# EFFECTS OF PRESCRIBED SHEEP GRAZING ON ELK AND WHITE-TAILED DEER FORAGE IN NORTHERN IDAHO

A Thesis

Presented in Partial Fulfillment of the Requirements for the

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## Abstract

Effects of prescribed levels of sheep herbivory were examined on the quantity and quality of ungulate forage within a 4-year-old conifer plantation. The study site was divided into six 0.75-ha pastures and grazed at 6 prescribed levels of sheep herbivory during the summers of 1991 and 1992. Current year's standing crop of shrubs and herbs was clipped within each of the 6 pastures. Species composition was estimated using the dry-weight-rank method. Vegetation was sampled in September (Fall) 1992, November (Winter) 1991, and 1992, and May (Spring) 1992 and 1993. Residual standing crop (RSC) remaining at the end of the grazing seasons within each of the 6 pastures varied from 278-2267 kg $ha^{-1}$ in 1991, and 731-3016 kg $ha^{-1}$ in 1992. Grab samples of all plant species were analyzed for crude protein (CP), available CP, neutral detergent fiber, acid detergent fiber, and acid detergent lignin. Regression analysis was used to compare the effects of sheep herbivory on forage quality and quantity for white-tailed deer (*Odocoileus virginianua ochrourus*) and elk (*Cervus elaphus nelsoni*). Summer sheep grazing at the levels administered in this study generally reduced the quantity of forage available to elk and white-tailed deer. Fall regrowth did occur in both years of the study, but did not compensate for forage removed by sheep. Summer sheep grazing reduced shrub standing crop the following spring in both 1992 and 1993, but herb production was increased as RSC decreased. Despite the reductions in standing crop, however, there was adequate standing crop to meet intake requirements for both elk and white-tailed deer. Forage quality was improved by sheep grazing in fall, but was generally decreased in the winter and late spring. Crude protein requirements for maintenance (5%) for both deer and elk were met in all treatments in Fall 1992, all in Winter 1991-92 except the 744 kg $ha^{-1}$ RSC treatment, but only the 731 and 1042 kg $ha^{-1}$ RSC treatments met this requirement for the Winter 1992-93. Crude protein requirements for the healthy adults in spring (12%) were met in all treatments in Spring 1992, and all but the 731 and 1042 kg $ha^{-1}$ RSC treatments in Spring 1993.

## Study Site

The study was conducted on the Flat Creek Management Unit of the University of Idaho Experimental Forest located 56 km northeast of Moscow, Idaho.

A 3.75-ha area in a 4-year-old conifer plantation was selected in 1991. The plantation is located in a western red cedar/queencup beadlily (Thuja plicata/Clintonia uniflora) habitat type (Cooper et al. 1991). Soils on the site are Klickson silt-loam which are loamy-skeletal mixed, frigid Ultic Argixerolls. Slopes averaged 25-35%. Average annual precipitation is 610 mm, with approximately 30% falling as rain in May-September (NOAA 1992).The plant community presently on the site is a shrub-dominated overstory with a grass/forb understory.

partial extraction of condensed tannins and proteins by neutral and acid detergents produce a slight overestimate of lignin content (Van Soest 1982, Robbins et al. 1987).

## Study Area and Methods

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Barratt), and spiraea (*Spiraea betulifolia* Pall.). Herbaceous species most common on the site are mullien (*Verbascum thapsus* L.), everlasting (*Antenaria neglecta* Greene), hawkweed (*Heiracium albertinum* Farr), bluebells (*Mertensia paniculata* (Ait.) G. Don), Miner's lettuce (*Montia parvifora* (moc.) Scop.), fireweed (*Epilobium angustifolium* L.), Canada thistle (*Cirsium arvense* (L.) Scop.), bull thistle (*Cirsium vulgare* (Savi) Tenore), brackenfern (*Pteridium aquillinum* (L.) Kuhn.), sheep fescue (*Festuca ovina* L.), bluegrass (*Poa* spp.), elk sedge (*Carex geyeri* Boott), and water sedge (*Carex aquatilis* Wahl).

