# Livestock Grazing Influences on Community Structure, Fire Intensity, and Fire Frequency within the Douglas-fir/Ninebark Habitat Type

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**Abstract**

**Influences of livestock grazing on community structure, fire intensity, and normal fire frequency in the Douglas-fir/ninebark *(Pseudotsuga menziesii/Physocarpus malvaceus)* habitat type were studied at the University of Idaho's experimental forest in northern Idaho. Livestock grazing caused increased tree numbers, decreased production, cover, and frequency of major palatable grasses, and altered dominance of shrub and forb species. Grazing influences on community structure were increased accumulation of downed woody fuel in every size class, increased forest floor duff, and decreased herbaceous fuels. Livestock grazing influences were discussed in light of their significance in potential fire intensity and fire frequency in Douglas-fir forest communities.**

Historically, fire exerted a strong influence on the ecology of western forest communities, and the history has been widely studied. Arno (1976) reported the significance of fire in forest development. However, little information was available on the frequency and intensity of fires in the Douglas-fir/ninebark *(Pseudotsuga menziesii/Physocarpus malvaceus)*[1] habitat type. Wellner (1970) reported that these forests experienced fires that caused slight to extreme damage. Arno (1976) stated that fires in Douglas-fir forests of western Montana were frequent prior to 1900 (mean fire-free periods ranged from 7 to 19 years), and fire damage was usually not extreme. Fire was a major force in stand development, but during the last 50 years, its role has been reduced to one of minor significance because of effective fire suppression and logging activities.

Since different animals have different food preferences, seasons of use, and grazing intensities, they influence the forest community structure differently. Changes in overstory structure and in shrubby and herbaceous density and composition can affect the intensity and frequency of fires in forest communities. Grazing has exerted strong influences on the ecology of forest communities (Daubenmire 1968). Livestock grazing has been effective in reducing the fire hazard in the forests of the western United States (Adams 1975, Ingram 1931) since the early part of this century (Hatton 1920). Range managers have shown that grazing has influenced vegetal development and that it can change the path of secondary succession. Long-term interactions of livestock grazing wildfire, however, have not been reported.

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[1]All scientific and common names follow Hitchcock and Cronquist (1973).

Cholewa (1977) and Froeming (1974) discussed the importance of the Douglas-fir/ninebark habitat type. These communities support vegetation which provides adequate summer forage for livestock, summer and winter browse, and both visual and thermal cover for big game. Characteristically, this vegetation is dry in late summer, creating a fuel layer of high continuity and flammability. If an adequate supply of dry fuel particles in 1-centimeter and smaller size classes is available, fire can be ignited easily and spread rapidly (Dodge 1972). Livestock grazing has eased fire ignition and spread by removing herbaceous undergrowth and reducing the number of fuel particles and by hastening decay of litter through trampling (Hatton 1920).

This study was designed to determine influences of livestock use in the Douglas-fir/ninebark habitat type of northern Idaho. Specifically, the goal was to determine changes in community structure, composition, and distribution of fuel caused by livestock grazing, and to assess the extent to which these changes modify fire frequency and intensity.

## Study Area

The study was conducted in the forested hills along the western slope of the Bitterroot Mountains on the University of Idaho Experimental Forest located approximately 20 km (12 mi) northeast of Moscow in Latah County, Idaho.

Elevation of the area ranged from approximately 853 m (2,800 ft) to near 1,006 m (3,300 ft) with slopes varying from 5 to 40%. The area contained 2 main soil series. Areas with 5 to 20% slope, comprised of deep, moderately well-drained soils formed in deep loess, were classified as Carlinton silt loams. Steeper slopes, moderately well drained throughout, formed from granodiorite residuum with some loess influence, were classified as Uvi silt loams.

Vegetation of the area was characteristic of Douglas-fir/ninebark habitat type as described by Daubenmire and Daubenmire (1968). Vegetation was cover mapped by Basile (1954) and updated by Thilenius (1960). Overstories were a mixture of Douglas-fir and ponderosa pine *(Pinus ponderosa)*. Understories varied greatly but were generally dominated by ninebark *(Physocarpus malvaceus)*, oceanspray *(Holodiscus discolor)*, and snowberry *(Symphoricarpos albus)*. Graminoids, comprised primarily of pinegrass *(Calamagrostis rubescens)*, elk sedge *(Carex geyeri)*, bluebunch wheatgrass *(Agropyron spicatum)*, and Idaho fescue *(Festuca idahoensis)*, combined with an abundant number of forbs, formed the ground layer.

"High grade" logging occurred on the study area in 1925. Cutting practices ranged from light, selective cutting to clearcutting, and most of the merchantable timber was harvested regardless of species (Basile 1954). During the early 1940's, unregulated grazing by both cattle and sheep occurred on the area. Construction of the enclosure excluded livestock, but at various locations the fence fell into disrepair and did not consistently restrict big game use of the area. Observations showed that whitetail and mule deer and elk utilized areas both inside and outside the enclosure throughout the year. From 1945 to 1967, the area was utilized by a large number of domestic livestock, and it was grazed very heavily. During this period, for 5 months each year, the stocking rate was nearly double the herbaceous carrying capacity.[2] In 1969 a management plan was written that provided for gradual reduction in animal numbers and for shortening the grazing season to 4 months. Currently, the area surrounding the enclosure is grazed by cattle during the spring, summer, and fall.

