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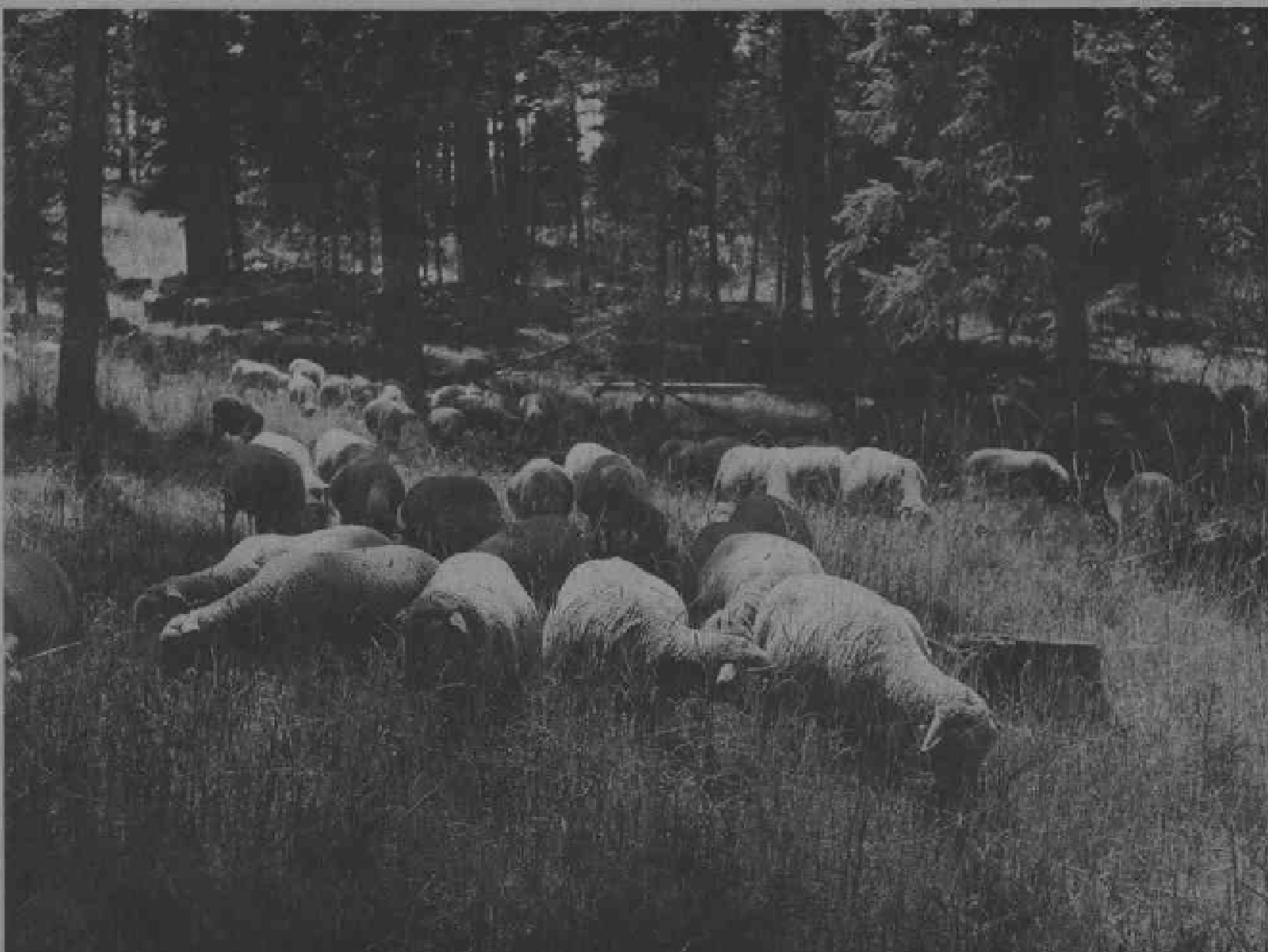

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AUTHORS

C. C. BOHN
former graduate research assistant, Department of Rangeland Resources at Oregon State University.

J. C. BUCKHOUSE
associate professor, Department of Rangeland Resources at Oregon State University.

P. S. DOESCHER
assistant professor, Department of Rangeland Resources at Oregon State University.

L. E. EDDLEMAN
associate professor, Department of Rangeland Resources at Oregon State University.

D. C. GANSKOPP
range scientist, U.S. Department of Agriculture - ARS at the Squaw Butte Station.

M. R. HAFERKAMP
assistant professor, Department of Rangeland Resources at the Squaw Butte Station.

W. C. KRUEGER
professor and head, Department of Rangeland Resources at Oregon State University.

W. C. LEININGER
graduate research assistant, Department of Rangeland Resources at Oregon State University.

H. F. MAYLAND
range scientist, U.S. Department of Agriculture - ARS at Boise.

R. F. MILLER
associate professor, Department of Rangeland Resources at the Squaw Butte Station.

B. D. RHODES
graduate research assistant, Department of Rangeland Resources at Oregon State University.

S. H. SHARROW
associate professor, Department of Rangeland Resources at Oregon State University.

F. A. SNEVA
range scientist (emeritus), U.S. Department of Agriculture - ARS at the Squaw Butte Station.

T. J. SVEJCAR
former graduate research assistant, Department of Rangeland Resources at Oregon State University.

M. VAVRA
professor, Department of Rangeland Resources at the Union Station.

R. P. YOUNG
graduate research assistant, Department of Rangeland Resources at Oregon State University.

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RESPONSE TO COLIFORM BACTERIA CONCENTRATION TO GRAZING MANAGEMENT[1]

J. C. Buckhouse and C. C. Bohn

Bacterial contamination of surface waters may impact human health by transmitting pathogenic organisms. For several decades, the fecal group of Escherichia coli have been used to indicate the presence of fecal material which may contain pathogens. State and federal water quality regulations employ fecal coliform counts to monitor point source fecal contamination and to define the sanitary status of urban watercourses. When the 1972 Federal Water Pollution Control Act (PL 92-500, Section 208) required evaluation of non-point source pollutants, the same techniques and similar standards were applied to wildland streams. However, certain aspects of fecal coliform behavior in wildland watersheds require careful interpretation for rangeland monitoring purposes. For example, coliform concentrations in streams readily respond to runoff events (Kittrel and Furfari, 1963; Morrison and Fair, 1966; Stephenson and Street, 1978; Doran and Linn 1979; Hanks et al., 1981). Apparently, cowpies can provide a protective medium which allows coliform survival for at least a year, during which time the bacteria could be carried to the stream with overland flow (Buckhouse and Gifford, 1976; Clemm, 1977). Only two to three percent of the bacteria theoretically available from an eastern United States pasture actually reached the stream (Kunkle, 1970) and runoff carried viable coliform only about three feet on a Utah range (Buckhouse and Gifford, 1976). However, when cattle concentrate in a riparian area, the stream might be within transport distance. In addition, on western United States rangelands, high intensity-short duration storms produce conditions which lower infiltration and increase the volume of runoff available to transport bacteria (Hanks et al., 1981).

Once in the streams, the organisms tend to bind to suspended sediments and settle out (Kittrel and Furfari, 1963; McSwain and Swank, 1977; Speck et al., 1981). In fact, coliform concentrations exhibit a hysteresis loop characteristic of suspended sediment concentration associated with high flows (Kunkle, 1970). Bottom sediments are apparently a significant reservoir for fecal coliform which may be resuspended by streamflow or animal disturbance (Kunkle, 1970, VanDonsel and Geldreich, 1971; Stephenson and Rychert, 1982). However, coliform bacteria may die-off in riffle areas due to increased contact with bacteria predators and good aeration (Kittrel and Furfari, 1963). Unfortunately, little is known about the behavior of pathogens in bottom sediments; Salmonellae apparently survive in mud similarly to fecal coliform (VanDonsel and Geldreich, 1971).

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[1] This work was funded by the U.S.D.A. Forest Service, Range and Wildlife Habitat Laboratory, La Grande, Oregon.

It appears that coliform bacteria concentrations from non-point sources may be indicating fecal contamination, entering with overland flow, or, mimicking suspended sediment concentrations. There is even some evidence, stemming from research related to septic tanks, that coliform bacteria may survive in some soils and move laterally as far as a few hundred feet with subsurface flow under saturated flow conditions. Well-drained colluvium apparently favored bacterial movement (VanDonsel et al., 1967; Hagedorn and McCoy, 1979; Moore et al., 1981). It may be crucial to understand the mechanism by which the fecal coliform arrive in the stream and the behavior of the pathogens in each circumstance.

Livestock grazing is considered a major source of fecal pollution on wildland streams. Doran et al. (1981) estimated that one third of all water pollutants in the United States are from non-point sources and that animal wastes from grazing are an important non-point source. Several studies have correlated fecal contamination with livestock grazing (Morrison and Fair, 1966; Kunkle and Meiman, 1967; Darling and Coltharp, 1973; Johnson et al., 1978, Stephenson and Street, 1978; Doran and Linn, 1979; Dixon et al., 1981; Gifford, 1981). One week to several months may be necessary for coliform counts to return to background levels following livestock removal (Johnson et al., 1978; Stephenson and Street, 1978). However, other mammals, such as wildlife, also transmit coliform bacteria. When local big game populations concentrated in a protected watershed in Montana, the water produced higher coliform concentrations than did a comparable watershed open to recreation (Walter and Bottman, 1967; Stuart et al., 1971). Background levels of coliform may vary with wildlife use.

In many areas, livestock depend on access to streams for water, and feed on the succulent vegetation throughout the season. For economic reasons, controlling fecal contamination by use of a particular grazing system is preferable to livestock exclusion. The only study of the influence of different grazing systems on coliform counts found lower counts on a deferred rotation system compared to a continuous grazing system (Speck et al., 1981). The comparison was based on data from streams in mountain allotments. Recognizing the potential for management applications, the Forest Service Pacific Northwest Forest and Range Experiment Station initiated a multidisciplinary case study at Meadow Creek on the Starkey Experimental Forest and Range in northeastern Oregon in 1975. The study was conducted through the Range and Wildlife Habitat Lab in La Grande, Oregon, and spanned five years of controlled grazing. One of the objectives of this study was to compare levels of fecal contamination associated with different systems of grazing cattle.

METHODS

Our Meadow Creek study examined five grazing options. Four pasture rest-rotation, deferred rotation, season-long grazing and no grazing systems were applied to two blocks with one block open to big game (elk and deer) use and one block closed to big game. In addition, late season, high intensity-short duration grazing was tested in September and October. Season-long grazing was studied on pastures which had been rested one to four years. All pastures contained about one-quarter mile of stream frontage.

Water samples were cultured for fecal coliform bacteria following standard methods described for the membrane filter technique (American Public Health Association, 1975). Water samples (250 milliliters) were collected above and below each pasture every three to four weeks. The time of sampling remained constant for each station, but the sample collection period extended from 1000 hours to 1400 hours. On 1200 foot stream stretches, water flowing from one grazing treatment into the next confounds sampling in the lower pasture. Therefore, the arithmetic difference in counts as the stream enters and leaves a grazing treatment was considered representative of that treatment. The t-test was applied to above and below treatment pairs to determine whether changes were significant and confidence intervals were used to compare treatment means.

