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REDUCING FIRE POTENTIAL IN LODGEPOLE PINE BY INCREASING TIMBER UTILIZATION

James K. Brown[1]

ABSTRACT

Fuel and fire potential in clearcut lodgepole pine were compared after stands were logged to near complete and conventional utilization standards. After logging, material greater than 3 inches in diameter had been reduced threefold on the near complete units and had been increased threefold on the conventional units. Material smaller than 3 inches in diameter was slightly less plentiful on the near complete units than on the conventional units after logging; however, of this material, the conventional units retained 2.6 times more needles. Compactness of logging residue was twice as great on the near complete units as on the conventional units. Predictions of postlogging potential fire spread were 3 to 4.5 times greater and intensity almost 9 times greater on the conventional than on the near complete units. Fire hazard on the near complete units after logging was minimal and prescribed burning was impractical.

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KEYWORDS: fuel, fire hazard utilization, lodgepole pine

Land managers have long known that fuels and fire potential on logged areas can be reduced through increased utilization of residues; the question is, "Exactly how much does increased utilization reduce the fire hazard, compared to conventional utilization?" Some answers were obtained for lodgepole pine (*Pinus contorta* Dougl.) clearcuttings in Wyoming.

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[1] Research Forester, stationed at the Northern Forest Fire Laboratory, Missoula, Montana.

STUDY PROCEDURES

Two even-aged lodgepole pine stands near Union Pass on the Teton National Forest in Wyoming were selected for the study. The stands had an average site index (50-year base) of 40 and averaged 167 and 182 years of age.

Two 20-acre harvesting units were laid out in each stand. One unit was clearcut to "conventional" standards, the other to standards that for this study were called "near complete." On both the conventional and near complete harvesting units all sound trees to a merchantable top diameter of 6 inches were removed. In addition, on the near complete units chips were produced from (1) tops of all merchantable trees, (2) all remaining live and dead sound standing trees with a d.b.h. of 3 inches or larger, and (3) all sound dead material remaining on the ground that was more than 6 inches in diameter at the larger end and that was more than 6 feet long. On the conventional units, trees were limbed and bucked where felled, and skidded by crawler tractor to the landing. On the near complete units, trees were felled, and then bunched and skidded to a central point where the sawlog material was removed. The remaining top material was then skidded to the chipper.

Volumes of live and dead standing trees to a 6-inch top ranged from 6,250 to 8,180 ft^3 per acre for the four harvesting units. Effects of the different harvesting treatments on the yield of fiber are described in a paper by Gardner and Hann.[2]

To assess the effects of the two utilization standards on fuel characteristics, fuels were inventoried before and after logging. Sampling was done using a grid. At each sample point, fuel loading (weight per unit area) by size class, fuel depth, duff depth, and percent ground cover were measured. The branchwood size classes were 0 to 0.20 inch, 0.21 to 0.60 inch, 0.61 to 3.0 inches, and over 3.0 inches. The first three classes correspond to the 1-, 10-, and 100-hour moisture timelag classes used in the National Fire-Danger Rating System.[3] Bulk density of the duff was determined from ten 1-ft^2 samples systematically taken in each stand.

Fuel loading for downed dead branchwood was determined using the planar intersect technique.[4] For material less than 3 inches in diameter, a 5-foot line transect was located at each grid point. The numbers of branchwood particles intersecting the vertical plane projected by the 5-foot line were tallied by the first three size classes.

Loading for each size class was computed from

$$w = \frac{\rho \pi^2 d^2 n}{8L} \tag{1}$$

where

w = loading, lb/ft^2
ρ = particle density, lb/ft^3
d = root mean square for diameter of fuel particles, ft
n = number of intersections per sample line
L = length of sample line transect, ft.

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[2] R. B. Gardner and D. W. Hann. Utilization of lodgepole pine logging residues in Wyoming increases fiber yield. USDA For. Serv. Res. Note INT-160, 6 p. 1972.