Utilization of the graminoids for the last 20 years averaged 85% (one animal per 13 ha) with a maximum of 99% in 1966 and a minimum of 43% in 1972 (U.S. Forest Service). Prior to 1968, utilization exceeded 90%, based on U.S. Forest Service records. Grazing records were incomplete prior to 1959 and grazing was not uniform across the study area, but the area was very heavily grazed. Browsing by big game was probably never very high in the study area and had been insignificant for the last 20 years (Thilenius and Hungerford 1967).

Organized fire protection has been provided in the area since sometime in the 1920's. The only fire on record was a wildfire that burned a small portion, about 18 ha, of the study area in 1963. Fire scars on many mature ponderosa pines were evidence that periodic, low intensity fires historically occurred in the area about every 22 years. Fire frequencies were not adequately determined for these specific stands, but in similar Douglas-fir stands of western Montana the mean fire frequency was 19 years (Arno 1976).

## Methods

Vegetation was sampled in the Douglas-fir/ninebark habitat type using a series of macroplots established both inside and outside the enclosure during 1978. Each pair of grazed and ungrazed macroplots were on the same slope, aspect, and soil series. At least a 3-m distance was maintained as the minimum buffer width between plots and the enclosure fence to eliminate any bias associated with the fence right-of-way. A total of eighteen 15 × 25-cm (375 $m^2$) macroplots were sampled. Variables measured included cover, frequency, production, number of trees, basal area, shrub density, and accumulation of downed woody fuels.

Each macroplot was further subidived into three 5 × 25-m (125 $m^2$) sections. Along the central section, fifty 20 × 50-cm (.1 $m^2$) microplots were placed at 1-m intervals. In these microplots, the parameters of cover, frequency, and production were measured. Cover was estimated using 6 cover classes for plants inside the microplots (Daubenmire 1959). Rooted frequency was determined for all species. Herbaceous plant species in every third microplot were clipped, oven dried, weighed, and converted to kilograms per hectare to obtain production values. Grazing was unrestricted for the grazed plots, but very few animals were observed in the stands prior to the sampling period.

Trees were tallied by 1/2-dm diameter classes as measured at breast height (1.4 m). All trees of this height and taller were measured in the macroplot. Basal area was calculated by the formula:

$$ba = (\tfrac{1}{2}d)^2 \times \pi,$$

where d equals diameter at breast height (Mueller-Dombois and Ellenberg 1974). Densities of trees less than breast height and shrubs were measured in 2 belt transects, 1 × 25 m, which were located along the central 5 × 25-m section of the macroplot. Average tree ages were estimated by obtaining increment cores from a minimum of 2 trees per diameter class in each plot and counting annual rings. Downed woody fuel accumulations were measured by the planar intersect method (Brown 1974) in two 10-m line transects. This technique provided the following information:

1. Weights per hectare of downed woody material for:
   a. Diameter size classes 0 to 0.6 cm (0 to 0.25 inch)
      0.6 to 2.54 cm (0.25 to 1 inch)
      2.54 to 7.62 cm (1 to 3 inches)
   b. Sound and rotten fuel particles of diameters of 7.62 cm larger.
   c. Forest floor duff.
2. Depth of fuel and forest floor duff.

One-way analysis of variance and Student's *t*-test were used for statistical analyses of differences between grazed and ungrazed stands for all variables. Throughout the paper the term *significant* refers to $P<0.05$.

## Results and Discussion

### Overstory Structure

The largest number of trees in both grazed and ungrazed stands were in the smaller diameter classes. As diameters increased, total number of trees decreased. Number of ponderosa pine and Douglas-fir in grazed stands were greater than in ungrazed stands in every diameter class up to 4 dm (Fig. 1, 2), but, more significantly, in the .5 to 2-dm classes. There were no large or consistent

