Fuel-Load Reductions Resulting from Prescribed Burning in Grazed and Ungrazed Douglas-fir Stands

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Abstract

Prescribed understory burning was carried out in both grazed and ungrazed Douglas-fir stands on the University of Idaho Experimental Forest. Burning conditions were moderately cool with 10-hr time-lag fuel moisture varying from 11 to 19%. Preburn and postburn fuel loadings were determined by use of the planar intersect method. Preburn data indicated greater fuel accumulations in grazed stands, 55,460 kg/ha, as compared to ungrazed stands, 44,710 kg/ha. Difficulty in achieving a satisfactory rate-of-spread and fire intensity was encountered due to the combined effects of a very dry summer followed by a wet fall. Moist conditions on the study site, lack of fine fuels, and accumulation of heavy fuels in the grazed portion produced a burn of patchy nature. Fire rate of spread varied from 0 to 183 cm/minute with flame height up to 91 cm. Result was a fuel reduction of 60.2% in the grazed stand and 35.2% in the ungrazed stand. Prolonged grazing in this area had created a dense, overstocked stand with insufficient fine fuels to carry a fire, which severely limited the effectiveness of prescribed burning.

Although it has been a practice to utilize livestock to reduce fire hazard in forest areas of the western United States (Adams 1975), little research has been done to determine the validity of this practice. The objective of this paper was to determine the effect of prescribed fire on fuel loading in both grazed and ungrazed Douglas-fir *(Pseudotsuga menziesii)* stands.

In various forested areas of the United States, livestock grazing has been a determining factor in the success of many local economies (Wahlenberg et al. 1939). Since many western ranchers have been dependent upon federal range, numerous areas capable of producing palatable forage have been grazed.

Early in this century, it was widely believed that grazing could lessen the number, intensity, and size of fires (Hatton 1920). Foresters allowed heavy grazing to reduce fire hazard and to promote tree growth without consideration for sound range and watershed management principles. Heavy grazing has been distinctly advantageous in lessening the occurrence and intensity of accidental fire, due to the reduction of herbaceous undergrowth and hastened decay of litter by trampling (Ellison 1960). However, heavy grazing has severely damaged palatable species. The amount of understory herbage utilized by grazing animals has been considerably less than the total produced, though the highly palatable plants have been selected first (Froeming 1974). As a result, these species have gradually been replaced, often by highly flammable, unpalatable species.

Available research clearly demonstrates that fire has had certain beneficial effects on some forested environments. Complete fire exclusion in many areas has created dangerous fuel accumulations which have resulted in catastrophic fires, insect and disease buildup, range deterioration, changes in wildlife carrying capacity, and decreased watershed yield (Ahlgren 1974). Where fuels were permitted to accumulate, fires increased in severity and damage, and offered much greater resistance to control (Dodge 1972). For these reasons prescribed burning has been recognized as a valuable land management practice.

This practice has been extremely useful in ponderosa pine *(Pinus ponderosa)* and Douglas-fir ecosystems, with objectives such as (1) reduction of fire hazards after logging, (2) exposure of mineral soil for seedbeds, (3) control of insects and diseases, (4) thinning of dense stands of saplings, (5) increased yield and quality of forage, (6) improvement of big game habitat, and (7) modification of species composition in different plant communities (Habeck and Mutch 1975).

Zimmerman (1979) described the study area which is approximately 12 miles northeast of Moscow in Latah County, Idaho, on the East Hatter Creek portion of the University of Idaho Experimental Forest (Fig. 1). The specific area treated by burning was chosen because of the location of natural topographic changes which would have contributed to fire suppression strategies, if necessary, and the size of area which accommodated a concurrent big game study. Plots were located both inside and outside a big game enclosure on the southwest slopes of Basalt Hill, elevation ranging from 853 m to ~ 1006 m. Vegetation of the area was characteristic of the Douglas-fir/Ninebark *(Pseudotsuga menziesii-Physocarpus malvaceus)* habitat type, described by Daubenmire and Daubenmire (1968). Stages of vegetational development varied from seral to early climax with ponderosa pine and Douglas-fir equally represented.

