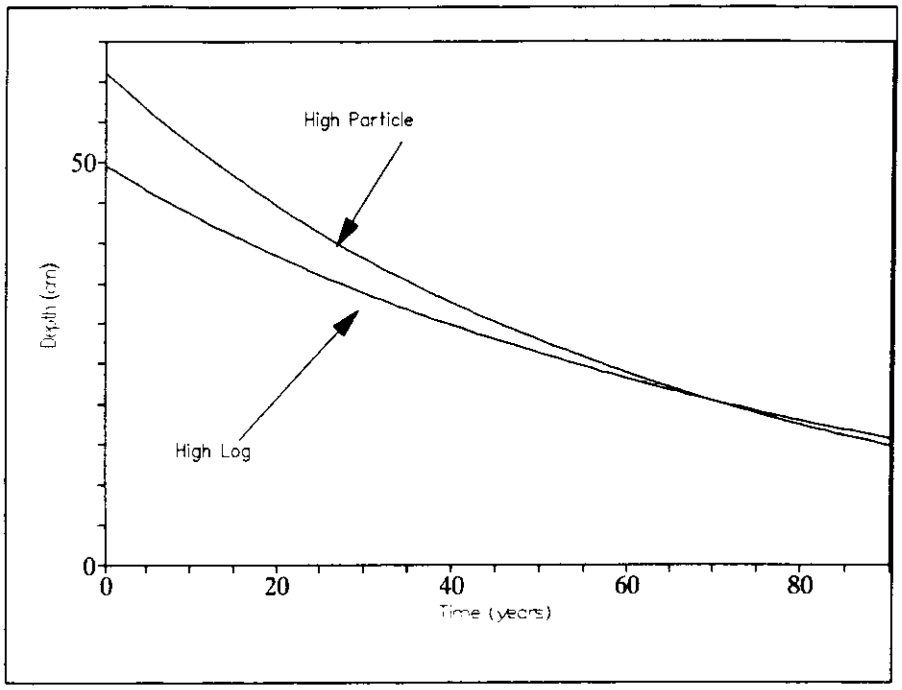

Figure 6. Trend line of plot averages for fuelbed depth in blowdown fuelbeds, Bull Run study area, Oregon.

The variation in duff depth with time since disturbance showed no consistent or logical pattern. Numerous studies have shown that transfer rates of material into and out of the duff layer depend on more than just time, and so no attempts to develop relationships for duff depth were made.

Discussion

The results of this study should be generally applicable to the western slope of the Cascade Mountains from about Mt. Jefferson to Mt. Rainier, and the western Olympic Peninsula. These areas are similar in rainfall and climatic patterns to the Bull Run, and thus should exhibit similar trends in decay. The results may also be applicable to the Oregon Coast Range and southern Oregon Cascades as well, but should be applied with caution, and with provision for testing predictions against rates of fuelbed decay.

Fuelbed changes in west-slope precommercial thinning slash are much more rapid than in east-slope ponderosa pine thinning slash (Carlton 1980). Fuelbed loading of fine fuels decreased by half in less than two years in the study area, while ponderosa pine fuelbeds lost less than half their loading over a period of 15 years. The time required to lose half the fuel loading in this study is more rapid by a year than that observed by Olson and Fahnestock (1955) in northern Idaho. Foliage on slash in this study disappeared within a year, while ponderosa pine slash lost only 50 percent of its needle mass in 3 years. This rate of needle loss agrees with that observed by Fahnestock (1960) in his study of the flammability of logging slash.

Fuelbed depth, measured by high particle intercept, dropped to 50 percent of the original value in less than two years in the thinning slash in this study, while a corresponding change took 10 years in ponderosa pine. This study substantially corroborates Lawson's finding (1978) that fire hazard in precommercial thinning slash is satisfactorily abated after three years for most situations of risk, weather severity and fire suppression capability.

Fuelbed changes in fine fuels in blowdown situations reflect patterns of change similar to those in precommercial thinning slash, except that there is typically more materials to begin with. Fine fuels essentially fall to background levels in two to four years. Larger (2.54-7.6 cm diameter) branch materials and 1000-hr fuels persist for longer periods and decay more slowly, but eventually 'melt' away. This agrees with observations of fire-killed timber by Kimmey (1955), in California, and Basham (1957), in Ontario. Forest managers fear the contribution of blowdown logs to fire hazard. This study suggests that the conversion of sound 1000-hr fuels to rotten 1000-hr fuels is a gradual process that nears completion in about 80 years under conditions like those found in the Bull Run study area.

The results of this study should enhance the quality of decisions regarding treatment and abatement alternatives in silvicultural slash and blowdown areas in the Northwest. However, as with any study of limited scope, the results should be applied with caution, and with provision for continued testing against observed conditions.

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