A predator-proof perimeter fence enclosed the 4.5-ha site and the site subdivided into six 0.75-ha pastures. Six prescribed levels of sheep herbivory, as measured by residual standing crop (RSC) remaining at the end of the sheep grazing period, were applied using yearling Targhee ewes. The sheep grazed from June to August in 1991 and 1992. The targeted RSC levels were 200, 400, 600, 800, 1000 kg $ha^{-1}$, and an ungrazed control.

The pastures were designed so that a stream running through the conifer plantation supplied adequate water to each pasture. Trace mineral salt was placed away from watering and loafing areas in an attempt to distribute animal use more uniformly within each pasture (Vallentine 1971).

Stocking rate for each treatment was determined by using 4 factors: 1) average daily forage allowance (ADFA) per ewe, 2) desired RSC, 3) annual above ground herb and shrub production per pasture (HSP), and 4) length of grazing season.

An ADFA of 2.6 kg DM 100 kg live weight$^{-1}$ was used to determine ADFA ewe$^{-1}$. The ADFA was based on the Society for Range Management's definition of an animal unit (26 lbs of forage disappearance per day per 1000 lb cow; SRM 1988).

Estimated average daily gain was 0.12 kg ewe$^{-1}$ (NRC 1985) for the 78-day grazing period in 1991 and 64-day period in 1992. This meant the ewes (50 kg) should have gained approximately 9 kg during the grazing season, and thus were estimated to weigh 59 kg at the end of the grazing season. The estimated average weight (i.e., 50+59/2) of 54.5 kg ewe$^{-1}$ was used for calculating the number of animals needed per treatment to reduce RSC to the target levels. Ewe average weight (54.5 kg) multiplied by ADFA gave an ADFA ewe$^{-1}$ of 1.42 kg DM day$^{-1}$, or 111 kg DM ewe$^{-1}$ for the 78-day grazing season in 1991 and 91 kg DM ewe$^{-1}$ for the 64-day grazing season in 1992. Stocking rates of each treatment were obtained by dividing total usable forage by the forage allowance/ewe/season (Table 1). Total usable forage per pasture was calculated by subtracting RSC from HSP.

The treatment pastures were monitored monthly by clipping total above ground current year's growth to assure the targeted RSC was met at the end of the grazing season. At least 4 ewes remained within each grazed pasture throughout the grazing season; additional ewes were removed or added as needed to achieve the targeted RSC.

Vegetation within each of the 6 treatment pastures was sampled during November of 1991 and 1992 (Winter), May of 1992 and 1993 (Spring), and September of 1992 (Fall). Herbs and shrubs were sampled in spring and fall, but only shrubs were sampled in winter due to snow cover. Above ground current annual growth was clipped within ten 50x50-cm quadrats per pasture and oven-dried for 48 hours at 100 C. Quadrats were spaced 10 m apart along a 100-m transect located through the center of each pasture. Before clipping each quadrat, percent species composition was estimated based on weight of current annual growth, using the dry-weight-rank method ('t Mannetjie and Haydock 1983).

Approximately a 50-g sample of current year's growth was hand-plucked from each plant species that was recorded in the dry-weight-rank procedure within any of the 10 quadrats. These hand-plucked samples were placed in paper bags and then oven-dried for 48 hours at 55 C. After drying, samples were ground in a Wiley mill using a 1-mm screen. Each sample was then analyzed for CP (AOAC 1990), available CP (ACP) through acid detergent insoluble nitrogen procedures (Goering and Van Soest 1970), NDF (Van Soest et al. 1991), ADF (AOAC 1990), and ADL (AOAC 1990).

Experimental design was completely randomized. Grazing treatments were replicated in time but not in space. Experiments not replicated in space are an appropriate alternative when the study's focus is on different grazing intensities (Bransby et al. 1988, Bransby 1989). Nonreplicated designs are also appropriate if the statistical inferences drawn are limited to the particular study site (Wester 1992). However, inferences from this study may be extended to other sites of similar seral stage within the red cedar/queencup beadliliy habitat type. This is because the habitat type classification system integrates the effects of environmental factors (e.g., soil, aspect, elevation, precipitation) on plant growth, reproduction, and competition (Daubenmire 1952, Hironaka et al. 1991).