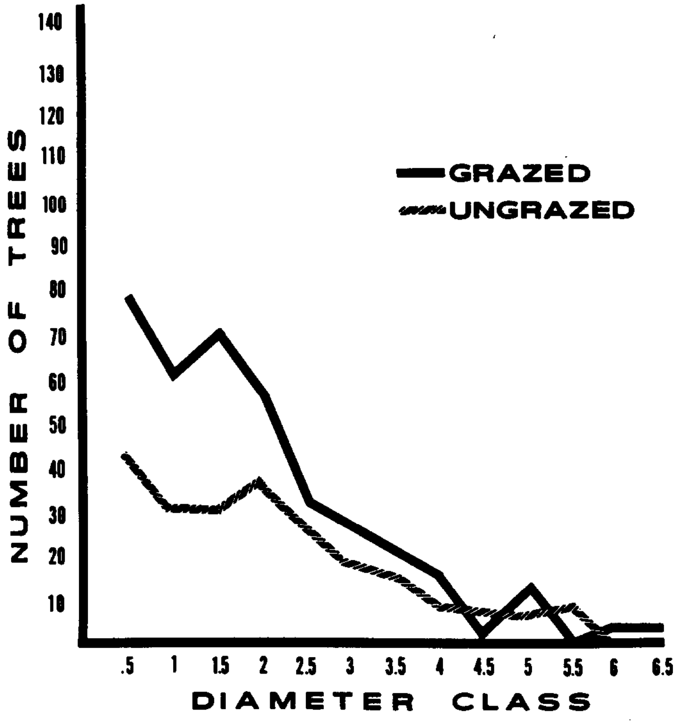


**Fig. 1.** *Mean number of ponderosa pine trees by .5 decimeter diameter classes for grazed and ungrazed stands.*

differences between the stands in the number of trees in diameter classes larger than 3 dm. In grazed stands there were more Douglas-fir trees than ponderosa pine in nearly every diameter class. In the ungrazed stand, with the exception of the .5-dm diameter class, there was a similar number of each tree species. However, in grazed stands, Douglas-fir were more abundant than ponderosa pine in the smaller size classes.

Number of Douglas-fir seedlings was about the same (1,277.6/-ha) on grazed and ungrazed stands. Number of ponderosa pine seedlings was significantly different, with only 55.6/ha on grazed stands but 555.6/ha on ungrazed stands. Many researchers have

[2]Flat Creek-Hatter Creek Allotment Management Plan. Cooperative plan developed by the University of Idaho, Palouse Ranger District (USFS), and Latah Soil and Water Conservation District. On file at Palouse Range Station, Potlatch, Ida.

found an increased number of seedlings following natural regeneration on moderately grazed sites in freshly cut forested stands (c.f. Adams 1975, Young et al. 1942, Tisdale 1950), but this benefit is apparently reduced for ponderosa pine when succession advances. In grazed stands, ponderosa pine regeneration was reduced as the quantity of shading and duff increased. Douglas-fir is more shade tolerant than ponderosa pine, is climaxed on these sites, and has the greater ability to regenerate in both open areas of ungrazed stands and shaded areas of grazed stands. In the long term, heavy grazing is more beneficial for Douglas-fir regeneration than for ponderosa pine.

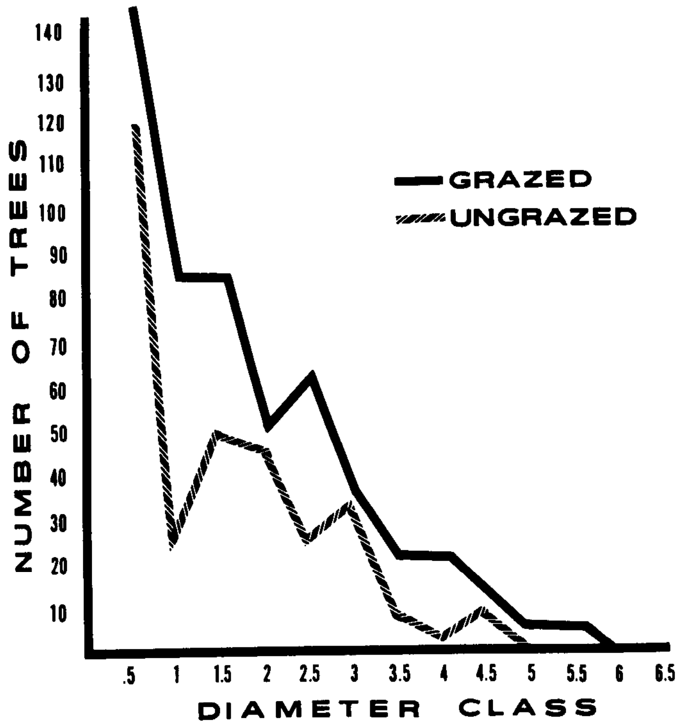


**Fig. 2.** *Mean number of Douglas-fir by .5 decimeter diameter classes for grazed and ungrazed stands.*

Increase in young tree densities has been attributed to the removal of the competing herbaceous layer by heavy grazing (Pearson 1923, Leopold 1924, Arnold 1950, Cooper 1960, Tisdale 1960, Pearson 1942, and Young et al. 1942). Weaver (1950) reported that overgrazing resulted in development of abnormally dense stands because it resulted in breakup of original sod and preparation of mineral seedbed. Rummell (1951) concluded that heavy grazing was primarily responsible for dense tree reproduction in central Washington.

In the majority of diameter classes, tree growth rates in grazed stands were slightly less than in ungrazed stands (Table 1). Lower growth rates in areas heavily grazed were reported by Adams (1975). Higher tree densities resulting from livestock grazing may have been the cause for decreased tree growth rates in grazed stands. Competition in dense stands reduced the growth and vigor of all trees, resulting in diameter growth reductions (Smith 1962).

Tree diameter classes which had the greatest difference between grazed and ungrazed stands (.5 to 2 dm), ranged in age from 16 to 56 years (Table 1). Thus, most of smaller diameter trees had become established during the past 50 years, a period of heavy grazing. Livestock grazing was probably the principal factor in creating and maintaining conditions that favored increased tree regeneration.

There was a significantly higher mean basal area in grazed stands (37 $m^2/ha$) than in ungrazed stands (22 $m^2/ha$) (Fig. 3). This large difference may be attributed to increased number of smaller trees in the grazed stands.