[3] J. E. Deeming, J. W. Lancaster, M. A. Fosberg, R. W. Furman, and M. J. Schroeder. National Fire-Danger Rating System. USDA For. Serv. Res. Pap. RM-84, 165 p. 1972.

[4] J. K. Brown. A planar intersect method for sampling fuel volume and surface area. For. Sci. 17:96-102. 1971.

The number of intersections for equation (1) was determined from the field inventory and the following values[5] used for the other two variables in equation 1:

Size class (*Inches*)	*d* (*Feet*)	ρ (*Lb/ft*^{3})
0.0 - 0.2	0.0082	35
.2 - .6	.0279	35
.6 - 3.0	.1180	30

The number of needle-bearing branches less than 0.6 inch in diameter was tallied along each 5-foot sample line. Using these data, the loading of needles attached to branches was computed from

$$w_n = RF(w_1 + w_2)^{6/} \tag{2}$$

where

w_n = needle loading, lb/ft^2
R = ratio of needle weight-to-stem weight
F = fraction of twigs bearing needles
w_1 = loading for 0 - 0.2 size class, lb/ft^2
w_2 = loading for 0.2 - 0.6 size class, lb/ft^2.

Loading of material greater than 3 inches in diameter was determined by recording the diameter of each piece intersecting a 50-foot line transect. For a particle density of 25 lb/ft^3, equation 1 then becomes

$$w = 0.6168\ \Sigma d^2 \tag{3}$$

where

d = diameters of intersected pieces, ft
w = loading, lb/ft^2.

Fuel depth was systematically sampied using three measurements at each grid point. Depth was measured as the vertical distance from the ground tc the highest dead fuel particle intersecting a cylinder whose central axis is the vertical projection from a point on the ground and whose radius is 5 cm. Maximum depth attainable was 6 feet.

Duff (F and H layers of forest floor) depth was measured twice at each grid point. Percent of the ground covered by mineral soil, forest floor litter, woody material (including branches and tree boles), grass and forbs, and brush were ocularly estimated on a 1/300-acre plot at each grid point.

Percent errors (100 X standard error of the mean ÷ estimated value) averaged 18 percent for each size class of branchwood, 17 percent for fuel depth, and 11 percent for duff depth, on each individual harvesting unit.

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[5] Values based on unpublished data on file at the USDA Forest Service, Northern Forest Fire Laboratory, Drawer G, Missoula, Montana.

[6] R = 0.9 and is a ratio adjusted for this study from data in: J. K. Brown. Vertical distribution of fuel in spruce-fir logging slash. USDA For. Serv. Res. Pap. INT-81, 9 p. 1970. F is necessary for current application of R and was determined from the field inventory.

RESULTS AND DISCUSSION

The main differences in the two harvesting treatments were in the amount of material over 3 inches and fuel depth after logging (table 1). On the near complete units, loading of material over 3 inches was reduced to one-third of the prelogging amount. On the conventional units, loading increased by a factor of 3. Although this size contributes little to the spreading flame front of a fire, it does contribute measurably to total fire intensity. It also contributes indirectly to fire spread by helping support smaller sized fuel at a more flammable level of compactness.