Data were analyzed with simple linear regression using SAS (SAS 1990). Scatter plot diagrams indicated that relationships were best described by one of these 2 equations: 1) $y=a+b_1x_1$, or 2) $y=ax^b$. The equation that best fit the data was reported. Relationships (by year and by season) between prescribed sheep herbivory levels and forage quantity and forage quality were evaluated for each pasture as a whole (all species combined), as well as the shrub component and herbaceous component. This provided an estimate of the effect of grazing on the pasture (P) as a whole (NDFP, ADFP, ADLP, CPP, ACPP); the shrub (S) component (NDFS, ADFS, ADLS, CPS, ACPS); and the herbaceous (H) component (NDFH, ADFH, ADLH, CPH, ACPH). Each pasture's nutritive variables were calculated by summing the product of each species' nutritive value and its percent composition in the pasture. Individual species more common on the site (i.e., occurring in at least 4 pastures) were also analyzed to determine effects of sheep grazing on each nutritive component. These species included sheep fescue, everlasting, redstem ceanothus, Scouler willow, ninebark, thimbleberry, and snowberry. Because of the importance of the relationship between NDF and lignin on digestibility, NDF:ADL ratios were also analyzed for the pasture as a whole, the shrub component, and the herbaceous component. Regression equations were declared significant at $p \leq 0.10$. Nonsignificant and/or poor correlations ($r^2 < 0.55$) from the fall and winter seasons were reported in Table 1, and from the spring season in Table 2.

# Results

Precipitation during the 1991 grazing season was 120 mm higher than the 20-year mean and 57 mm below that mean in 1992. Also, mean spring temperatures were 3 C higher in 1992 than in 1991. Because of the differences in weather conditions of the 2 years comparing the effects of grazing on forage quantity and quality between years was difficult. However, these differences also offered a good opportunity to examine the effects of different stocking levels on forage quantity and quality in different growing conditions.

Below average precipitation during the winter and early spring months, coupled with unusually warm temperatures, caused the vegetation to rapidly advance through its growth cycle in 1992. Heavy winter snowfall and cool spring temperatures in 1993 resulted in a delay of 30-40 days in vegetative growth. The differences in growing conditions are also reflected in standing crop data in Table 3, where mean standing crop across all 6 pastures was 971 kg $ha^{-1}$ in Spring 1993 vs. 1027 kg $ha^{-1}$ in Spring 1992.

Regrowth in September after the sheep were removed was apparently limited by insufficient soil moisture. This was true for both years, but especially 1992. The effects of the drier weather conditions in 1992 were reflected by the amount of shrub standing crop in the control pasture during winter (Table 4). Shrub standing crop in the control pasture in Winter 1992-93 was 55 % of standing crop in the control in Winter 1991-92.

Actual RSC levels on the grazed pastures ranged from 278-1032 kg $ha^{-1}$ in 1991 and 731-1042 kg $ha^{-1}$ in 1992. Corresponding percent utilization on the grazed pastures varied from 51 to 76 % in 1991, and 30 to 66 % in 1992 (Table 5). Percent utilization data were calculated by comparing estimates of current year's standing crop at the end of the growing season in each grazed pasture vs. amount present in the control pasture.

**Fall**

Although total standing crop (TSC) during Fall 1992 was positively correlated with RSC among the 6 pastures (Fig. 1: $r^2$=0.72, p=0.0316), the correlation among only the 5 grazed pastures was not significant (p=0.5806), giving unclear results as to what the effects of grazing were on TSC. Shrub standing crop (SSC) was positively correlated with RSC (Fig. 2: $r^2$=0.88, p=0.0055), but as with TSC, grazed pastures alone were not correlated with RSC (p=0.7153). Comparisons between the standing crop data and RSC levels reflect the irregular amounts of regrowth that occurred amongst the 6 pastures (Table 6). The 805 and 942 RSC levels had the most regrowth, whereas standing crop in the other grazed pastures and the control actually declined due to leaf drop and senescence.