Zimmerman (1979) studied the effect of grazing on the East Hatter Creek area. He found that grazing in the absence of fire at

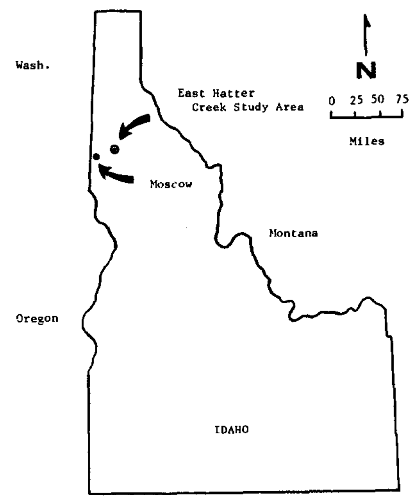

Fig. 1. *General location of study area.*

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the normal fire frequency of about every 22 years advanced the closure of the overstory, increased the quantity of duff and down woody fuel, and reduced the quantity of herbaceous and shrubby vegetation. He presented tree age and diameter class data suggesting that these changes occurred within the last 50 years. Before that time, the stands protected from grazing in the enclosure had similar overstory as the stands that were heavily grazed. Grazing outside the enclosure, based on U.S. Forest Service records, was heavy, with utilization averaging 85% for the last 20 years.

Methods

Prior to, during, and immediately after burning, measurements for temperature, relative humidity, wind speed, 10-hr time lag fuel moisture content, surface fine fuel moisture content, surface soil moisture content, and estimated cloud cover were collected. Samples were collected on north and south aspects under the canopy of shrubs and trees and in open areas.

Fuel-loading was measured by the planar intersect technique (Brown 1974). This technique provided the following information:

1. Weights per acre of downed woody material:
   a. Diameter size classes: 0 to 0.6 cm
      0.6 to 2.54 cm
      2.54 to 7.62 cm
   b. Sound and rotten fuel particles of diameters 7.62 cm and larger.
2. Depth of fuel and forest floor duff

Table 1. Fuel moisture and weather data for East Hatter Creek burn treatment days.[1]

	Grazed		Ungrazed		
Date of burn	10/5	10/21	10/5	10/6[1]	10/17
Temperature (° F)	56	57	56	60	74
Relative humidity (%)	30	40	30	35	27
Wind speed (mph)	0	0–3	1	3-6	0–3
Cloud cover[2]	0	.3	.3	.7	0
10-hr T.L. (%)[3]	19	17	11,15[3]	12	9
Soil moisture (%)	11	12	10	10	9

[1]Weather measurements taken prior to movement of cold front through area.
[2]Cloud cover measurements are expressed as tenths of sky obscured by clouds.
[3]Ten-hour time lag fuel moisture sticks were placed in an open stand (first number) and a closed stand (second number).

Weight calculations for this inventory were computed by the following simplified formulae (Brown 1974):

a. 0 to 0.6 cm class : $W = 0.9533\ nc/Nl$
b. 0.6 to 2.54 cm class : $W = 1.825\ nc/Nl$
c. 2.54 to 7.62 cm class : $W = 14.52\ nc/Nl$
d. 7.62+ cm sound : $W = 4.656\ \Sigma d^2c/Nl$
e. 7.62+ cm rotten : $W = 3.492\ \Sigma d^2c/Nl$
f. duff : $W = 14.5 \times$ average depth[1]

Where: $n =$ number of pieces sampled
$c =$ slope correction factor
$Nl =$ total length of sampling plane
$\Sigma d^2 =$ sum of squared diameters

[1]Formula derived from unpublished data.