**Table 1. Average tree age by diameter class for ponderosa pine and Douglas-fir in grazed and ungrazed stands.**

| Diameter class (.5 dm) | Age[1] *Pinus ponderosa* Grazed | *Pinus ponderosa* Ungrazed | *Pseudotsuga menziesii*[1] Grazed | *Pseudotsuga menziesii* Ungrazed |
|---|---|---|---|---|
| .5 | 20.25 | 15.67 | 22.14 | 22.50 |
| 1.0 | 32.20 | 26.67 | 34.86 | 30.00 |
| 1.5 | 36.50 | 38.00 | 41.33 | 35.60 |
| 2.0 | 42.71 | 55.75 | 48.83 | 32.20[2] |
| 2.5 | 55.20 | 51.17 | 51.17 | 41.33 |
| 3.0 | 67.67 | 61.50 | 59.40 | 43.00 |
| 3.5 | 64.67 | 65.20 | 67.25 | 39.00 |
| 4.0 | 96.00 | 91.00* | 81.00 | 112.00* |
| 4.5 | 123.00*[a] | 74.00*[b] | 97.75[ab] | 86.50[b] |
| 5.0 | 105.33 | 119.00 | 80.00* | — |
| 5.5 | — | 108.00 | 96.00 | — |
| 6.0 | 104.00* | — | — | — |
| 6.5 | 165.00* | 98.00* | — | — |

[1]Species ages followed by different letters are significantly different at the 0.05 level.
[2]Tree ages followed by different numbers are significantly different at the 0.05 level.

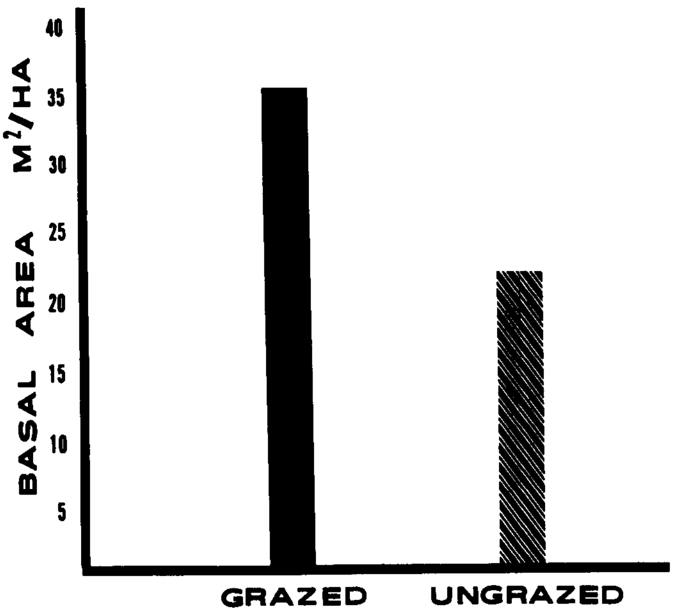


**Fig. 3.** *Mean basal area for ponderosa pine and Douglas-fir in grazed and ungrazed stands.*

## Shrub Layer

Total shrub density did not differ significantly between heavily grazed and ungrazed stands, but individual species density did (Table 2). Of the 12 shrub species sampled, only 3, serviceberry *(Amelanchier alnifolia)*, ninebark, and white spiraea *(Spiraea betulifolia)*, had a greater density in grazed stands. Serviceberry was either very tall and out of reach of livestock and big game, or very small and unutilized. The 9 other species had greater densities in ungrazed stands, but only redstem ceanothus *(Ceanothus sanguineus)*, chokecherry *(Prunus virginiana)*, and yerba buena *(Satureja douglasii)* densities were significantly greater. Redstem ceanothus, apparently suppressed through heavy use by livestock and big game, was nearly absent in grazed stands. Chokecherry and scouler willow *(Salix scouleriana)* occurred in such low densities in all stands that comparisons were not meaningful. Yerba buena, kinnikinnick *(Arctostophylos uva-ursi)*, and creeping Oregon grape *(Berberis repens)*, were probably less resistant to trampling by livestock due to their small size and shallow rhizomes, and were present in lesser amounts in grazed stands. Little wild rose *(Rosa gymnocarpa)* and snowberry also had higher densities in