ADLH was positively correlated with RSC (Fig. 3: $r^2$=0.68, p=0.0444), whereas CPH was negatively correlated with RSC (Fig. 4: $r^2$=0.63, p=0.0585). ACPP and ACPH were also negatively correlated with RSC (Fig. 5: $r^2$=0.69, p=0.0407; Fig. 6: and $r^2$=0.68, p=0.0433). Available CP does not address the confounding factors of secondary compounds common in many wild browse species. Secondary compounds may reduce the availability of CP in forage to zero, especially in situations where winter forage CP is very low (Happe et al. 1990). In this study I did not assay secondary compounds, and this should be kept in mind when reviewing these data.

Results for sheep fescue were not conclusive. NDF was positively correlated with residual standing crop (Fig. 7: $r^2$=0.96, p=0.0036) indicating digestion was negatively affected as RSC increased. ADL, however, was negatively correlated with RSC (Fig. 8: $r^2$=0.76, p=0.0533), indicating digestibility improved as RSC increased. ADL was the only nutritive component for everlasting that was correlated with RSC (Fig. 9: $r^2$=0.88, p=0.061) and it indicated that digestibility increased as RSC decreased.

**Winter**

For the 1991-92 and 1992-93 winters combined, none of the correlations between RSC and standing crop were significant. ADLS was related with RSC, but it was poorly correlated ($r^2$=0.26, p=0.0920). CP of Scouler willow increased as RSC decreased (Fig 10: $r^2$=0.55, p=0.0563).

For the Winter 1991-92 sampling period, SSC was strongly correlated with RSC (Fig. 11: $r^2$=0.91, p=0.0033). ADF of snowberry was negatively correlated with RSC (Fig. 12: $r^2$=0.92, p=0.0392), which indicates digestibility increased with increased RSC.

For Winter 1992-93, SSC had a positive relationship with RSC (Fig. 13: $r^2$=0.57, p=0.0835). CP and ACP of snowberry increased with increased RSC (Fig. 14: $r^2$=0.84, p=0.0848; and Fig. 15: $r^2$=0.95, p=0.0242). All other nutritive components were not significantly correlated with RSC.

**Spring**

None of the standing crop values were significantly correlated with RSC when the data were combined from Spring 1992 and Spring 1993. The NDF:ADL ratio for the herbaceous component was correlated with RSC (Fig. 16: $r^2$=0.71, p=0.0006). The positive slope indicated digestibility increased with increased RSC. NDF in everlasting was negatively correlated with RSC (Fig. 17: $r^2$=0.59, p=0.0091), indicating digestibility increased as RSC increased. CP and ACP in everlasting also increased with increased RSC (Fig. 18: $r^2$=0.62, p=0.0072; and Fig. 19: $r^2$=0.80, p=0.0005). CP and ACP of snowberry, however, decreased as RSC decreased (Fig. 20: $r^2$=0.64, p=0.0317; and Fig. 21: $r^2$=0.76, p=0.0103).

For Spring 1992, SSC was positively correlated with RSC (Fig. 22: $r^2$=0.70, p=0.0393), and HSC was negatively correlated (Fig. 23: $r^2$=0.80, p=0.0165). NDFS, ADFP, ADFS, and ADLP were all negatively related to RSC (Fig. 24: $r^2$=0.77, p=0.0222; Fig. 25: $r^2$=0.66, p=0.0489; Fig. 26: $r^2$=0.78, p=0.0202; Figure 27: $r^2$=0.67, p=0.0624). These results suggest poorer fiber digestibility with less RSC. Also, because ACPP, ACPH, and the NDFH:ADLH ratio were positively correlated with RSC (Fig. 28: $r^2$=0.62, p=0.0622; and Fig. 29: $r^2$=0.81, p=0.0144; Fig.30: $r^2$=0.72, p=0.0321), results suggest that quality and quantity of standing crop were higher with increased RSC.

NDF and ADF in Scouler willow decreased as RSC increased (Fig. 31:$r^2$=0..96, p=0.0041, and Fig. 32: $r^2$=0.76, p=0.0538). NDF in snowberry was also negatively correlated with RSC (Fig. 33: $r^2$=0.81, p=0.0892). Fiber components for all 3 species indicated a decrease in digestibility of forage with decreased RSC levels.