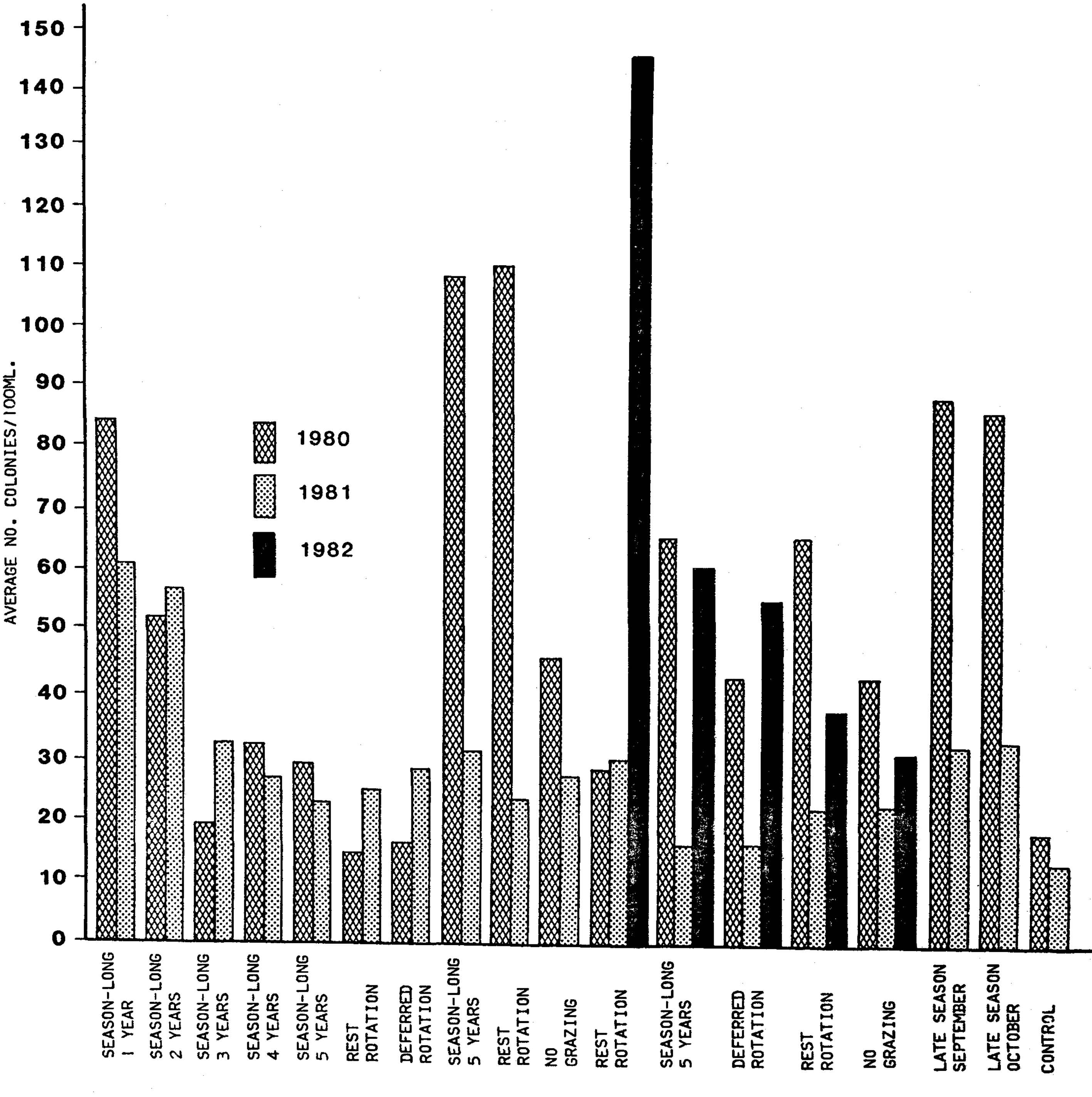
In 1980, a year when livestock were present, sampling was conducted monthly from June through October. In 1981, the same areas were sampled on the same dates as the previous year. However, livestock were not present. In 1982, livestock were again on the area, and selected treatments were sampled intensively during the month of September.

RESULTS

A t-test was applied to determine if counts changed significantly within that treatment. Although large numerical differences in water from the top and bottom of the treatment were sometimes detected, the sampling variation apparently was too great to establish many statistical differences between the points. Even when samples were collected on consecutive days in 1982, statistical differences were not apparent (Figure 1).

When livestock were removed in 1981, mean coliform counts dropped for most treatments. The changes sometimes were numerically large but never statistically significant due to large sampling variation (as indicated by the t-test). Counts were fairly uniform throughout the study when cattle were absent, averaging between 13 and 61 colonies per 100 milliliters. The upstream pastures which received water from grazed areas above the study recorded the highest counts. In contrast, during the 1980 season, counts showed considerable variation throughout the study area, ranging between 14 and 111 colonies per 100 milliliters.

FIGURE 1. AVERAGE NUMBER OF COLONIES: GRAZED VS. UNGRAZED YEARS



HEALTH STANDARDS

The Oregon Department of Environmental Quality requires that coliform bacteria in the waters of the Grande Ronde Basin do not exceed a log mean of 200 fecal coliform per 100 milliliters, based on five samples in a 30-day period. Furthermore, no more than 10 percent of those samples may exceed 400 colonies per 100 milliliters (Oregon D.E.Q., 1980). Although coliforms were never sampled five times within 30 days for the study, it is noteworthy that counts seldom exceeded 100 per 100 milliliters. Oregon State Health Division allows an arithmetic mean of one colony per 100 milliliters with any individual sample showing no more than four per 100 milliliters for drinking water. Few, if any, wildland streams meet this criteria regardless of grazing management.

SUMMARY AND CONCLUSIONS

1. Although large numerical differences sometimes were seen, differences between grazing systems were not statistically significant.

2. The number of colonies and the range of the counts generally decreased the first year livestock were not present. Although the changes were often numerically large, they were statistically insignificant.

3. Meadow Creek apparently conforms to Oregon's coliform standards for wildland waters in the Grande Ronde Basin.

4. Interpretation of coliform data from non-point sources must be cautious and must recognize a number of sources of variation. In addition, recent literature suggests large indicator bacteria populations are present in the bottom sediments and may or may not track with the pathogenic organisms.

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GROWTH AND WATER RELATIONS OF THREE BIG SAGEBRUSH SPECIES

R. F. Miller, P. S. Doescher, T. J. Svejcar, and M. R. Haferkamp[1]

Big sagebrush (Artemisia tridentata) dominates 90 million acres in the western United States. Available soil moisture and phenology are probably the two most important factors determining the level of sagebrush kill with application of 2,4-D. This paper will discuss the correlation between plant growth, internal plant water stress and soil water over a two-year period (1981 and 1982).

EXPERIMENTAL PROCEDURES

Wyoming big sagebrush (A. tridentata subsp. wyomingensis), basin big sagebrush (A. tridentata subsp. tridentata) and mountain big sagebrush (A. tridentata subsp. vaseyana) sites were studied at Squaw Butte in eastern Oregon. The three study sites are characterized in Table 1.

Table 1. Site characteristics for the three locations studied

Habitat type	Soil depth (in.)	Elevation (ft.)	Shrub canopy (%)	Herbage production (lb/a)
Wyoming big sagebrush/ Thurbers needlegrass	30	4620	15	560
Basin big sagebrush/ basin wildrye	40	4620	20	570
Mountain big sagebrush/ Idaho fescue	60	5115	15	630

Long term average precipitation for Squaw Butte is 11.8 inches. However, both 1981 and 1982 growing seasons were wetter than normal, reflected by soil moisture content 140 percent of normal in both years.

Plant growth, internal water stress and soil moisture were measured on the same day every two weeks during June and July and monthly during August through November in 1981 and 1982 and twice in May 1982.

[1] This work was sponsored and funded by the Oregon Agricultural Experiment Station.

Phenological development was recorded in both years. In 1982, stem elongation and leaf fall were also measured. Several hundred overwintering leaves were marked in March with a non water-soluble ink. Just prior to leaf fall in August a leaf trap made out of cheese cloth was placed over individual branches to measure the proportion of leaves lost during this period. Internal water stress was measured with a pressure chamber at pre-dawn and 2 p.m. Soil moisture was measured gravimetrically.

RESULTS AND DISCUSSION

The following data were collected in two consecutive years of above-average soil moisture. We acknowledge that above average moisture could increase productivity and the duration of rapid growth into the summer.

Due to high levels of available soil water on all three sites in 1981 and 1982, initiation and rate of growth in the early spring were probably controlled by atmospheric influences. The rapid growth period was characterized by cool to warm temperatures and soil water ranging from field capacity down to -2.0 bars. During this period leaf growth for Wyoming and basin big sagebrush was initiated in early May followed by stem elongation approximately two weeks later (Figures 1 and 2). Leaf and stem growth of mountain big sagebrush followed a similar pattern but were initiated in mid-May and late May, respectively (Figure 3). Reproductive stems were recognizable by mid-June for all three subspecies.

Soil water tension dropping below -2.0 bars coincided with termination of vegetative growth and a sharp decrease in plant water potential (Figures 1, 2, and 3). Reproductive stem elongation continued for approximately two more weeks and terminated by August 1. During the later part of July, ephemeral and perennial leaves began turning yellow. By August soil water tension had been below -2.0 bars for approximately two weeks and plant water potentials were at or below -20 bars.

During August, which was characterized by hot temperatures, low soil water and high plant water stress, 53 percent of the total leaf biomass dropped off the plants. The pattern was similar for all three subspecies. Wyoming big sagebrush and basin big sagebrush began to shed their leaves by the first of August. Mountain big sagebrush followed about 10 days later. Leaf fall was made up of two kinds of leaves. The entire crop of perennial leaves produced in 1981 that persisted through the winter fell with ephemeral leaves produced in 1982. The majority of leaf fall occurred in a three-week period. After this intensive leaf fall period a small percentage of ephemeral leaves continued to die into the fall.

Although plants were under high water stress during the late summer, green leaf tissue persisted on the plant and reproductive effort continued.

CONCLUSION

Although big sagebrush is well adapted to growing in arid environments, active vegetative growth is dependent upon moist soil conditions. Active leaf and stem growth occurred at soil water tensions between field capacity and -2.0 bars. This represents approximately 30 percent of the total water found in the soil profile. Once soil water decreased below -2.0 bars and internal plant water potentials approached or passed -20 bars, active growth was terminated and drought avoidance mechanisms initiated. In August, the plant reduced its transpiration surface by over one-half. This included large ephemeral leaves and perennial leaves produced during the previous growing season. Based on one year of data, perennial leaves persisted for only two growing seasons and one winter. In both 1981 and 1982 all three subspecies were capable of continuing development of reproductive tissue under extreme levels of internal plant water stress and very limited soil water.

Although the timing and duration of certain phenological stages will vary from site to site, and year to year, the pattern or sequence is not likely to change. In years when soil moisture remains below or above -2.0 bars for only a short period during the growing season, only limited growth will occur, probably. However, this study will be conducted in a year of limited soil moisture to verify this hypothesis.