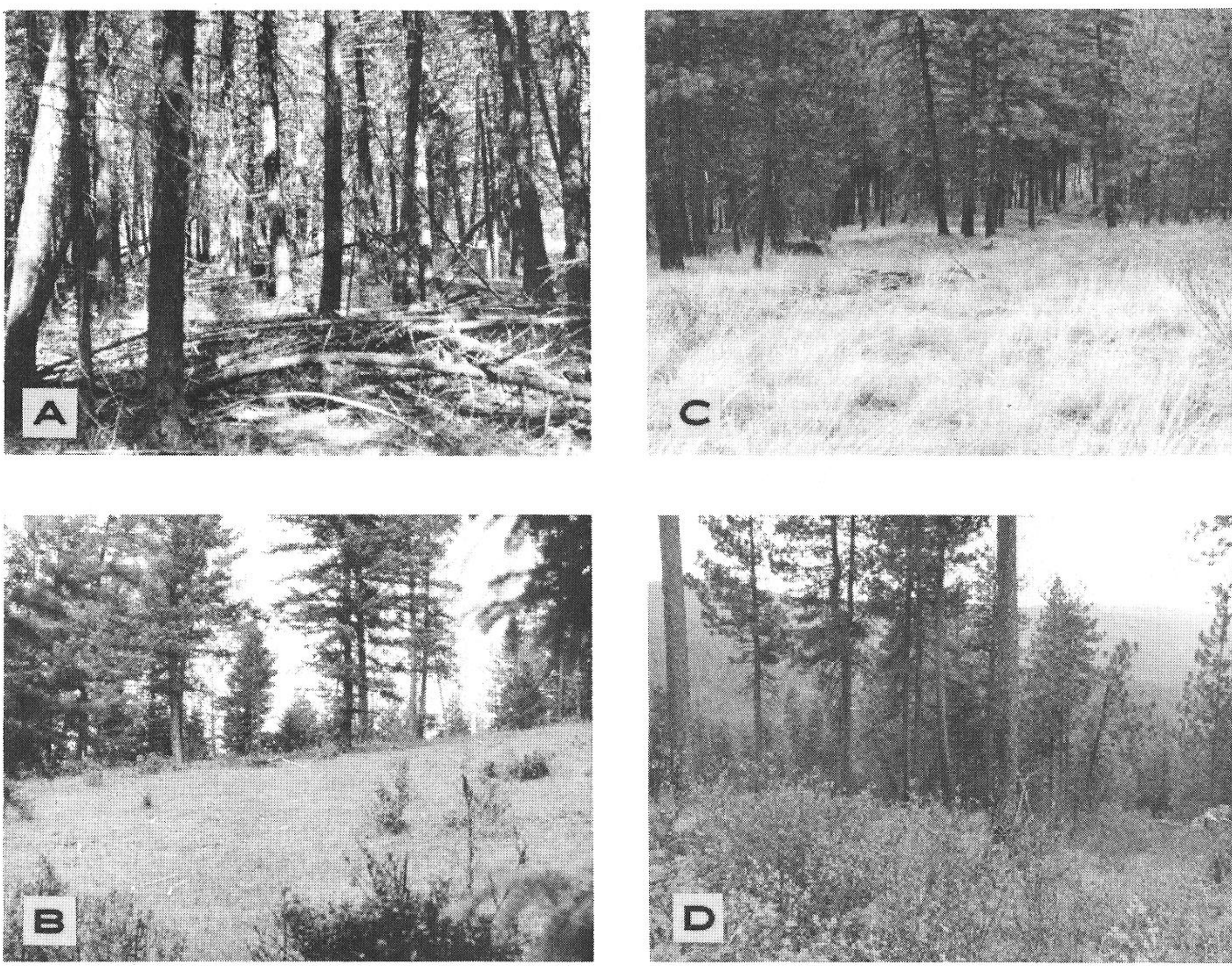

Fig. 2. *Typical preburned areas comparing grazed (A and B) to ungrazed (C and D) stands.*

Vegetative cover was determined by the line intercept method (Daubenmire 1968). Dead and standing herbaceous vegetation (standing litter) and the 01 horizon (surface litter) were often the fuels that carried the fire. Standing and surface litter samples were collected from 20 × 50 cm (0.1 m^2) quadrats, oven-dried and weighed, then converted to kilograms per hectare values.

In preparation for burning, firelines were constructed by bulldozer. Burning in the ungrazed area was initiated by firing the area adjacent to those lines and then igniting the lower portion and permitting the fire to move up hill. In the grazed stand, strip fires were used to maintain sufficient burning intensity. Fire weather, fuel moisture, and soil moisture data for each burning day are listed in Table 1.