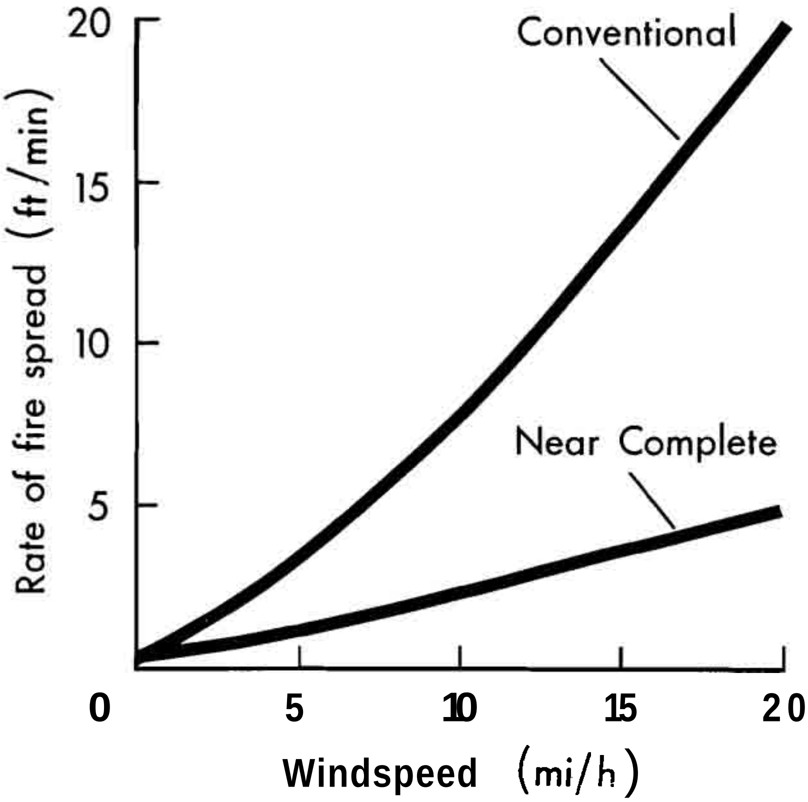
Fuel depth was lowered by both harvesting methods, primarily by removing grouse whortleberry (*Vaccinium scoparium*). However, change in fuel depth is not as important as the depth and packing ratio of fuel after logging. (The packing ratio is the ratio of fuel volume to the volume of the fuel bed.) The packing ratio for material less than 3 inches averaged 0.062 on the near complete units and 0.030 on the conventional units. The optimum packing ratio for combustion for this study using Rothermel's[7]

Table 1.--Ground *fuels* averaged for near complete and conventional utilization standards before and after logging

Fuel item	Near complete			Conventional		
	Before	After	Change	Before	After	Change
Loading	*Tons/acre*					
Needles	0	0.40	0.40	0	1.05	1.05
Branchwood (inch)						
0 - 0.2	.14	.10	-.04	.20	.15	-.05
0.2 - 0.6	.82	1.32	.50	.96	1.92	.96
0.6 - 3.0	3.38	8.64	5.26	4.22	9.70	5.48
Total	4.34	10.46	6.12	5.38	12.82	7.44
Over 3.0	27.0	9.0	-18.0	16.5	44.0	27.5
Ground Cover	*Percent*					
Mineral soil	2	42		1	29	
Forest floor litter	48	26		51	40	
Wood	21	31		19	29	
Grass	22	0		13	1	
Brush	2	0		16	1	
	Inches					
Fuel Depth	10.8	3.0		13.7	7.4	
Duff Depth	.92	--		.92	--	

[7]R. C. Rothermel. A mathematical model for predicting fire spread in wildland fuels. USDA For. Serv. Res. Pap. INT-115, 40 p., illus. 1972.

Figure 1.--Predicted rate of fire spread for fuels left after logging to conventional and near complete utilization standards.



model of fire spread was 0.009. Thus, fuel on the near complete units was compacted an average of twice as much as on the conventional units, resulting in a packing ratio that restricts combustion to a greater degree than on the conventional units.

Logging under conventional utilization standards produced only slightly more material less than 3 inches in diameter than did logging under the near complete standards. On the conventionally logged units, however, a substantially greater percentage of this material was highly flammable needles than on the near complete units. Even on the near complete units, much of the branchwood from harvested trees remained on the site, apparently broken off during the bunching and skidding of whole trees. A higher proportion of dead limbs was broken off than live limbs. The decrease in material 0 to 0.2 inch in diameter occurring after logging on all conventional and near complete units probably resulted from small twigs being crushed and churned into the forest floor by logging equipment.

Disruption of fuel continuity and exposure of mineral soil were greater on the near complete units than on the conventional units.