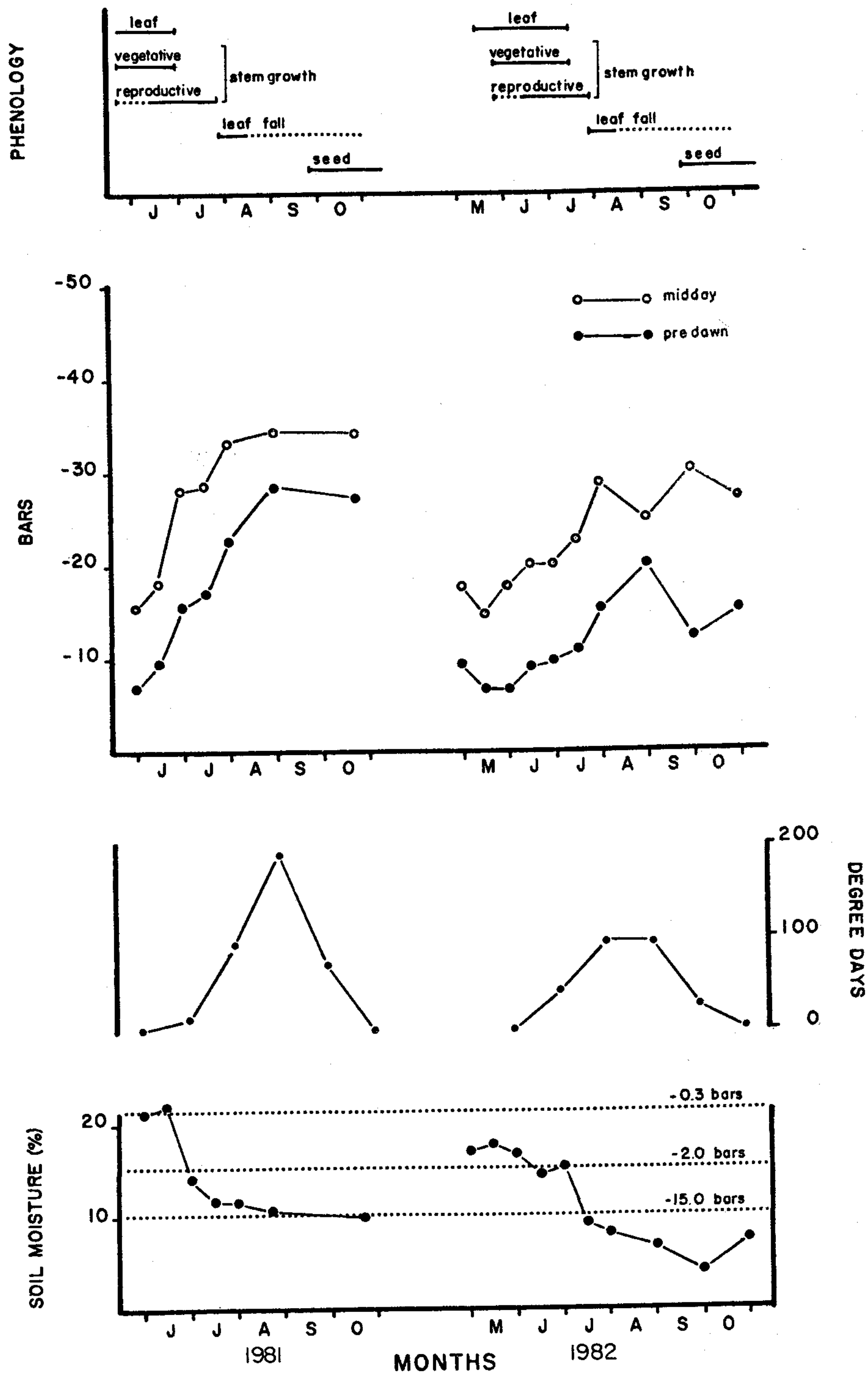

Figure 1. Phenology and xylem potential (bars) for Wyoming big sagebrush, and degree days and soil moisture on the site for the two growing seasons. For plant phenology (-----)reproductive stems could not be separated from vegetative stems and leaf fall minimal and restricted to ephemeral leaves.

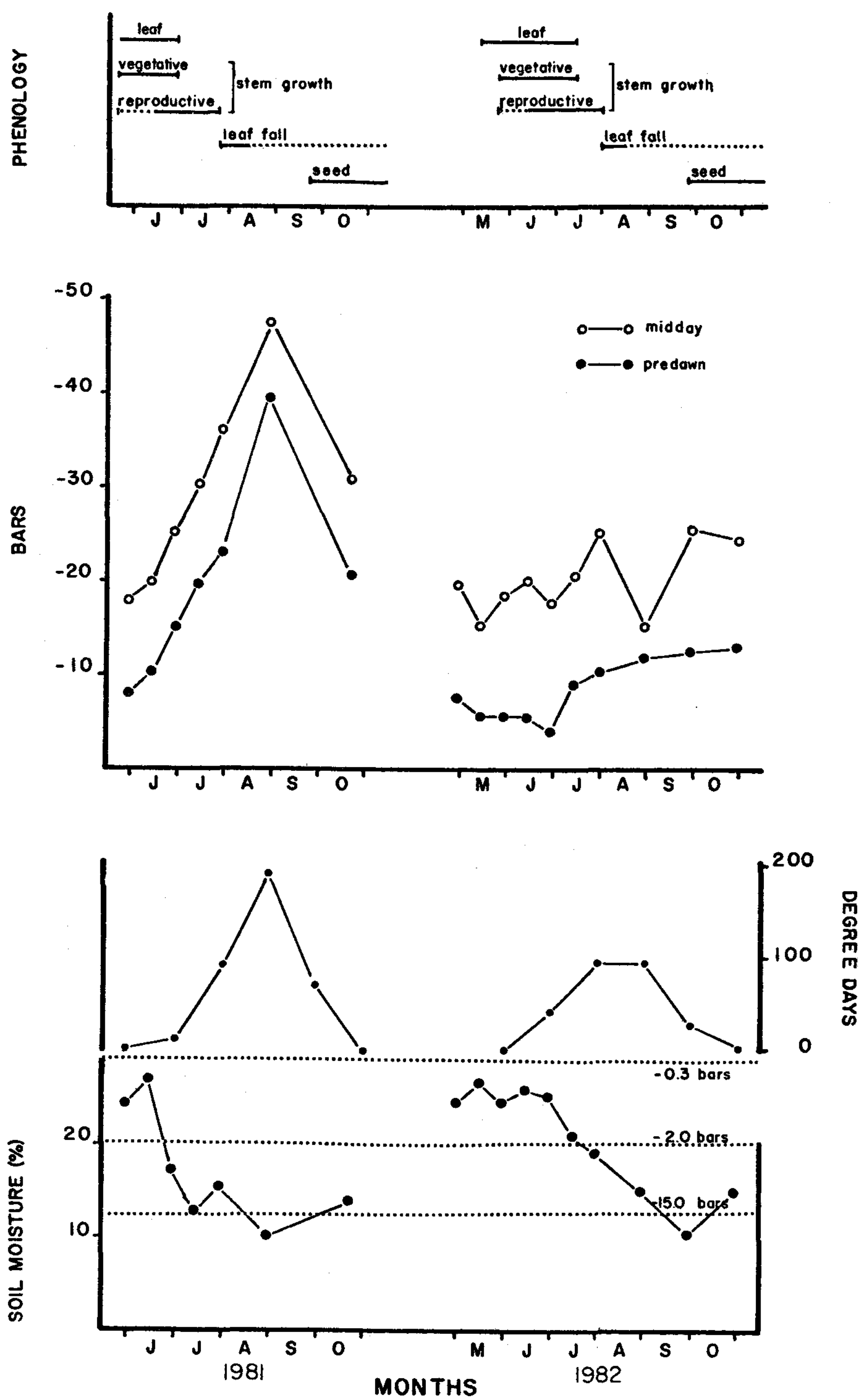

Figure 2. Phenology and xylem potential (bars) for basin big sagegrush, and degree days and soil moisture on the site for the two growing seasons. For plant phenology (----) reproductive stems could not be separated from vegetative stems and leaf fall minimal and restricted to ephemeral leaves.

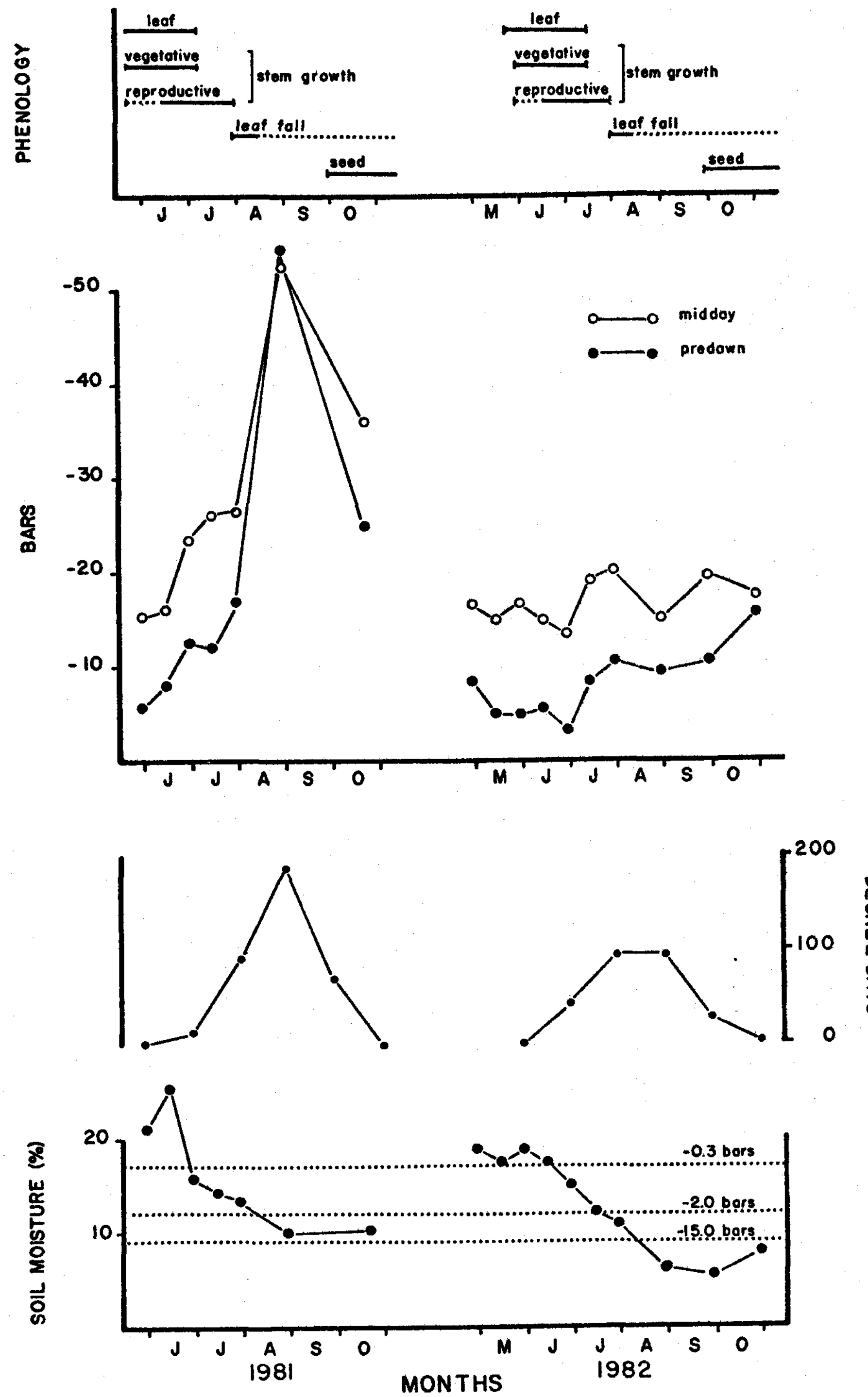

Figure 3. Phenology and xylem potential (bars) for mountain big sagebrush, and degree days and soil moisture on the site for the two growing seasons. For plant phenology (----) reproductive stems could not be separated from vegetative stems and leaf fall minimal and restricted to ephemeral leaves.

HOME RANGE SIZE AND HABITAT USE BY WILD HORSES

David C. Ganskopp and Martin Vavra[1]

Historically, management and development of much of our public rangeland have been single-use oriented. However, within approximately the last 15 years, federal legislation has mandated that public land management be shifted more toward optimum development of the land's many potentials. Management under this policy demands an intimate knowledge of an area's resources and an understanding of the requirements, utilization patterns, and impacts of the various users present on each piece of ground.

The federal protection granted wild horses (Equus caballus) in 1971 forced management agencies to assume responsibility for wild horses with only a scattering of information available for consideration in management and policy making. The Bureau of Land Management's Vale District was faced with this problem in the Three Fingers Rock area where cattle (Bos spp.), wild horses, mule deer (Odocoileus hemionus hemionus), and California bighorn sheep (Ovis canadensis californiana) have access to common grazing lands. This paper will review efforts to document wild horse home ranges and activities, as well as slope and water use patterns.