Results

Stand Structure and Condition

Inspection of the grazed and ungrazed stands prior to burning revealed that stand structure and condition differed significantly, although they were of similar habitat type, soils, and physiography. The ungrazed stand was an open park-like forest, while the grazed stand resembled a relatively dense forest with little understory vegetation. Similar densities of large diameter trees occurred in both areas, but the stand structure of smaller trees was significantly different. Because at least one fire and no grazing occurred in one area, while no fires and continuous grazing occurred in the other, the difference between the two stands was assumed to be the result of grazing-fire interactions. The specific effects of grazing by domestic livestock in this habitat type were studied by Zimmerman (1979). In Douglas-fir habitat types of Idaho, production of forage and shrubs decreased following the closure of the overstory canopy (Froeming 1974, Zimmerman 1979).

The Douglas-fir stand that was subjected to prolonged grazing was comprised of an overstory of mixed sized Douglas-fir and ponderosa pine, and an understory ranging from needles to sparse shrubs (Fig. 2). Distribution of trees varied from overstocked sapling thickets to large and scattered sawtimber. Evidence of insect and disease damage was obvious. Understory was characterized by a general lack of both dead down woody and live fine fuels. The forest floor fuel ranged from stands of heavily cropped grasses and bare ground to needle mats and scattered shrub patches. Soil surface litter averaged 0.8 cm while the duff averaged 7.2 cm.

The stand protected from grazing appeared as a seral stage comprised of slightly more ponderosa pine than Douglas-fir. Overstory structure varied from well-stocked pole stands of fir to open, park-like stands of pine (Fig. 2). The ungrazed stand contained fewer snags, rotten stumps, and insect and disease infected trees than the grazed stand. Understory ranged from thick mats of needle to dense, vigorous stands of perennial grasses and tall shrubs.

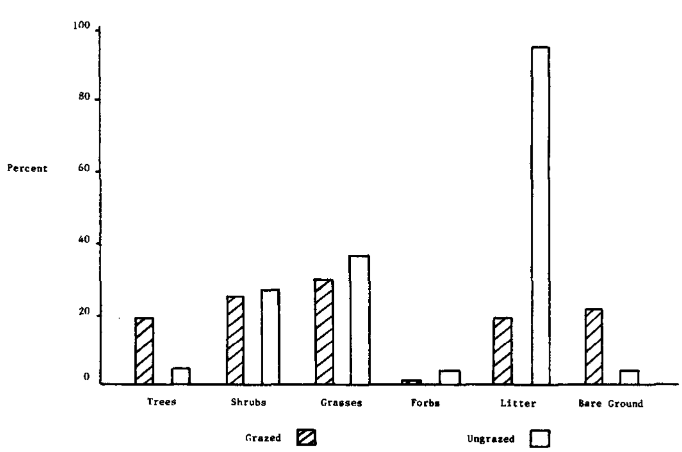

Fig. 3. *Comparison of canopy coverage for grazed and ungrazed stands.*

Fuel Inventory

Bare ground and canopy coverages of trees were greater and coverages of litter, forbs, grasses, and shrubs were lesser on grazed than ungrazed sites (Fig. 3). Fuel loadings, greater in grazed stands, were comprised of nearly equal distributions of fuel particles of greater and less than 2.5 cm in diameter. Preburn fuel loading in the ungrazed stand, 45,558.4 kg/ha, was not significantly different from that of the grazed stand, 36,726.4 kg/ha (Fig. 5), but was comprised almost entirely of particles less than 2.5 cm in diameter (fine fuels). Comparisons of the fine fuel loading between the two areas revealed that fine fuels made up 55% of the total preburn loading on the grazed areas; while on the ungrazed areas they represented 100 percent of the total (Fig. 4).