**Table 2. Numbers per hectare, percnt cover, and average percent frequency for major shrub species.**

| Species | Number of shrubs[1] | | Cover • Frequency | |
|---|---|---|---|---|
| | Grazed | Ungrazed | Grazed | Ungrazed |
| *Amelanchier alnifolia* | 5622 | 1755* | 0.3 • 2.2 | 0.3 • 2.0 |
| *Arctostaphylos uva-ursi* | 233 | 755 | +[3] • 0.4 | 0.2 • 2.0 |
| *Berberis repens* | 1600 | 1755 | 0.7 • 4.0 | 1.1 • 5.8 |
| *Ceanothus sanguineus* | 122 | 2033* | 0.0 • 0.0 | 2.7 • 5.3* |
| *Holodiscus discolor* | 522 | 989 | 0.6 • 1.3 | 2.6 • 4.4* |
| *Physocarpus malyaceus* | 2077 | 1611 | 2.3 • 6.9 | 1.7 • 4.4 |
| *Prunus virginiana* | 0 | 67* | 0.0 • 0.0 | 0.0 • 0.0 |
| *Rosa gymnocarpa* | 3489 | 4510 | 1.2 • 8.2 | 2.1 • 12.4* |
| *Satureja douglasii* | 78 | 700* | + • 0.4 | 0.5 • 3.3* |
| *Salix scouleriana* | 67 | 253 | 0.0 • 0.0 | 0.2 • 0.9 |
| *Spiraea betulifolia* | 7900 | 5033 | 5.8 • 42.0 | 4.7 • 32.0 |
| *Symphoricarpos albus* | 9767 | 12377 | 4.6 • 26.0 | 7.2 • 39.3* |
| Total for all shrub species | 31477 | 31838 | 15.8 • — | 24.5* • — |

[1]Species means followed by an asterisk are significantly different at the 0.05 level.
[2]Numbers represent percent cover (first) and average frequency (second).
[3]Values less than 0.1 are represented by +.

ungrazed stands indicating that livestock grazing retarded their spread, possibly through rhizome damage by trampling.

Total percent cover for all shrubs was significantly lower in grazed stands (15.8%) than in ungrazed stands (24.5%) (Table 2). This reduction in cover suggested that shrub species sustained heavy use by livestock. Because of the unequal size distribution of individual plants, ninebark and white spiraea had higher cover and frequency values in grazed stands. Serviceberry had higher frequency in the grazed stands but equal cover in both grazed and ungrazed stands. All nine of the other individual species had higher cover and frequency in ungrazed stands. Five of these, redstem ceanothus, oceanspray, little wild rose, yerba buena, and snowberry were significantly higher. Krueger and Winward (1974) found similar results with oceanspray and snowberry in northeastern Oregon. They also found that ninebark had lower percent cover in stands grazed by cattle and big game in stands grazed by big game only. Redstem ceanothus occurred frequently with one of the higher cover values in the ungrazed stands, but was not encountered in microplots in grazed stands.

### Herbaceous Layer

Production, percent cover, and frequency of grasses indicated that livestock grazing was a substantial influence (Table 3). Production of bluebunch wheatgrass, pinegrass, and Idaho fescue were significantly lower in grazed stands. Bluebunch wheatgrass production in grazed stands was nearly 140 times greater than that in stands grazed by livestock. Pinegrass production in grazed stands was only 28% of that found in ungrazed stands (a reduction of nearly 72%). Idaho fescue was absent in stands grazed by livestock (Evanko and Peterson 1955). Columbia brome *(Bromus vulgaris)* production was slightly less in grazed stands. Kentucky bluegrass *(Poa pratensis)* and elk sedge production increased in grazed stands and was nearly absent in ungrazed stands.

In grazed stands, cover of Columbia brome and Kentucky bluegrass was significantly higher, while cover of bluebunch wheatgrass, pinegrass, and Idaho fescue was lower. Pinegrass had the largest difference, with cover in grazed stands less than one-half the cover in ungrazed stands. Elk sedge cover was the same in grazed and ungrazed stands. In central Washington ponderosa pine stands, Rummell (1951) found that the most striking effect of heavy grazing was reduction of grasses, principally pinegrass, to half or less of the cover found in ungrazed stands. R. and J. Daubenmire (1968) reported that Kentucky bluegrass increased under heavy grazing.

Combined production of all forb species was found to be significantly lower in stands grazed by livestock (340 kg/ha) than in ungrazed stands (469 kg/ha) (Table 3). Bigleaf sandwort *(Arenaria macrophylla)* and mountain sorrel *(Rumex paucifolia)* production was higher in grazed stands. Producton of Piper's anemone *(Anemone piperi),* raceme pussytoes *(Antennaria racemosa),* showy aster *(Aster conspicuus),* pinewoods peavine *(Lathyrus bijugatus),* western starflower *(Trientalis latifolia),* American vetch *(Vicia americana),* and early blue violet *(Viola adunca)* was lower in grazed stands. No meaningful responses to grazing were found for other species.

Total forb cover was not substantially different between the stands (Table 3). However, bigleaf sandwort, heartleaf arnica *(Arnica cordifolia),* and narrowleaf collomia *(Collomia linearis),* had significantly higher cover in grazed stands. Raceme pussytoes, showy aster, mountain sweetroot *(Osmorhiza chilensis),* Gairdner's yampa *(Perideridia gairdneri),* cinquefoil *(Potentilla gracilis),* western starflower, and American vetch had significantly lower cover in grazed stands. There were no substantial differences in cover of other species.

Frequency of forb species in grazed and ungrazed stands generally followed the same trends observed in production and cover (Table 3), but some very distinct changes in species occurrence were obvious. In grazed stands, Piper's anemone and western starflower decreased markedly from (22.2% to 12.2% and from 15.6% to 3.1%, respectively) and bigleaf sandwort increased substantially (from 15.8% to 39.1%). Krueger and Winward (1975) found that frequency of forbs generally increased under heavy grazing pressure.