PROCEDURES

The study area is situated approximately 40 miles south of the town of Vale in southeast Oregon and borders the east bank of the Owyhee Reservoir. Total area was approximately 145 square miles and the area was divided into three pastures by fencing and natural boundaries. Wild horse home range estimates were based on repeated relocations of radio equipped or easily identified horses. A coordinate grid was superimposed on a map of the area and appropriate X and Y values recorded when animals were sighted. Resolution of the coordinate system placed animals in a 40 acre area. Home ranges were defined by constructing a 90 percent confidence ellipse about relocation points (Koeppl et al., 1975), thus enabling one to define the probability of finding an individual or group of animals in a given area (Harrson, 1958).

Simultaneous with animal relocations, data on activity and percent slope were noted. Horse watering patterns were monitored with time-lapse cameras placed over developed water holes. Slope availability data were derived from U.S. Geological Survey topographic maps. Horse watering patterns and slope use data were analyzed by Chi square procedures as outlined by Marcum and Loftsgaarden (1980).

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[1] This work was funded by the Bureau of Land Management and the Eastern Oregon Agricultural Research Center.

RESULTS AND DISCUSSION

Home range sizes were estimated for 14 bands and nine studs (Table 1). Average home range size was 10.91 square miles for bands and 9.95 square miles for studs, with no significant differences between the two.

Table 1. Number of relocations, span of months observed, and 90 percent confidence ellipse estimates of home range size for 14 bands and nine studs

	Number relocations	Number months observed	Ellipse areas (square miles)
Band			
A	56	23	6.55
B	30	17	4.35
C	24	20	5.15
D	17	19	5.44
E	14	19	6.02
F	16	19	5.02
G	18	18	5.13
H	23	22	6.16
K	15	7	4.54
K	10	15	28.11
L	23	23	20.87
N	15	15	23.43
P	10	17	17.70
S	14	14	14.29
Mean	20.4	17.7	10.91
Standard deviation			8.27
Stud			
1	49	22	7.84
2	47	21	8.51
5	29	24	8.91
6	11	3	3.14
8	13	22	10.25
11	17	22	14.70
12	16	22	12.80
26	14	20	5.78
28	10	17	17.65
Mean	22.9	19.2	9.95
Standard deviation			4.49

Horses did not appear to be confined by fences, as no home range encompassed the entire area within a pasture. With few exceptions, both bands and studs showed remarkable fidelity for their home ranges. No seasonal shifts in use areas were detected. Only one animal, a stud, appeared unwilling to settle in a defined area The home range estimate for this horse was 91.5 square miles. As this value seemed atypical, and inflated the mean substantially, it was dropped from the data summary.

One band and two studs made permanent shifts to new home ranges during midstudy. Band K moved approximately 5.3 miles south and east and established a new home range (K'). Two studs who were in an area by themselves moved into a pasture occupied by other horses and remained for the duration of the study. This was a move of about 3.0 miles.

Band and stud home ranges overlapped substantially on the area and in many cases were nearly superimposed. Harem studs defended a small perimeter in the immediate vicinity of their bands, but no territorial behavior was observed. Miller (1980) defined a horse herd which consisted of bands and studs having overlapping and similar movement patterns, intergroup recognition, and an intergroup dominance hierarchy. This concept appeared quite applicable on the area. Six herds were defined, and bands and studs making up each herd habitually remained within well defined areas with very few interherd exchanges or encounters occurring (Figure 1). Herd boundaries consisted of fences and major drainages, however, no physical restraints continuously impeded horse movements. Gates were often left open, and natural boundaries were quite passable. No horses were observed breaching or jumping fences even when left behind by other animals. Herd E utilized two pastures through gates which allowed a single water hole to service both pastures.

Horse watering activities were concentrated in the early and late hours of daylight. Only 20 percent of their watering efforts occurred during the central portions of the day. Generally, groups of horses moved rapidly to and from water and spent very little time lounging in the vicinity of water. Average time spent at water was 16.1 minutes, with drinking efforts averaging 6.3 minutes. No aggressive behavior by horses toward other species was observed at water or elsewhere on the area.

Daily horse activity patterns are depicted by Figure 2. Feeding efforts averaged 68 percent of their daylight activities. Three peaks of feeding: morning, midday, and evening. Feeding was most intense during evening, when 95 percent of the animals were involved. Resting averaged 18 percent of daylight activities and was most intense in early afternoon. Other activities, primarily traveling and drinking, accounted for an average of 14 percent of the day.

Horses on the area generally had an affinity for high benches and gently sloping ridgetops. The average grade for horse sightings was 11.2 percent. They favored slopes between 0 and 19 percent and showed no preference or avoidance for slopes in the 20 to 29 percent category (Table 2). Thirty percent or greater grades were avoided by horses, with the 50 to 59 percent category being the upper limit of use.

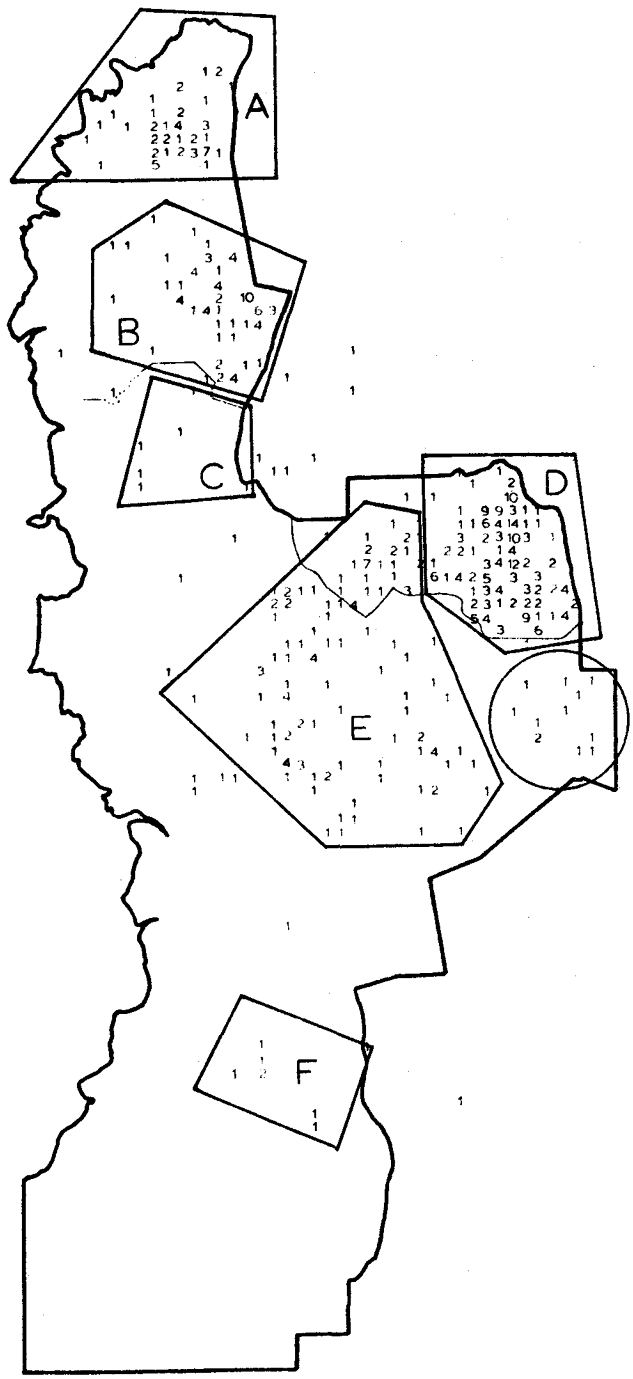

Figure 1. Distribution of six horse herds on the Three Fingers study area. The circled area designates relocations for two studs prior to a permanent move north into the next pasture. Approximate scale 1:253440.

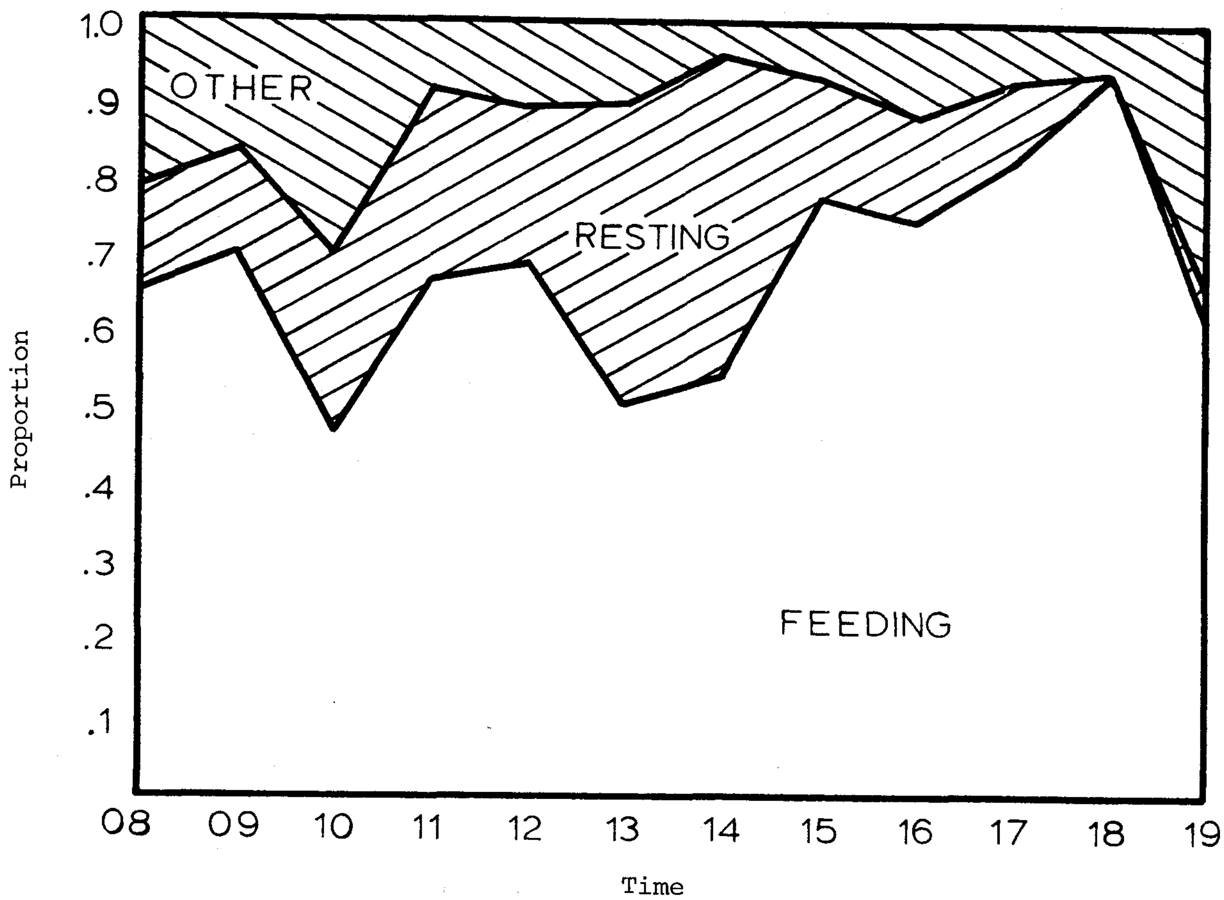

Figure 2. Daily horse activity patterns on the Three Fingers study area.

Table 2. Percent of study area and percent of horse observations falling in progressive 10 percent slope categories. The +, 0, and - preference ratings indicate significantly favored, no preference, and avoided categories, respectively (P<.02). N=394.