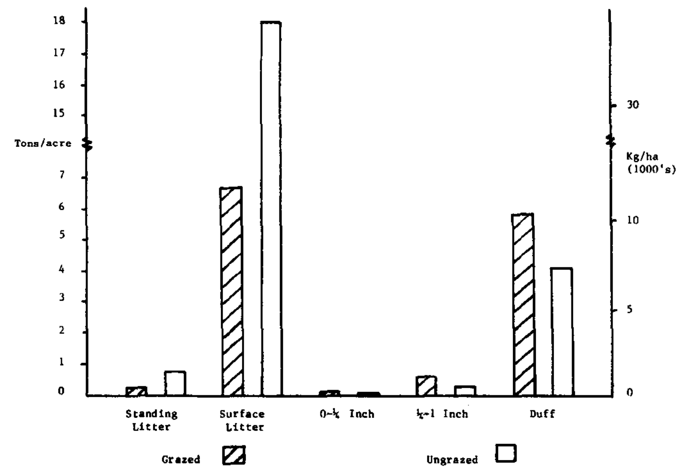

Fig. 4. *Comparison of surface fuels in grazed and ungrazed stands.*

Surface files of varying intensities were supported and carried by the quantity of fuels and continuity of fine fuels in the ungrazed stand. Within the grazed stand, the lack of fine fuels prohibited rapid movement of fire across the ground. But the presence of large size class fuels, shrubs, sapling thickets, snags, stumps, closed canopies, and lack of wind presented a significant opportunity for the development of crown fires, i.e., fuel combinations that would

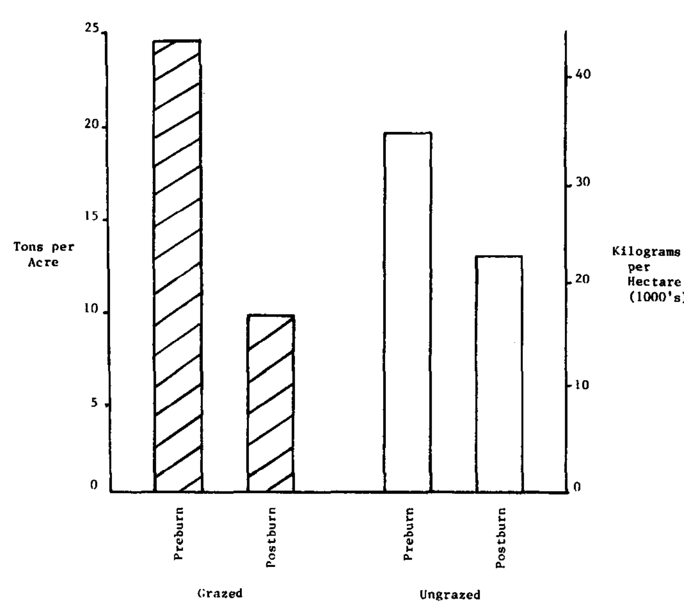

Fig. 5. *Comparison of total fuel loadings before and after burning in grazed and ungrazed stands.*

result in a fire ladder situation.

The two areas responded differently to prescribed fires. On the grazed site greatest reductions were observed in standing litter and all fuel sizes greater than 2.5 cm. Numerous trees up to 10 cm dbh were killed by the fire in the grazed stand. Reduction of total fuel accumulation for this area amounted to 60.2% (Fig. 5). On the ungrazed portion the highest reductions were observed in all size classes less than 2.5 cm. Total fuel reduction on this site accounted for 35.2% of the preburn total.

Fire Description

Higher fuel moisture contents on the grazed portion occurred as a result of combination of heavy fuel accumulations and a closed canopy shading. This higher fuel moisture, coupled with a lack of fine fuels, resulted in a less intense burn. The resultant, slow spreading fire burned through the grazed Douglas-fir stand at a rate of spread that ranged to .5 m/min with flame heights up to 15 cm (Fig. 6). The fire consumed the majority of larger size class fuels. Only a few healthy trees larger than 15 cm dbh were killed. This fire burned in a very patchy pattern, limited by fuel continuity and moisture content.

Quite different results were observed in the ungrazed Douglas-fir stand. As a consequence of the abundance of fine fuels, slightly lower fuel moisture content, and less canopy coverage, the fire spread rapidly, although some of the more shaded areas remained unburned. This fire consumed nearly all the fine fuels, top killed 50 to 75% of the shrubs, and scored only the lower crowns of the threes (Fig. 6 and 7). Healthy trees with diameters greater than 15.24 cm were not harmed by the fire. Observed rate of spread in this area was from .3 to 1.8 m/min, while surface flame lengths varied up to 91 cm.