### Fuel Accumulation

Livestock grazing did not directly alter the fuel loading. However, grazing did change the density and composition of woody and herbaceous material, which indirectly influenced the fuel accumulation. Total accumulation of downed woody material was found to be greatest in stands grazed by livestock (75,804 kg/ha compared to 53,984 kg/ha) (Fig. 4). Inspection of downed woody material accumulation by size classes revealed that stands used by livestock contained higher weights per area in every category (Fig. 4). The largest differences were found in the 7.62 cm and larger size classes, with sound particles of this size comprising 9,200 kg/ha (5.11 tons/acre) in grazed and only 3,881 kg/ha (2.16 tons/acre) in ungrazed stands. Rotten particles of this size comprised 9,759 kg/ha (5.42 tons/acre) in grazed and 5,729 kg/ha (3.81 tons/acre) in ungrazed stands. In each of the smaller size classes, grazed stands contained nearly double the amount of fuel found in ungrazed stands. Accumulations of duff comprised the highest weights per area of any single category in both grazed and ungrazed stands. Stands grazed by livestock had 52,563 kg/ha (29.2 tons/acre) of duff. Grazing has reduced duff accumulation by compacting litter and increasing the rate of decomposition of western forests (Hattin 1920, Weaver 1951). However, as tree

**Table 3. Production in kilograms per hectare, percent cover, and average percent frequency for major herbaceous species.[1]**

| | Production | | Cover frequency[2] | | | |
|---|---|---|---|---|---|---|
| | Grazed | Ungrazed | Grazed | | Ungrazed | |
| Graminoids: | | | | | | |
| *Agropyron spicatum* | 0.17 | 23.98* | +[3] | 0.9 | 0.5 | 10.2* |
| *Bromus vulgaris* | 1.00 | 2.00 | 1.3 | 24.0 | 0.7 | 19.3* |
| *Calamagrostis rubescens* | 47.09 | 165.48* | 0.8 | 21.3 | 2.1 | 34.2* |
| *Carex geyeri* | 114.26 | 57.48 | 2.5 | 49.6 | 2.6 | 44.9 |
| *Festuca idahoensis* | 0.00 | 10.85* | + | 0.0 | 0.4 | 8.2* |
| *Poa pratensis* | 16.95 | 0.00* | 0.9 | 14.7 | 0.0 | 0.0* |
| Total for all graminoids | 188.83 | 273.47 | 5.9 | — | 6.3 | — |
| Forbs: | | | | | | |
| *Achillea millefolium* | 50.20 | 83.10 | 0.9 | 15.8 | 0.7 | 16.2 |
| *Apocynum androsaemifolium* | 25.30 | 8.20 | 0.4 | 4.7 | 0.5 | 5.3 |
| *Anemone piperi* | 1.30 | 4.00* | 0.8 | 12.2 | 1.1 | 22.2 |
| *Antennaria racemosa* | 0.10 | 0.30* | + | 0.2 | 0.1 | 1.8* |
| *Arenaria macrophylla* | 5.20 | 1.90* | 2.9 | 39.1 | 0.6 | 15.8* |
| *Arnica cordifolia* | 6.90 | 6.60 | 2.9 | 27.8 | 1.5 | 26.2* |
| *Aster conspicuus* | 0.00 | 4.50* | + | 0.7 | 0.4 | 4.4* |
| *Collomia linearis* | 4.20 | 6.90 | 0.2 | 9.8 | 0.1 | 4.4* |
| *Collinsia parviflorus* | 0.00 | 0.00 | 0.2 | 6.9 | 0.2 | 8.7 |
| *Cryptantha echinella* | 41.70 | 34.00 | 0.1 | 1.1 | + | 1.6 |
| *Fragaria virginiana* | 2.00 | 2.70 | 4.2 | 39.8 | 4.9 | 50.7 |
| *Galium boreale* | 161.80 | 196.00 | 0.4 | 6.0 | 0.4 | 9.8 |
| *Goodyera oblongifolia* | 18.80 | 34.10 | + | 0.7 | + | 0.7 |
| *Gypsophila paniculata* | 0.20 | 0.30 | + | 1.6 | + | 1.1 |
| *Lathyrus bijugatus* | 3.40 | 7.40* | 0.5 | 12.0 | 0.6 | 10.9 |
| *Lupinus sericeus* | 9.00 | 22.00 | 0.7 | 6.4 | 0.8 | 8.9 |
| *Madia exigua* | 0.10 | 2.40 | 0.2 | 1.8 | + | 3.4 |
| *Osmorhiza chilensis* | 0.03 | 0.12 | + | 1.6 | 0.4 | 6.2* |
| *Perideridia gairdneri* | 0.30 | 1.00 | + | 0.2 | 0.1 | 2.9* |
| *Potentilla glandulosa* | 0.00 | 28.70 | 0.3 | 4.0 | 0.4 | 5.8 |
| *Potentilla gracilis* | 3.20 | 10.00 | + | 0.2 | 0.2 | 1.8* |
| *Rumex acetosella* | 0.40 | 0.10 | + | 0.9 | + | 0.4 |
| *Rumex paucifolia* | 1.00 | 0.10* | 0.2 | 2.4 | + | 1.3 |
| *Smilacina stellata* | 3.20 | 1.30 | 0.7 | 6.0 | 0.4 | 2.4 |
| *Taraxacum officinale* | 0.20 | 7.30 | 0.3 | 4.0 | 0.2 | 7.1 |
| *Thalictrum occidentale* | 1.30 | 2.10 | 0.6 | 6.2 | 0.7 | 8.4 |
| *Trientalis latifolia* | 0.60 | 1.90* | 0.2 | 3.1 | 0.5 | 15.6* |
| *Vicia americana* | 0.00 | 1.30* | + | 0.2 | 0.2 | 5.6* |
| *Viola adunca* | 0.03 | 1.40* | 0.2 | 3.1 | 0.3 | 8.0 |
| Total for all forbs | 340.46 | 469.72* | 17.6 | — | 17.3 | — |