	Grade percent								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Study area percent	15.3	19.2	15.2	13.6	10.8	8.2	8.5	3.0	6.2
Horse obs. percent	42.9	36.0	14.2	3.6	2.3	1.0	0.0	0.0	0.0
Preference rating	+	+	0	-	-	-	-	-	-

CONCLUSIONS

Horses appeared to remain within relatively well-defined boundaries, with bands and studs having approximately equal-sized home ranges. Band and stud ranges overlapped and constituted herd units, which also tended to remain within well-defined boundaries. Should localized horse-related range management problems occur, removal of the offending animals or herd probably would rectify the problem for some years until immigration again repopulated the area. Standard four-wire stock fencing will contain horses if gates are kept closed. Horses watered primarily at dusk and dawn and rapidly vacated water sources when finished. No interspecific antagonism was observed at water and horses would not be expected to continuously occupy water unless large numbers were forced to use a single source. Horses favored relatively gentle slopes between 0 and 19 percent and avoided grades over 30 percent. Thus, one should not expect intensive horse use on relatively steep slopes.

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EFFECTS OF PRESCRIBED BURNING ON BOTTLEBRUSH SQUIRRELTAIL

Richard P. Young and Richard F. Miller

Bottlebrush squirreltail (Sitanion hystrix) is a short-lived, perennial bunchgrass found in most of the sagebrush-grasslands of central and eastern Oregon. An outstanding feature of this grass is its ability to become established and spread in poor condition rangelands. Squirreltail is probably our only native bunchgrass capable of natural establishment in stands of cheatgrass (Bromus tectorum) and medusahead (Taeniatherum asperum).

Fire is considered a natural component of many range ecosystems. In recent years some of the potential benefits of controlled burning have come to be recognized, and its use as a range improvement tool has increased considerably. A prerequisite to the successful use of prescribed fire is an understanding of the effects of fire on range plants. The purpose of this study, therefore, was to evaluate the response of bottlebrush squirreltail to a midsummer, prescribed burn.

METHODS

In July of 1980, the Burns District of the BLM conducted a prescribed burn over an area covered with a dense stand of cheatgrass. The site was seeded to crested wheatgrass (Agropyron desertorum) that fall. This area is typical of many eastern Oregon annual ranges in that squirreltail occurs scattered throughout the stand. Prior to the burn, 144 squirreltail plants were located, permanently marked, and measured so that we could calculate the basal area of each bunchgrass. Half of these plants were located in control areas to be protected from burning.

The burn was conducted under warm, dry conditions, and with light to moderate winds: 75-80°F, 16-25 percent relative humidity, 5-10 mph winds. Foliage of all the grasses were dry and fully cured at this time, and squirreltail plants were in a state of summer dormancy. In June of the following summer we relocated the marked squirreltail plants. The basal area of each was remeasured. In addition, we sampled a number of morphological and biomass features of the plants. The root and crown portions of each plant were removed and later chemically analyzed for total nonstructural carbohydrates (TNC). This allowed us to evaluate the effects of fire on squirreltail relative to the unburned control plants. Results were statistically analyzed using standard analysis of variance and Student's t test methods.

RESULTS AND DISCUSSION

One concern of prescribed burning is the potential of injury to bunchgrasses from excessive heat or burnout of portions of the crown. A comparison of individual plant basal areas from 1980 to 1981 showed the fire caused no damage to the squirreltail plants (no change was observed in the control plants).

Table 1 summarizes some of the measurements we obtained in 1981 for both the burned and unburned squirreltail plants. Results of statistical analyses of each plant characteristic indicate significantly larger values for burned plants. Production of burned plants exceeded that of the unburned controls both aboveground (5.6 times greater) and belowground (1.5 times greater). Shoot growth, therefore, was favored proportionally over growth of roots. In addition, both the numbers of seedheads produced and the average weight of seedheads were greater among burned plants (7.6 times and 1.7 times, respectively). Finally, reserve carbohydrates in roots and crowns of burned plants were 1.3 times that of unburned plants. Therefore, in all cases, burning resulted in increased productivity in squirreltail.

Table 1. Comparison of average values for some characteristics of burned and unburned squirreltail plants[1].

Plant characteristic	Burn	Unburned
Total aboveground weight (g/cm^2)	0.52	0.09
Root weight (g/cm^2)	0.36	0.24
Number of seedheads ($no./cm^2$)	2.14	0.28
Seedhead weight (g/head)	0.12	0.07
Total nonstructural carbohydrates (g/cm^2)	6.66	5.29

[1] To account for the various sizes of plants, all values have been standarized to a per-unit basal area basis, ie. measurements on each plant were divided by its basal area.

Past work with wildfires and artificial combustion chambers have shown that squirreltail is one of our more fire-tolerant bunchgrasses. This is attributed primarily to its growth form: Its loosely clustered, coarse stems, with a minimum of leafy material, burn rapidly with little heat transferred downward into the growing points. However, all previous work indicates at least some degree of damage to squirreltail as a result of burning. Recovery periods of 1-3 years after fire have been observed. Our results indicate that under conditions of a controlled burn, squirreltail is not necessarily damaged by fire; and, in fact, production may increase immediately following this treatment.

A plant's response to fire is the result of two interacting factors. The first deals with the direct effects of fire on the plant itself. In our study, the effects of fire on basal area of squirreltail was used to test for direct fire damage. Negative impacts were not observed. Fire indirectly affects a plant by altering its environment: It reduces or increases competition with neighboring plants, and thus affects the availability of water and nutrients, and it has the fertilizing effect of nutrient release. Our results show that, indirectly, this prescribed burn had a positive effect on production of squirreltail. This is likely explained, in part, by other changes we observed in the vegetation after the burn. Production of cheatgrass was similar for both the burned and unburned areas (999 pounds per acre versus 1008 pounds per acre). Cheatgrass density, however, was much less in the burn area (8 plants per square foot versus 166 plants per square foot). This resulted in fewer, but larger cheatgrass plants competing with the squirreltail bunchgrasses.

MANAGEMENT IMPLICATIONS

Bottlebrush squirreltail can be prescribe-burned with no damage to this bunchgrass. In this study, squirreltail production was increased manyfold one year after burning. Furthermore, the health and vigor of burned plants appeared to improve, as indicated by larger root systems and increased amounts of total nonstructural carbohydrates in roots and crowns. Greater numbers and weights of seedheads, and the reduced density of cheatgrass, indicate a potential to establish squirreltail seedlings after burning.

SHEEP AND TIMBER: ARE THEY COMPATIBLE?

W. C. Leininger and S. H. Sharrow

The Douglas-fir (Pseudotsuga menziesii) forests of western Oregon and Washington are among the most productive forests in the world. Following timber harvest, herbaceous and woody plants rapidly establish themselves and compete with planted crop trees for soil nutrients and light. In the past, foresters have mainly relied on phenoxy herbicides to control the competing vegetation. Due to increasing costs, and public concern over possible health risks associated with herbicides, silviculturists are becoming increasingly interested in the potential usefulness of sheep as a biological control agent for brush. Sheep grazing also offers the potential for increased red meat production and improvement of wildlife habitat.

Past research on sheep grazing in the Pacific Northwest has produced conflicting results. Some information indicates that controlled sheep grazing can increase soil moisture and enhance tree growth, while other data show high levels of browsing on young timber regeneration and, consequently, reduced growth rates.

A study was initiated in 1980 to evaluate the potential of using herded sheep as a silvicultural tool to suppress brush in Douglas-fir plantations. A major objective of this research was to determine methods of grazing clearcuts which are compatible with forestry objectives.

EXPERIMENTAL PROCEDURE

The study was conducted in the Coast Range approximately 10 miles west of Alsea, Oregon. Five clearcuts within the vine maple (Acer circinatum) - sword fern (Polystichum munitum) vegetation type were selected for observation. Included in the study were plantations which were three years old and forage-seeded with a mixture of grasses (GS1 and GS2), and five- to six-year-old plantations which had not been forage seeded (NS1, NS2, and NS3).

A 100-foot-by-100-foot livestock exclosure was established in each study clearcut to serve as an ungrazed reference area. Differences in standing crop of vegetation at the end of the growing season were determined by comparison of material harvested inside to material clipped outside the exclosure. Soil moisture inside the exclosure was compared to levels in grazed areas on sites NS1 and GS1 in mid-summer each year. The effects of sheep grazing on tree growth was evaluated by comparing yearly height and diameter growth for 100 permanently marked trees within the exclosure to those of 100 adjacent trees in the grazed region of the clearcut. Browsing and mechanical damage (trampling and debarking) to 150 permanently marked trees were visually assessed prior to and immediately after sheep grazed each study clearcut.

A band of 600 ewes and their lambs in 1981 and a band of 900 dry ewes in 1982 grazed the forest from May to September. Clearcuts GS1 and NS1 were grazed in the spring (May), GS2 and NS2 in the summer (July), and GS1 (regrazed) and NS3 in the late summer (August) each year.

RESULTS AND DISCUSSION

Heavy browsing of Douglas-fir regeneration was largely confined to the spring period when new, soft needles were present (Table 1). Spring-grazed clearcuts (NS1 and NS2) showed obvious browsing with 13 to 44 percent of all new conifer growth being consumed by the sheep. High levels of forage utilization on both plantations undoubtedly contributed to the amount of tree browsing observed.

In contrast to the spring period, little browsing of Douglas-fir occurred during the summer through fall periods. An exception to this was on GS1 where a new flush of growth from secondary bud break coincided with a second grazing period, producing conditions similar to those encountered in the spring. When Douglas-fir was browsed by sheep in the summer, use was generally confined to nipping one or two small lateral branchlets on the browsed trees. This pattern of use often resulted in the apparent severity of damage being greatly overstated by the percent of trees browsed (Table 1). The actual amount of browsing which occurred on Douglas-fir trees during the summer period was so light as to be detectable only by careful examination.

No effects of sheep grazing on height growth of Douglas-fir trees was evident on sites GS2, NS1, NS2, and NS3 (Table 2). Trees on grazed plantations, however, had diameter growth which ranged from 7 to 14 percent greater than that of trees in ungrazed control areas. Failure of tree growth to be reduced by loss of as much as 13 percent of current year's foliage growth (NS1) indicated that, while browsing of terminal leaders may reduce height growth, moderate browsing of lateral branches alone is unlikely to adversely affect tree growth.

Repeated, severe browsing of young trees may reduce their growth, especially if terminal leaders are consumed. This occurred on GS1, where two periods of heavy grazing in both 1981 and 1982 resulted in consumption of approximately 65 percent of current year's foliage growth together with extensive use of terminal leaders each year. Tree height growth was reduced by 51 percent, and 24.9 percent less diameter increase was recorded for grazed compared to ungrazed trees in GS1. The long-term effects of such growth losses are unclear.

Table 1. Percent of Douglas-fir trees damaged as a result of sheep grazing, height of trees, and utilization of ground vegetation by sheep on five study clearcuts in 1981 and 1982.

Item	NS1	GS1 Spring	NS2	GS2	GS1 Summer	NS3
	Study clearcuts					
1981						
Terminals browsed (%)	5	59	0	2	--	0
Laterals browsed (%)	75	98	37	11	--	12
Mechanical damage (%)	2	3	5	1	--	2
Douglas-fir CYG consumed (%)+	13	41	2	1	--	1
Ground vegetation CYG consumed (%)+	65	67	57	37	--	40
Average Douglas-fir height (ft)	5.4	2.3	9.7	3.1		10.1
1982						
Terminals browsed (%)	0	70	0	1	58	0
Laterals browsed (%)	87	100	14	21	87	50
Mechanical damage (%)	1	1	1	0	2	0
Douglas-fir CYG consumed (%)+	18	44	1	2	19	3
Ground vegetation CYG consumed (%)+	59	36	26	44	35	24
Average Douglas-fir height (ft)	7.5	2.7	12.3	4.3	3.1	13.0

+ CYG is current year's growth within the reach of sheep (4.9 ft above the soil surface).