Forest floor duff, which averaged almost 1 inch on all units, had an average bulk density of 8.7, ±1.9 lb/ft^3. Logging methods did not reduce the amount of duff but did change its distribution.

Fire spread and intensity for the propagating flame front of a fire (this excludes spotting of firebrands) were estimated using the inventoried fuel data as inputs for a mathematical model of fire spread.[8] The predictions showed that rate of spread after logging would be about 3 to 4.5 times greater on the conventional blocks (fig. 1).

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[8] Ibid.

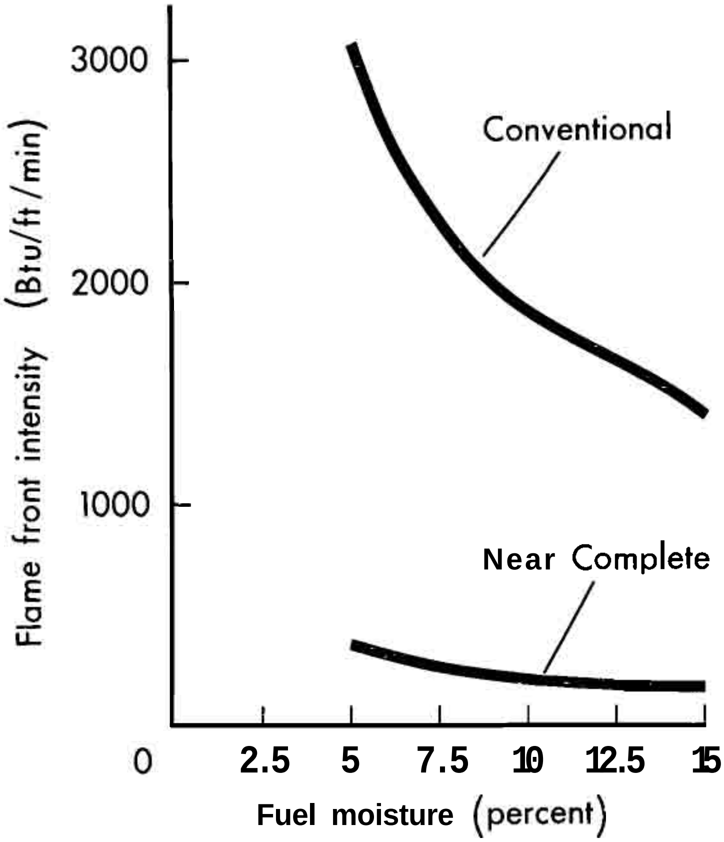

Figure 2.--Predicted intensity for a flame front for fuels Zeft after logging to conventional and near complete utilization standards.

Intensity of the flame front (Btu/ft/min - heat from a 1-foot-wide cross section through the propagating flame front) would be 8.8 times greater on the conventional blocks for any fuel moisture (fig. 2). Intensity would vary from that figure somewhat for different wind conditions. The estimate of intensity on the conventional units is conservative because material greater than 3 inches in diameter was not included in the mathematical model. Further, the packing ratio used in the prediction model was higher than for the slash itself because many depth measurements had been taken on areas where no slash existed. This also resulted in lower than expected intensity values on the conventional units.

CONCLUSIONS AND IMPLICATIONS

Logging to near complete utilization standards reduced fire potential to a point that no further fuel modification should be required for hazard reduction. In fact, not enough fuel remained for prescribed burning, a treatment that might be required to meet silvicultural objectives.

Logging to conventional utilization standards left the fire potential high enough to warrant fuel modification for hazard reduction. Without fuel modification, direct attack on a fire would not be possible under many burning conditions.

On this lodgepole pine study site, and probably in many other timber stands, conplete utilization eliminates unreasonable fire hazards. The desirability of conplete utilization, however, must also consider the need for residue material to carry prescribed fire, stabilize soils, shade seedlings, and recycle nutrients. The wisdom of complete utilization should be evaluated by considering the land nanagement goals for each individual site.