densities increased in dry Douglas-fir stands following grazing, the quantity of litter fall increased and the composition of the duff changed. Probably this created a microenvironment that was not conducive to increased litter fall or reduced rate of decomposition. Heavily grazed stands had greater accumulations of duff and downed woody fuel suppression mortality and lower branch drop that followed the canopy closure. Heavy grazing indirectly increased the accumulation of organic debris in the grazed stands of this study.

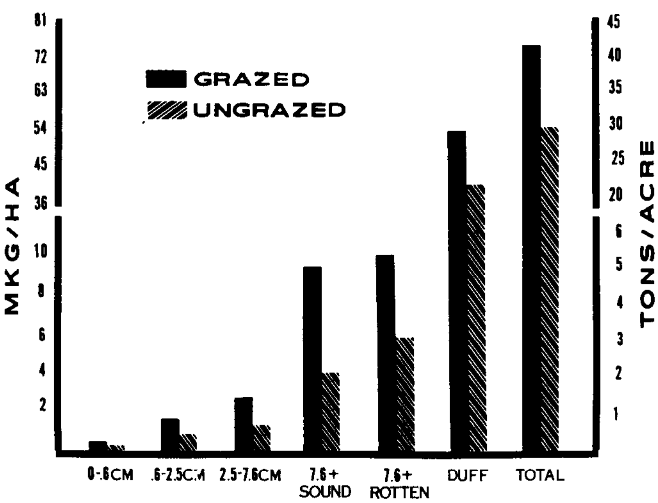


**Fig. 4.** *Mean fuel loading by size classes for grazed and ungrazed ponderosa pine and Douglas-fir stands.*

In general, in fire-danger ratings, living fuels are burnable fine fuels when dry and are part herbaceous and part nonherbaceous material (Fosberg and Schroeder 1971). Nonherbaceous fine fuels are perennial foliage of shrubs and tree reproduction, and woody stems less than .6 cm in diameter. Herbaceous fine fuels are comprised of vegetation such as grasses, sedges, and forbs. Nonherbaceous fine fuels were not measured in this study because of sampling difficulty. Total live herbaceous fine fuels were found to be significantly lower in grazed (467 kg/ha) than in ungrazed stands (719 kg/ha) (Table 3).

Little research has been done concerning burning characteristics of living fuels, but their importance in reaction intensity and rate-of-spread has been discussed (Richards 1940, Fosberg and Schroeder 1971, Rothermel 1972). Based on fuel arrangement, Rothermel (1972) indicated that herbaceous fuels were considered as flashy and have the highest potential reaction intensity. He also showed that with the addition of wind, herbaceous fuels had the highest rate-of-spread. Richards (1940) reported that plant moisture content was the major factor controlling vegetative influence on fire rate-of-spread. Decreased moisture content occurring during the summer resulted in increased flammability. He also found that the rates at which plants lost moisture when subjected to fire caused different fire behavior. Hatton (1920) directly attributed reductions in the incidence of fire to removal of herbaceous material and increased decomposition through trampling from grazing livestock. Jemison (1934) reported that tree canopy density significantly influenced flammability. Increasing tree canopy density reduced temperature, humidity, wind, and evaporation below the canopy, which resulted in increased moisture holding capacity of understory vegetation and reduced flammability. Thus, as livestock grazing influenced canopy density and reduced fine fuels, it also affected the ability of the forest to sustain a surface fire.

## Management Implications

Livestock grazing has altered the composition and quantity of ground cover vegetation. Removal of herbaceous competition combined with exposure of mineral soil has aided in preparing stands for increased tree reproduction. Consequently, regeneration success of both ponderosa pine and Douglas-fir has increased with potentially long-lasting effects.

Douglas-fir habitat types in northern Idaho have typically supported uneven-aged forests with many age and diameter classes represented. The proportion of trees in each diameter class has remained relatively constant over time (until complete crown closure has occurred), with the diameter distribution usually taking the form of a falling exponential curve with the number of trees plotted against diameter. In grazed stands the balance in forest structure shifted so that greater numbers of trees now occur in smaller size classes. Overstocked ponderosa pine and Douglas-fir stands may stagnate, causing reductions in growth rates, and increased susceptibility to damage from insects or disease. Increased stocking levels and basal area have reduced both shrub and herbaceous layers. In the Douglas-fir/snowberry habitat type, understory production decreased as tree canopy cover increased (Froeming 1974). An inverse relationship between overstory canopy or basal area and the density or production of shrubby and herbaceous understories had been reported by researchers working under a wide variety of conditions (Arnold 1950, Tisdale 1950, Pase 1958, Cooper 1960, McConnell and Smith 1965, Hedrick et al. 1968). Also, as stocking levels increased, livestock movement became more difficult. Cattle concentrated in open areas, or along roads or fences, causing further pressure on already overused range. These concentrations may have caused trampling and compaction damage to tree reproduction.