Table 2. Diameter growth and height growth of Douglas-fir trees from grazed (G) and ungrazed (U) portions of five study clearcuts during the 1981-82 growing season.

Clearcut	Diameter (in)		Height (in)	
	G	U	G	U
GS1	0.17**	0.22	4.3	8.9**
GS2	0.29	0.27	15.0	16.3
NS1	0.53*	0.51	27.1	28.1
NS2	0.68*	0.60	41.2	41.3
NS3	0.70**	0.61	36.4	89.9

*, ** Grazed differs from ungrazed $P < .05$, $P < .01$, respectively.

Mean standing crop of brush species at the end of the growing season in October each year was consistently higher on ungrazed compared to grazed plots (Table 3) regardless of season of grazing use. Biomass of vine maple, one of the principal target species, was reduced 57, 88, and 67 percent on units NS1, NS2, and NS3, respectively, as a result of grazing in 1981. These data suggest that brush suppression was occurring. Target brush species such as vine maple, salmonberry (*Rubus spectabilis*), and thimbleberry (*Rubus parviflorus*) did not regrow substantially following defoliation even when grazed early in the spring.

Table 3. Mean standing current year's growth of browse (lbs/acre) on grazed (G) and ungrazed (U) treatments in 1981 and 1982.

Clearcut	Year			
	1981		1982	
	G	U	G	U
GS1	210	270	280*	450
GS2	330	450	600	700
NS1	230**	950	610**	1640
NS2	180	290	200*	370
NS3	460	730	150*	330

**, * Grazed less than ungrazed $P < .01$, $P < .05$, respectively.

Defoliation of ground vegetation by sheep apparently reduced soil moisture withdrawal by the deeply rooted brush species, while stimulating regrowth, and therefore soil moisture use, by herbaceous plants. Spring-grazed plantations had similar or slightly less soil moisture in the upper two feet of soil, but more soil moisture below two feet, than did the controls in August each year.

In addition to suppressing competing vegetation, sheep grazing may enhance tree growth by increasing the effective fertility of a site. The amount of nitrogen consumed by sheep was estimated for each clearcut in 1981 by multiplying the amount of forage consumed by its percent nitrogen content. This was done for each major plant species and the resulting values were summed to get a total for each clearcut. Estimates were 17, 21, 11, 10, and 10 lbs per acre of nitrogen consumed by sheep for clearcuts NS1, GS1, NS2, GS2, and NS3, respectively. The majority of nitrogen consumed will pass through the animal and will be excreted in the clearcut as urine. Urine nitrogen, because of its solubility in water, is readily available to plants. The resulting increase in nitrogen fertility is equivalent to application of about 80 lbs per acre of ammonium sulfate to spring-grazed plantations and 50 lbs per acre of ammonium sulfate to summer-grazed clearcuts.

MANAGEMENT IMPLICATIONS

Our observations suggest that sheep may be successfully employed as a silvicultural tool to suppress the growth of brush in Douglas-fir plantations. When proper season and degree of use are observed, growth of the tree crop may be enhanced by grazing. Brush suppression is more easily achieved in the summer through fall period than it is during the spring. Relative palatability of Douglas-fir to sheep and, therefore, potential for tree damage are greatest in the spring following bud break. Proper livestock management, including careful selection of bedding grounds and light to moderate use of forage plants (less than 35 percent utilization), should allow even young plantations to be safely grazed in the spring. Unfortunately, the relatively high levels of utilization which will force sheep to consume substantial amounts of brush in the spring also will result in considerable use of Douglas-fir new growth. Once needles have matured, Douglas-fir is not readily eaten by sheep. In addition, as herbaceous plants mature in late spring, sheep were observed to more readily consume browse. Greater inclination of sheep to accept browse, together with the relatively high grazing pressures which may be safely applied to plantations in the summer, make it an attractive season to manage livestock for brush suppression.

Information gathered to date indicates that a grazing system employing light to moderate utilization of clearcuts in the spring by either dry ewes or ewes with 12-plus-week-old lambs, followed by heavy utilization of units targeted for brush reduction in the summer through fall period, should provide both brush suppression and acceptable levels of animal production. Damage to Douglas-fir trees under this system should be minimal.

EFFECT OF SHEEP GRAZING ON BIG GAME HABITAT IN OREGON'S COAST RANGE

B. D. Rhodes and S. H. Sharrow

Forests within the Coast Range of western Oregon are known for their tremendous biotic productivity. These forests form some of the highest timber-producing areas in the world. Following harvesting of a tree crop, large amounts of herbaceous and shrubby vegetation, while providing soil stabilization and wildlife habitat, are generally considered detrimental to the regeneration of commercially valuable trees. Sheep grazing on Douglas fir (*Pseudotsuga menziesii*) plantations has been proposed as a means to suppress unwanted vegetation, while simultaneously providing a resource base on which red meat can be produced.

Oregon's Coast Range also supports large populations of black-tailed deer (*Odocoileus hemionus columbianus*) and Roosevelt elk (*Cervus canadensis roosevelti*). Plantations within the forests provide frequent and important feeding grounds for these two species. Therefore, a reduction in the quantity of forage and/or alteration of forage quality could have significant impacts on the value of these areas as big game habitat. The objective of this study was to evaluate the effect of sheep grazing on big game habitat in Oregon's Coast Range.

EXPERIMENTAL PROCEDURES

The study area is located on the Alsea Ranger District, Siuslaw National Forest, approximately 10 miles west of Alsea, Oregon. Elevations range from 500 to 1500 feet. The area receives approximately 100 inches of precipitation annually.

Five plantations were chosen for study. Douglas-fir seedlings on the plantations ranged from three to six years old. Before grazing began, a 100-foot-by-100-foot exclosure was constructed on each plantation. This allowed comparisons and observations to be made on adjacent areas which were grazed and ungrazed.

Bands of approximately 600 ewes with lambs and 900 dry ewes grazed the forest in 1981 and 1982, respectively. The sheep were on the forest from May to September both years. Each season, a series of approximately 40 plantations were grazed according to a predetermined schedule. Within this schedule, study plantations were grazed once each year, with the exception of one plantation which was grazed twice each year.

Two sampling periods, October and March, were chosen as important times of evaluation. Vegetational biomass was estimated by clipping current year's growth within randomly selected 4.8 ft^2 plots, both inside and outside the exclosures. From each study plantation, selected forage species were collected, dried and ground for forage quality determinations. The ground samples were analyzed for percent crude protein and *in vitro* dry matter digestibility (IVDMD). Data presented in Tables 1 and 2 represent means across all five study plantations.

RESULTS AND DISCUSSION

In general, sheep grazing reduced October standing crop (Table 1). However, in March, there was generally more standing crop in the grazed areas than in the ungrazed areas. This was especially true of herbaceous vegetation.

Table 1. Mean standing crop (lbs/ac) from grazed (G) and ungrazed (U) areas, and the difference between them (D).

	Plant Type								
	Herbaceous			Browse			Total		
Date	G	U	D	G	U	D	G	U	D
Oct. 1981	660	1111	451	318	572	254	978	1683	705
March 1982	455	354	101	43	33	10	498	387	111
Oct. 1982	1044	288	434	434	834	400	1190	1878	688

In both years, the effect of grazing on IVDMD of species collected in October seemed to be more pronounced in herbaceous species than in browse species (Table 2). In general, herbaceous plants from grazed areas had higher IVDMD values than plants from ungrazed areas. Browse species tended not to change in IVDMD in response to grazing either year. There appeared to be no meaningful trends in differences in IVDMD between plants from grazed areas versus plants from ungrazed areas in March.

The effect of grazing on levels of crude protein in herbaceous species collected in October was similar to that for IVDMD (Table 2). Most species from grazed areas had higher crude protein values than samples from ungrazed areas, both in 1981 and 1982. Browse species which were grazed also tended to have higher levels of crude protein than those which were not grazed. The trend of crude protein levels of samples collected in March was similar to that for IVDMD in that there were no consistent differences between plants from grazed areas and plants from ungrazed areas.

Table 2. Mean percent crude protein (CP) and percent *in vitro* dry matter digestibility (IVDMD) of selected forage species.

Date	Species	CP		IVDMD	
		G	U	G	U
Oct. 1981	Herbaceous:				
	bentgrass	8.0	4.3	45	27
	pearly everlasting	9.4	5.5	44	26
	velvetgrass	7.1	5.2	41	28
	Browse:				
	vine maple	7.4	5.1	43	35
	thimbleberry	8.1	7.8	36	35
	salmonberry	9.0	8.3	34	33
March 1981	Herbaceous:				
	bentgrass	17.6	18.0	69	76
	pearly everlasting	21.9	20.0	65	59
	velvetgrass	16.5	16.0	69	71
	Browse:				
	vine maple	--	--	--	--
	thimbleberry	22.5	25.2	47	47
Oct. 1982	Herbaceous:				
	bentgrass	11.6	4.3	52	37
	pearly everlasting	11.4	5.8	42	30
	velvetgrass	11.3	7.8	54	43
	Browse:				
	vine maple	7.6	6.0	34	35
	thimbleberry	9.0	8.2	31	33
	salmonberry	8.6	6.9	24	23

These data suggest that sheep grazing can improve big game habitat in the Coast Range. Though grazing in the spring and summer tends to reduce total forage biomass present in autumn, it increases forage quality. Winter diets of deer in the Coast Range are probably deficient, not in forage quantity, but in forage quality. Forage must be approximately 7 to 10 percent crude protein during the winter in order to meet the nutritional needs of black-tailed deer. Many of the ungrazed plants collected in October would barely meet this minimum criterion. However, higher crude protein values observed for plants from grazed areas should assist animals in selecting a diet which more nearly meets their minimum nutritional needs. Similarly, higher IVDMD of grazed plants should help deer and elk meet their energy requirements.

Grazing also appears to enhance big game habitat in the spring. At this time, most of the forage present on the forest is past year's growth and is of very low quality. However, new growth which occurs in the spring is of high quality in terms of both digestibility and crude protein. Our data suggest that in March there is more high quality forage in the grazed areas than in the ungrazed areas. This was especially evident in herbaceous vegetation, an important component in the diets of deer and elk at this time of the year.

CONCLUSIONS

These data suggest that sheep grazing can increase the amount of high quality forage available to big game during the critical fall through early spring period in the Coast Range. If quality rather than quantity of forage determines the nutritional status of big game animals in the Coast Range, then sheep grazing should improve big game habitat in this area.

SOME ECOLOGICAL ATTRIBUTES OF WESTERN JUNIPER

L. E. Eddleman

Western juniper (Juniperus occidentalis ssp. occidentalis) is a long-lived short to medium height tree present in almost all eastern Oregon counties. The center of its distribution and largest continuous expanse is in the central part of the state. Estimates of aerial extent range from 1,773,000 acres to more than 2,816,000 acres.

Since the turn of the century, western juniper has been actively invading previously unoccupied rangelands in central and eastern Oregon and although the rate of expansion has not been determined, the present area may be as much as double that present in the late 1800's. Expansion is usually attributed individually to reduce fire frequency, climatic changes, heavy grazing or to some combination of the three.

Increasing juniper density and size has the apparent effect of reducing understory plant cover and productivity, with forage grasses being most severely reduced. Also, water infiltration rates are reduced while sediment yield is increased. Understory plants may be negatively affected by juniper induced reduction in light, soil moisture, and soil nutrients and by allelopathic factors (plant toxins) in juniper litter and root exudates.

Research on the western juniper type has not been extensive. Available data do not provide adequate guidelines for control or management. Therefore, during the summer of 1982 studies were begun on the biology and ecology of western juniper. Long term objectives are to determine geographic distribution of invasion stands, magnitude of spread and site conditions conducive to invasion. Current primary effort is centered southeast of Prineville in Crook County where site-specific effects of juniper on associated vegetation and soils are under investigation.