Conclusions

Heavy livestock grazing in the East Hatter Creek portion of the University of Idaho Experimental Forest resulted in increased downed woody material and early closure of tree canopies. It also tended to create ladder type fuels (Zimmerman 1979). Through reduction of herbaceous material and trampling of litter, grazing increased litter mats, number of trees, and large diameter fuels. At the same time, Zimmerman (1979) suggested that grazing was responsible for decrease in fine fuels and acceleration of plant succession. Total fuel accumulations differed slightly on grazed on ungrazed sites, but fuel size classes differed significantly. Grazed area fuels were characterized by grazed number of large size classes, while ungrazed fuels were almost entirely comprised of fuels less than 2.5 cm in diameter.

When grazed and ungrazed Douglas-fir stands were prescribed burned, fuel weight reductions were greater on the grazed site, but administering prescribed fire was more difficult on these sites. For fire to consume and spread through the heavily grazed area which is dominated by the larger diameter fuels, hotter and drier burning conditions are necessary. Such conditions may pose increased potential for the rapid movement of surface fires into the crowns

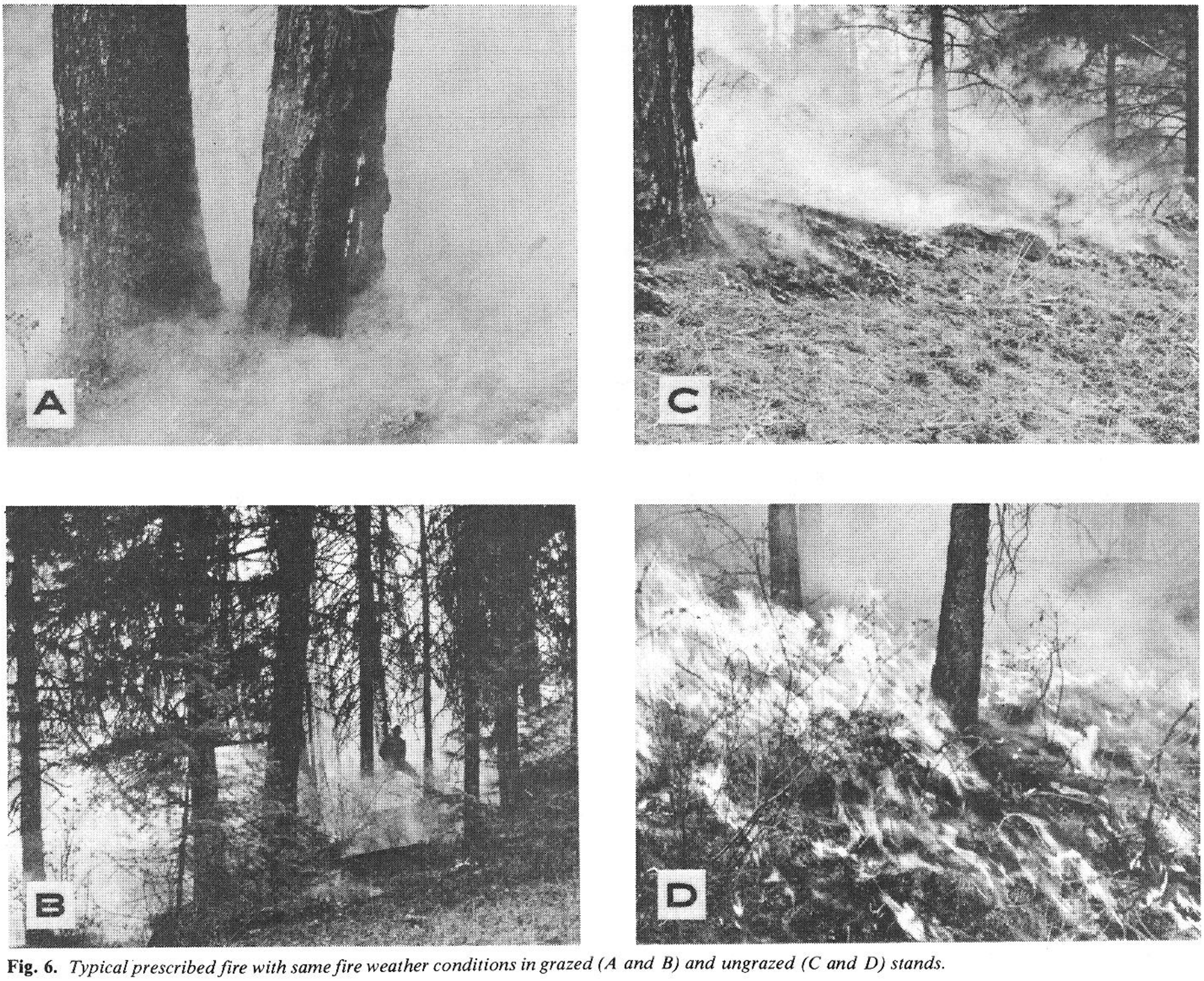

Fig. 6. *Typical prescribed fire with same fire weather conditions in grazed (A and B) and ungrazed (C and D) stands.*