Livestock grazing appeared to have no significant influence on density of shrubs, although it did cause significant reductions in cover and composition. Continuous heavy grazing suppressed the growth of redstem ceanothus, a browse species highly desirable and important to big game species. Thilenius (1960) found that cattle first used palatable forage grasses, then were forced to subsist on browse and forbs for the remainder of the growing season. He also found that browse species comprised the greater part of the food supply of livestock using forested ranges when the areas were overused. Thus, as tree canopy cover increased, the browse component received heavier use from grazing livestock, causing additional shrub species to be suppressed.

Generally, influence of livestock grazing on the herbaceous layer was most pronounced in production. Significant reductions were found in the major palatable grass species and in total forb production.

It appeared that livestock grazing was responsible for retrogression of plant succession within the herbaceous layer. Climax grass species were replaced by species common to seral communities. There were apparent changes in dominance of certain forb species.

In the overstory, grazing advanced succession. Ponderosa pine was the most prevalent seral tree species found in these stands, although there were occasional lodgepole pine *(Pinus contorta)*. Douglas-fir regeneration was most pronounced, and comprised the majority of trees in all of the smaller diameter classes. It appeared to be gaining dominance in the heavily grazed stands.

Modifications in plant succession were not defined as clearly in the shrub layer. Livestock showed preference for the more palatable browse species, which were commonly seral in this habitat type. In climax situations, ninebark was the principal species, with oceanspray, snowberry, and white spiraea also well represented. In stands used by livestock, ninebark had increased, although not significantly, but was not the dominant species. In the grazed stands, oceanspray and snowberry had decreased while white spiraea had increased.

Livestock grazing increased total accumulations of downed woody fuels. While it is possible that incidence of low intensity surface fires was reduced through the increase in forest canopy and removal of the herbaceous layer, this reduction may not be as significant as once thought. As the highly palatable species were selectively removed, they were replaced in lesser amounts by unpalatable and high flammable species.

Douglas-fir forest communities and environmental conditions that influenced them interacted to establish a level of duff accumulation and decomposition rates of woody material. Livestock grazing in these forests increased duff accumulation but apparently did not accelerate decomposition rates. Larger fuels and forest floor duff contributed very little to the rate-of-spread, but once ignited, persisted in the form of smoldering fires. These smoldering fires are difficult to extinguish, providing a source of burning embers for further fire spread. Thus, over long periods of time, the physical accumulation of large amounts of downed woody fuels and duff layers may induce flammability (Bloomberg 1950.).

Increased total tree numbers and unpalatable shrub species, when combined with increased duff and all size classes of dead organic material, created bridges between the ground layers and tree canopies. This manner of fuel distribution is highly conducive to the vertical spread of fire through a forest canopy.

Douglas-fir/ninebark forest stands have historically experienced damage from wildfires (Wellner 1970). In western Montana, extreme fire damage was, generally, confined to northern exposures. Southern exposures experienced frequent, low intensity fires (Arno 1976). Concentrations of flashy or herbaceous fuels and moderate stocking levels permitted surface fires to pass quickly through stands, causing little damage. In the future, if grazing-induced fuel buildups and fuel ladder situations are permitted to continue, the potential destructiveness of crown carrying wildfires will increase.

Several types of forest management practices lend themselves to the mitigation of adverse fuel conditions in these stands. Prescribed understory burning can remove herbaceous fuels, reduce litter and downed woody fuel accumulations, and control excessive tree reproduction. For dense sapling and pole-sized stands, precommercial and commercial thinning can achieve and maintain desired stocking levels. Depending on the residual stand, prescribed burning can be used in conjunction with thinning operations to control fuel levels.

If effects of intensive grazing are allowed to continue over long periods of time, prescribed burning treatments will be difficult to administer. During attempts to carry out prescribed understory burning in grazed and ungrazed Douglas-fir stands, Zimmerman (1979) found that the 2 areas could not be burned under the same fire weather conditions. He found that temperature and moisture conditions suitable for burning quickly drying herbaceous fuels of ungrazed stands created fuel moisture conditions that severely restricted the ignition and spread of fire in the abundant, larger fuels of grazed stands. These stands only burned under dry, wildfire weather conditions.

The influence of excessive livestock grazing on community structure in the Douglas-fir/ninebark habitat type resulted in modifications of plant cover and fuel distribution and composition.

The modifications that resulted in fuel distribution and composition were slightly less favorable to frequent surface fires, highly conducive to vertical spreading of fire, and potentially more capable of major conflagrations. Therefore, continued livestock grazing without fuel management will cause reductions in the frequency of low intensity fires, but will promote conditions that favor the occurrence of infrequent, high intensity fires.

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