PROCEDURE

Several sites have been selected in the Comb's Flat area and adjacent slopes for measuring relationships of tree density and size to understory vegetation patterns. Particular emphasis is being placed on forage plants. Understory plant cover and productivity are being determined from belt transects which radiate out from tree boles. Tree measurements include age, height, canopy spread, and distance from other trees. Attributes of the physical environment being measured include precipitation, soil moisture, temperature, and light.

Paired areas are being selected, one of which is to be cleared of juniper trees after completing tree measurements. In cleared areas understory plant response to tree removal will be measured and compared to uncleared areas. Measurements will be similar to those used on the uncleared plots.

Western juniper litterfall exceeds decomposition. Therefore, a buildup of leaves and twigs in various stages of decay is evident beneath the canopy. Roots extend well beyond the canopy; however, depth and distance of spread is not known. These roots may be removing minerals from the open areas between canopies and concentrating them within the tree. Litter which is composed of leaves and small twigs transfer some of these minerals to the soil surface beneath the canopy.

The possibility of nutrient impoverishment in the interspaces and nutrient enrichment beneath the tree is being studied by nutrient analyses of soils from these areas and by measuring plant growth response of the same soils in greenhouse experiments. Leachate obtained from the litter fraction is being used to water some of the plants for evaluating the presence of water soluble phytotoxic compounds.

RESULTS

Research just began in the summer of 1982. However, certain aspects provide insight into western juniper ecology.

Distinct vegetation zones appear about the bole of western juniper trees. Larger trees, more than 70 years of age, generally have a bare zone next to the bole followed by an outer bunchgrass zone. Some trees, however, have a cheatgrass (Bromus tectorum) zone inside that of bunchgrass and an outer zone from which larger bunchgrasses are absent. Vegetation beyond the canopy edge is usually quite different from that beneath the canopy. Frequently, plant species are different under the southwest portion of the canopy as compared to those under the northeast portion of the canopy.

Rain gauges located between and beneath tree canopies indicate that the canopies of larger trees intercept nearly 74 percent of the precipitation. Rainfall at Comb's Flat totaled 14.3 inches from October 1, 1982, to April 29, 1983. Beneath juniper canopies only 3.6 inches reached the surface. In particular, the litter surface on the northeast side of the tree received the least moisture. Only 1.3 inches of precipitation were measured in this quadrant for the above period; indeed, for several months the northeast canopy segment appeared to intercept 98 to 100 percent of the total rainfall.

Maximum juniper canopy cover encountered on the areas examined was 38 percent and the maximum number of stems per acre was 283. Forage plants present beneath the juniper canopy are not readily available to the grazing animal and, although not all such forage is unavailable, a 38 percent canopy cover would represent a sizable loss of grazable area for livestock. If, in addition, the canopy intercepts 74 percent of the rainfall, then a 38 percent canopy cover could reduce rainfall reaching the soil surface on each acre by as much as 28 percent. This latter value is an overestimate due to unaccounted for stem flow of rainfall and also due to many canopies being of less height than those under which interception was measured.

Areas under study have been invaded by juniper during the last 100 years. The mean age of juniper trees on the lower slopes was 43 years, while that of the upper slope was 64 years. Plots in the lower flat indicate that more than 80 percent of the trees became established between 1935 and 1950, while on the upper slopes more than 70 percent became established between 1908 and 1925.

Average height growth of the older trees (60-70 years old) was four inches per year, and these had an average bole diameter growth of 0.16 inches per year. Dominant and unsuppressed trees in the stand did not grow any faster in height but did increase their bole diameter as much as 0.6 inches per year. Individuals which appeared late in the invasion phase exhibited suppression by larger, older trees. Height growth for these younger trees frequently was less than one inch per year, and bole diameter growth was less than 0.03 inches per year.

SUMMARY

Impacts of western juniper appear evident since the trees markedly change patterns of vegetation and moisture at the ground surface. Research is to continue on nutrient redistribution, magnitude of forage loss, juniper root development, soil moisture use patterns, and several biological aspects such as phenology, sex development in invading stands, and physiology.

SOIL INGESTION BY UNGULATES GRAZING A SAGEBRUSH-BUNCHGRASS RANGE IN EASTERN OREGON

Forrest A. Sneva, H. F. Mayland, and M. Vavra

Ingested soil by the grazing animal not only contributes to the wear of the animal's teeth, but may also be a source of dietary minerals. Thus, an estimate of soil intake is a necessary factor in the determination of the amount of minerals entering the animal via the soil.

Titanium (Ti), a rare earth element, is relatively abundant in soils, but is found only in small quantities (1 part per million) in plants not contaminated with soil (Healy, 1968). Thus, its presence in the feces of grazing animals is a reflection of: (1) eating soil-contaminated forage; (2) ingesting soil directly; (3) drinking soil-contaminated water. Mayland et al. (1975) investigated the Ti method in Idaho and found it useful for estimating soil ingestion by cattle grazing a semiarid range. Recently, Mayland and Sneva (in press) discuss the Ti method's usefulness to range investigations.

This paper presents Ti values determined in the soil and in feces of five ungulates grazing a sagebrush-bunchgrass range over a two-year period. From those findings the annual mean soil intake per ungulate was estimated and discussed relative to the variability in the data.

PROCEDURE

Sagehen Summit, an elevated plateau of about 65 square miles, lies about 4,501 feet above sea level 13 miles west of Burns, Oregon. It is a mule deer winter range which is also grazed by sheep and cattle in spring, summer, and fall under a Bureau of Land Management permit. It is also grazed all year by about 200 antelope and 25 to 35 wild horses.

Vegetation on the plateau is a mosaic of western juniper (*Juniperus occidentalis*), big and low sagebrush (*Artemisia tridentata* and *arbuscula*), rabbitbrush (*Chrysothamnus* spp.), and bitterbrush (*Purshia tridentata*). The associated grasses are bluebunch wheatgrass (*Agropyron spicatum*), needlegrass (*Stipa* spp.), bottlebrush squirreltail (*Sitanion hystrix*), Idaho fescue (*Festuca idahoensis*), Junegrass (*Koeleria cristata*), and bluegrass (*Poa sandbergii* and *cusikii*). Broadleaf plants contribute less than 10 percent of the total understory and are dominated by the phloxes (*Phlox* spp.) and locoweeds (*Astragalus* spp.). Cheatgrass (*Bromus tectorum*) is present in some areas.

Fecal samples were collected periodically over the two-year period from May 1975 to April 1977. Animals first were located and observed in the field and the area then was searched for fresh feces. The goal was to obtain five fecal samples from each animal class per date, but this was not always achieved. Field sampling attempted to minimize obtaining soil contaminated feces. Samples were immediately frozen and stored in a freezer until analyzed.

Soil samples from the surface two inches were taken in four locations to provide an estimate of soil Ti concentration. Preparation of soil and feces for subsequent colormetric determination of Ti followed that described by Mayland et al. (1975).

RESULTS AND DISCUSSION

Titanium concentration was 5,300, 5,900, 9,400, and 13,900 parts per million (ppm) for soil associated with low sagebrush, big sagebrush, rabbitbrush and buckwheat (Eriogonum) sites, respectively. Such a wide range in Ti concentration was unexpected and created difficulty in interpreting results. The mean of those values, 8,525 ppm, was used in subsequent computations; but the reader is cautioned that the Ti concentrations varied greatly and computed results could be from 62 percent less to 58 percent more than the concentrations estimated from the mean.

Mean Ti concentration in the feces by animal species per sampling date is presented in Table 1. Fecal samples visually observed to be contaminated with soil at time of sample preparation in the laboratory were so noted--all had exceedingly high Ti values and were excluded from the data presented in Table 1. Six percent of the 232 samples were so excluded. Standard errors averaged 48, 23, 31, and 38 percent of the mean for mule deer, antelope, cattle, and horses, respectively. Tests to determine significant mean differences between and among animal species on dates on raw or on transformed data all produced nonsignificant differences. This is not surprising in light of Ti variability encountered in the soil and feces. Also, because of complex patterning of the soil-vegetation type, the free-roaming nature of the animals, and the delayed time interval between foraging and defecation, the opportunity for variability is great. Thus, we were hampered statistically in discussing Table 1; yet, there were some overall trends, differences, and incidences which can be pointed out and perhaps are real.

Mule deer feces had the lowest Ti concentrations, averaging 442 ppm. Forage selectivity by deer was strongly oriented towards sagebrush, juniper, and bitterbrush, which all present an elevated browsing surface, thereby minimizing soil contamination except for dust via air turbulence. Most deer samples were from late fall, winter, and spring periods when soil surfaces were most apt to be moist or snow-covered, further minimizing soil contamination. Elevated Ti values in deer feces in February, March, April and December of 1976 were associated with increased intake of Sandberg bluegrass and fall germinated cheatgrass. Both grasses are low-growing and grazing them would increase the susceptability to soil intake.

Sheep grazed the area for only a short time in the spring of each year. Diets were primarily the large bunchgrasses. Mean Ti concentration of 702 ppm was similar to that for cattle (720 ppm), which selected similar forage for those months.

Titanium levels in cattle feces from March through December varied from 390 to 1721 and averaged 879 ppm. Cattle diets consistently contained 95 percent or more of the dominant bunchgrasses. Variation among dates is not readily explained. Direct soil contamination should have been minimal, as the sample was spooned from the center of the pat. Differences may be the result of Ti level in soil relative to where the animal was grazing, or intake of soil through drinking of muddied surface water.

Table 1. Concentrations of Ti in feces of ungulates grazing sagebrush-bunchgrass range (means of 2 to 5 samples/date[1].

	Cattle	Horse	Mule deer	Antelope	Sheep	Surface condition
			ppm			
May 1975	716[4]	-	-	688[2]	-	dry
June 1975	390	339	212	353	239	dry
Aug. 1975	739[3]	690[4]	-	673[3]	-	dry
Sept. 1975	-	-	122	491[2]	-	dry
Nov. 1975	-	-	-	478	-	dry
Jan. 1976	-	108[2]	337	305[4]	-	5-12 inches snow
Feb. 1976	-	1279	611[4]	-	-	freewater surface
Mar. 1976	-	1128	841	631	-	moist to muddy
April 1976	576	2029[4]	618[2]	2230[4]	936	dry
May 1976	1497	1389	-	2633[2]	700[3]	dry
June 1976	415[2]	846[3]	-	532[2]	758[4]	dry
Aug. 1976	1721	1827	-	1880	-	dry
Sept. 1976	1197	1174[4]	-	-	-	dry
Dec. 1976	796	982	762	1134	-	dry
Jan. 1977	-	1204	286[4]	-	-	4-5 inches snow
Mar. 1977	-	1451[4]	227	610	-	moist to muddy
April 1977	747	1137	405[3]	875[2]	-	dry
Mean	879	1113	442	965	702	

[1] Superscripts denote number of individual samples comprising the mean . No superscript denotes 5 sample/mean.

Antelope feces exhibited the widest range of Ti concentration, ranging from 305 to 2,633 and averaging 964 ppm. These estimates may be biased because (1) antelope tended to be most often observed in the buckwheat and rabbitbrush sites which had the highest Ti concentrations in the soil, and (2) it was most difficult to obtain feces from antelope that were not directly contaminated by soil particles. Antelope, like deer, browsed primarily on sagebrush, juniper, and bitterbrush except in early spring when Sandberg bluegrass and forbs made up 50 percent of their diet, and in late fall when that grass and the major bunchgrasses contributed significantly to their diet. Generally, spring and fall samples showed elevated Ti concentrations.