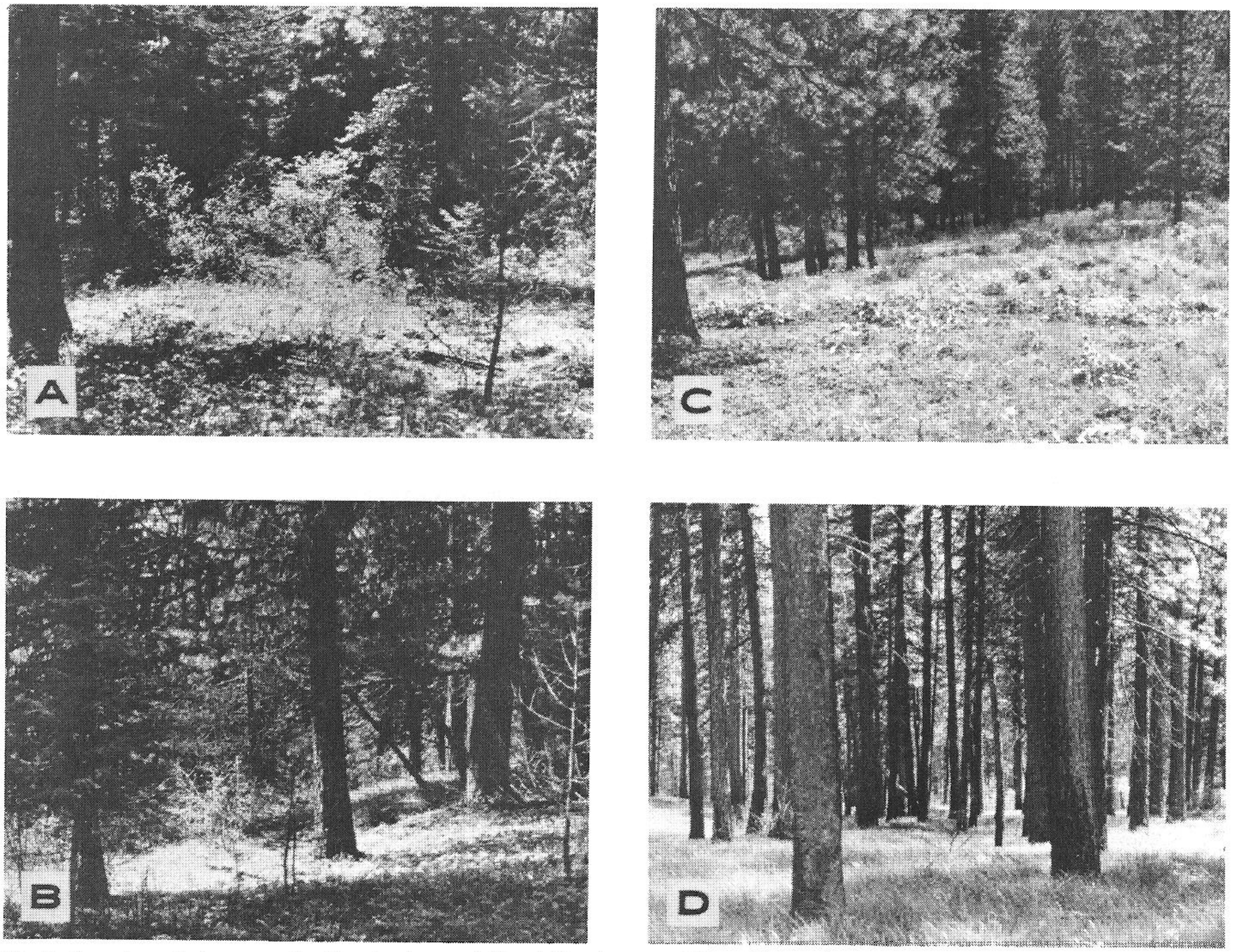

Fig. 7. *General results from prescribed burning in grazed (A and B) and ungrazed (C and D) stands.*

of the larger trees. In areas dominated by small size class fuels such as those on ungrazed sites, surface fires consume a majority of available ground fuels, and fires have little potential for crowning in larger trees. Fires of this type can be expected to move rapidly through an area, quickly exhaust the surplus of fine fuels, and do little damage to larger trees.

Prescribed burning in ungrazed Douglas-fir forest stands will produce satisfactory results if strip fires are carried out under the following conditions:

Temperature	50–70° F
Relative Humdity	25–55%
Wind speed	0–10 mph
Fuel moisture sticks (10 hr time lag)	10–17%

Prescribed burning in grazed Douglas-fir stands under these conditions did not yield results of a degree comparable to burning in ungrazed sites (Fig. 7). Most fire managers have recognized that it is more difficult to burn in areas that have a closed canopy compared to areas with open canopies, but few managers have recognized that this difficulty could have been induced by heavy grazing.

Prescribed fire has advantages in many situations and limitations in others. One of the major limitations arises from the fact that the effects of livestock grazing on fuel accumulations and natural fire frequencies have not been well documented. A noticeable lack of information also has existed concerning the effects of the interaction of livestock grazing and complete fire exclusion. Data obtained from this study will not resolve these problems, but does demonstrate that, from a fire management standpoint, improper grazing can adversely alter natural fuel accumulations in Douglas-fir forest ecosystems.