Horse feces contained the highest mean Ti, 1,113 ppm, and ranged among dates from 339 to 2,029 ppm. Forage selected by horses was nearly 100 percent from the major bunchgrasses. The higher concentration of Ti in horse feces compared to cattle feces is perhaps best explain by differences in foraging habit. The horse rolls his lips back and bites the forage off, whereas the bovine wraps the tongue around the forage, binds the forage between teeth and pad, and then tears the forage loose. The horse is apt to have direct soil contact around the grass clump.

Annual amounts of soil ingested by cattle, horses, mule deer, and antelope are shown in Table 2. Mean body weights are those commonly used by management agencies in Oregon. Daily forage intake was computed as 2.5 percent per 100 pounds of live body weight. Sixty percent dry matter digestibility was utilized throughout. Mean fecal Ti are those recorded in Table 1. Calculations for total Ti amount followed procedures set forth by Mayland et. al. (1975) with total soil ingestion adjusted by the mean soil Ti concentration of 8,525 ppm.

Table 2. Soil intake estimates for ungulates grazing a sagebrush-bunchgrass range

Species	Body weight[1]	Forage intake[2]	Fecal Ti[3]	Soil intake[4] lbs/yr
	lbs	lbs/day	ppm	
Cattle	1000.9	25.0	879	458.6
Horse	1000.9	25.0	1113	526.5
Antelope	100.0	2.5	965	37.5
Deer	109.1	2.7	442	6.6

[1] Mean body weights commonly used.

[2] Computed as 2.5% of mean body weight.

[3] Obtained from Table 1.

[4] Determined by computation using 60% dry matter digestion and 8525 ppm soil Ti.

The annual soil intake of 458 pounds by cattle is approximately 2.9 pounds per day. This mean is about two times the median value reported by Mayland et al. (1975) and is also higher than reported by Healy (1973). Mean body weight used herein is higher than that reported by Mayland et al. (1975) and the forage intake is also higher; thus, some of the difference is explained. However, Mayland et al. (1975) reported very high concentrations of soil due to root pull-up by cheatgrass. Such was probably not a factor in this study, as cheatgrass was only a minor part of cattle diets and pull-up is not a problem with the bunchgrasses.

The estimate of 566 pounds per year for horses is probably conservative, as it is generally recognized that they are "hay burners" and estimates of 2.5 percent body weight for daily intake, and a 60 percent digestion value, may be too low for intake and too high for digestibility.

Because the mean body weights of antelope and mule deer are about one-tenth that used for cattle and horses, the soil intakes are considerably lower. However, only that of deer are notably lower when compared on a per-unit-of-body-weight basis. Part of the difference may be because mule deer samples are primarily from the fall-winter and early spring versus a season-long sample period for antelope.

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DIURNAL VARIATION OF NITROGEN IN FLOOD MEADOW VEGETATION

Forrest A. Sneva

Nitrogen is a primary dietary nutrient of forage. Past research has shown that crude protein concentration in flood meadow vegetation declines about one-half of a percent per week after it reaches its peak (generally in late June or early July). We have not previously looked at the nitrogen trend throughout a day's time. If such a trend is present, then the time of cutting for hay or the time of application (within a day) of a chemical such as paraquat may have an influence on the level of crude protein in the hay. This is particularly true if the chemical is either enhanced or degraded in activity by darkness or light, such as is the case with paraquat.

This study reports the nitrogen levels of three flood meadow vegetation types when sampled up to seven times during the daylight hours.

PROCEDURES

Plots were established in (1) a pure _Juncus_ ssp., (2) _Carex_ ssp. - _Poa_ spp., and (3) a _Carex_ spp. - _Elymus_ spp. site. In the first two named sites the vegetation was sampled from 0400 to 2200 hours at three-hour intervals. In the latter named site samples were taken at 0700, 1300, and 1900 hours. At each time of harvest, an area of 7.9 by 19.7 inches was clipped, dried at 120°F, ground through a Wiley mill, and subsequently analyzed for nitrogen concentration. Each site study was conducted with plots allocated completely at random, with 5 to 8 replications harvested on July 13 and 14, 1978.

RESULTS AND DISCUSSION

There were no significant fluctuations of nitrogen throughout the time of 0400 to 2200 hours in this study. Nitrogen means averaged 1.16, 1.10 and 1.18, respectively, for the pure _Juncus_, the _Carex-Poa_, and the _Carex-Elymus_ site. Their respective standard errors were 0.02, 0.04, and 0.01 percent.

It is inferred from this that the nitrogen concentration of meadow vegetation throughout the daylight hours is not a significant factor that would interact with the time of cutting the vegetation or the application of chemicals for the preservation of the vegetation.

RESPONSES OF HERBACEOUS VEGETATION, PLANTED TREES AND CATTLE ON A FOREST PLANTATION

W. C. Krueger and M. Vavra

This is a synthesis of information collected on a mixed coniferous forest on the Hall Ranch that was clearcut in 1963 and has been managed for production of cattle and a timber crop, with ancillary wildlife uses, since the initial harvest. The study was implemented to quantify changes in vegetation with successional growth of the plantation and responses of trees and cattle over time. In the last 20 years the plantation has progressed to a point where competition between forages and timber is reducing yield, and the plantation is now being thinned to maintain the forage crop and enhance growth of individual trees.

EXPERIMENTAL METHODS

Through the course of study the area was classified as a mosaic of vegetation types, with the upslope representing a Douglas-fir/ninebark (*Pseudotsuga menziesii*/*Physocarpus malvaceous*) habitat type and the toe slope representing a grand fir/mountain lover (*Abies grandis*/*Pachistima myrsinites*) habitat type. The area was clearcut in 1963, broadcast burned in 1964, and seeded to a forage mixture with appropriate controls in the fall of 1964. Trees were planted in spring of 1965 and grazing at 1.3 acres per animal unit month was begun in summer, 1966.

Through the course of the study, understory vegetation was measured for frequency utilization and yield, trees were measured for survival and height growth, and cattle were studied to define botanical and nutritive quality of the diet and animal production (for details of study procedures see Krueger, 1983, and Vavra, et al. 1980).

RESULTS AND DISCUSSION

Plant succession continued to progress through the first 20 years of measurement. The early stages were dominated by bull thistle (*Cirsium vulgare*). By the end of the period, Kentucky bluegrass (*Poa pratensis*), elk sedge (*Arrhenatherum elatius*), orchardgrass (*Dactylis glomerata*), and blue wildrye (*Elymus glaucus*) dominated the seeded areas (Table 1). Grazing treatments also directed succession so that the area ungrazed by big game had a greater amount of shrubs which competed with the forage plants used by cattle. Herbaceous plants also showed differential responses when grazed or not grazed by cattle.

Grazing by cattle and big game together depressed annual yield of vegetation after the bull thistle stage from the late 1960's to mid 1970's (Table 2).

Table 1. Average frequency of understory vegetation for the most abundant species on the clearcut, 1965-1982.

	Average Percent Frequency									
Species	Overall 1965 1/	Overall 1967 1/	Cattle 4/ 1971 5/	Dual 1971	Cattle 1977	Big Game 1977	Dual 1977	Cattle 1982	Big Game 1982	Dual 1982
GRAMINOIDS										
Tall oatgrass	1	7	6	6	53	56	58	25	23	22
Smooth brome	t 2/	3	-	-	11	14	4	9	7	t
Mountain brome	15	21	12	14	9	14	18	6	30	28
Elk sedge	3	4	18	20	26	66	47	51	64	41
Pinegrass	3	3	t	5	6	14	17	10	10	14
Orchardgrass	10	13	12	7	28	22	24	32	31	30
Blue wildrye	17	21	35	26	33	31	44	16	21	15
Western fescue	1	4	-	-	16	23	32	6	7	7
Timothy	19	20	7	-	30	11	20	7	10	14
Kentucky bluegrass	1	3	2	-	38	61	35	20	55	37
Tall trisetum	-	t	-	-	3	8	5	26	53	35
FORBS										
Western yarrow	t	4	43	50	41	50	55	46	69	53
Rose pussytoes	-	-	-	-	2	6	5	11	19	23
Heartleaf arnica	5	8	16	8	26	15	31	55	86	50
Canada milkvetch	10	37	15	8	29	38	26	33	42	34
Bull thistle	26	59	42	59	4	6	2	8	5	20
Strawberry	10	17	40	39	44	86	84	84	95	95
Northern bedstraw	2	2	5	-	3	2	3	7	6	8
Western meadowrue	1	1	-	-	2	1	4	5	8	3
SHRUBS										
Redstem ceanothus	- 3/	8	2	5	27	6	3	15	t	t
Snowbrush	2	1	-	-	37	12	11	8	9	6
Baldhip rose	1	1	-	-	3	4	3	6	5	5
Birchleaf spirea	9	9	2	11	18	11	7	15	13	12
Snowberry	2	2	3	-	20	9	12	11	17	9
Ninebark	10	8	19	38	35	13	11	27	5	5

------ plot size changed ------

1/ From Pettit, 1968; 2/ t = <1%; 3/ included with snowbrush in 1965; 4/ cattle = cattle grazing only, Big game = big game grazing only, Dual = grazing by cattle and big game; 5/ From Erickson, 1974.

Table 2. Herbaceous production for the clearcut, 1965-1982, in pounds oven dry herbage per acre.

Grazing Treatment	1965 1/	1967 1/	1974	1982
Cattle only	1100 a 2/	1400 a	1600 a	400 a
Game only	—	--	1500 a	850 b
Dual	1700 b	900 b	950 b	750 b

1/ From Pettit, 1968
2/ Values within years followed by different letters are significant.

By the 1980's the encroachment of brush in the pasture not grazed by big game further reduced yields.

Utilization of vegetation was heaviest on orchardgrass at about 55 percent per season. Other important grasses and sedges were utilized to a level of about 40 to 50 percent. The diet of cattle was predominantly grass as measured from fistulated steers grazed in the pasture (Table 3). In one dry year shrubs increased substantially in the diet of cattle in the pasture where they were abundant. No planted conifers were grazed by cattle. Daily gains of yearlings ranged from 1.25 to 2 pounds per day.

Table 3. Class of forage in diets of fistulated steers.

Year	Grass	Forb	Browse
Normal (1972)			
Cattle only	67	10	23
Cattle and big game	65	11	24
Dry (1973)			
Cattle only	45	10	45
Cattle and big game	68	10	22

Survival of planted conifers was similar for each species under each grazing treatment (Table 4). Lower survival of western larch (Larix occidentalis) and western white pine (Pinus monticola) was attributed to planting stands and site effects. There were no significant differences in survival of planting trees for areas seeded to forages compared to unseeded areas.

Table 4. Survival of planted trees in 1977, thirteen years after planting.

Species	% Survival Game Grazing	Cattle Grazing	Dual Grazing
Douglas fir	62	56	58
Ponderosa pine	62	55	58
Western larch	32	22	28
Western white pine	28	30	36

Height growth of Douglas fir and ponderosa pine (Pinus ponderosa) was significantly higher in the pasture grazed by cattle and big game (Table 5). Western larch and western white pine were tallest under grazing by cattle or cattle and big game. There were no significant differences in height growth of planted trees for areas seeded to forages compared to unseeded areas.

Table 5. Height growth (in feet) of planted conifers in 1977, thirteen years after planting.

Species	Game Grazing	Cattle Grazing	Dual Grazing
Douglas fir	9.0[ab1/]	8.8[b]	10.1[a]
Ponderosa pine	8.7[a]	7.7[b]	9.5[c]
Western larch	11.3[a]	14.7[b]	14.4[b]
Western white pine	5.2[a]	7.4[b]	6.8[b]

1/ Values within species followed by different letters are significant.

This study illustrated a management technique that is compatible for forestry, livestock, and big game production objectives. The possibility for intensive management of these plantations is good and should help diversify income of these lands over a long time frame.

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