Literature Cited

Adams, S.N. 1975. Sheep and cattle grazing in forests: A review. J. Applied Ecology. 12:143-152.

Ahlgren, C.E. 1974. Introduction. *In:* Fire and ecosystems. Ed. Kozlowski, T.T., and C.E. Ahlgren. Academic Press, New York.

Brown, J.K. 1974. Handbook for inventorying downed woody material. USDA Forest Serv. Gen. Tech. Rep. INT-16.

Daubenmire, R.F. 1968. Plant communities, a textbook of synecology. Harper and Row, New York, N.Y.

Daubenmire, R.F., and J.B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington Agr. Exp. Sta. Tech. Bull. 60. Pullman.

Dodge, M. 1972. Forest fuel accumulation—a growing problem. Science. 177:139-142.

Ellison, L. 1960. Influence of grazing on plant succession of rangelands. Bot. Rev. 26(1):1-78.

Froeming, D.K. 1974. Herbage production and forest cover in the *Pseudotsuga menziesii/Symphoricarpos* habitat type of northern Idaho. Thesis. Univ. of Idaho. Moscow.

Habeck, J.R., and R. Mutch. 1975. Forest and forestry. *In:* Yearbook of science and technology. McGraw-Hill Book Co.

Hatton, J.H. 1920. Livestock grazing as a factor in fire protection on the national forests. USDA Cir. 134.

Wahlenberg, W.G., S.W. Greene, and H.R. Reed. 1939. Effects of fire and cattle grazing on longleaf pine lands as studied at McNeil, Mississippi. USDA Tech. Bull. No. 683. Washington, D.C.

Zimmerman, G.T. 1979. Livestock grazing, fire, and their interactions within the Douglas-fir/ninebark habitat type of northern Idaho. M.S. Thesis, Univ. of Idaho, Moscow. p. 1-28.