For Spring 1993, TSC and HSC were not correlated with RSC, but SSC was (Fig. 34: $r^2$=0.63, p=0.0603). Although SSC was positively correlated with RSC, without the data point from the ungrazed pasture the correlation was not significant (p=0.6184). Distribution of the data points from the grazed pastures was clumped, making the effects of sheep grazing on shrub standing crop unclear. Unlike SSC, HSC had a distinctly negative correlation with RSC when the ungrazed data point was excluded (Fig. 35: $r^2$=0.81, p=0.0376). Heavier levels of summer sheep grazing apparently suppressed shrub growth, allowing the herbaceous species to grow with reduced competition. Visual examination of utilization in August 1992 supported this conclusion. Shrub species were used much heavier than herbaceous species.

NDFH was positively correlated with RSC (Fig. 36: $r^2$=0.87, p=0.0072) during Spring 1993. The positive relationship between NDFH and RSC indicate grazing had a positive effect on the digestibility of herbaceous plant material available to white-tailed deer and elk. However, the NDFH:ADLH ratio contradicts these assumptions in that the ratio was positively correlated with RSC (Fig. 37: $r^2$=0.78, p=0.0192), indicating digestibility increased with increased RSC levels.

NDF, ADF, and ADL in everlasting were negatively correlated with RSC (Fig. 38: $r^2$=0.76, p=0.0112; Fig. 39: $r^2$=0.64, p=0.0299; and

Fig. 40: $r^2=0.58$, $p=0.0468$). ACP in everlasting increased with increased RSC (Fig. 41: $r^2=0.78$, $p=0.0087$).

## Discussion and Conclusions

### Forage Quantity

Summer sheep grazing at the levels administered in this study generally reduced the quantity of forage available to elk and white-tailed deer. Standing crop was not sampled in Fall 1991, but data from Winter 1991-92 reveal that regrowth did occur in pastures 3 and 6 (Table 5). Forage quantity in all pastures, including the ungrazed control, declined sharply due to leaf drop and senescence (Table 6). Regrowth was stimulated in Fall 1992 when utilization by sheep in summer was 30 and 61 %, but in neither year nor in any pasture did the regrowth compensate for the forage removed by the sheep. Rhodes and Sharrow (1990) similarly reported that summer sheep grazing reduced forb and shrub standing crop in coniferous forests of western Oregon.

Summer sheep grazing reduced shrub standing crop the following spring for both 1992 and 1993. Herb production, however, was increased as utilization increased. Rhodes and Sharrow (1990) reported early spring graminoid growth following summer sheep grazing was the result of the canopy being opened, and increased soil fertility from fecal and urinal deposition. These authors also commented on the importance of early growth of herbaceous species because of the importance of high quality forage to deer (Crouch

1981) and elk (Leslie 1982) in late winter and early spring to meet nutritional demands during late gestation.

Anderson et al. (1990) suggested prescribed grazing to stimulate regrowth should be administered at levels sufficient enough to retard phenological development, but also at levels that leave enough green foliage to allow regrowth to be easily initiated. Also, grazing should be terminated early enough in the growing season for there to be adequate soil moisture for regrowth. Levels of use in this study's prescribed treatments may have removed too much green foliage to allow plants to readily and quickly initiate regrowth. Grazing may have also extended too late into the growing season for there to be adequate soil moisture and time remaining in the growing season for appreciable regrowth to occur. Young and Payne (1948) reported vigor was greatly reduced when utilization of several northern Idaho browse species exceeded 60-65 %, and death was common when utilization exceeded 75%. These values are consistent with results of this study. There was a visible reduction in the amount of shrubs present as well as the amount of shrub growth on the heaviest grazed pastures.

Despite the reductions in standing crop and the lack of regrowth, there was adequate standing crop to meet intake requirements for both elk and white-tailed deer. Although standing crop was reduced, individuals were able to satisfy daily DM intake requirements from standing crop remaining on the site. A 250-kg elk requires approximately 5 kg DM day$^{-1}$ (Collins and Urness 1978). If the animal forages 14 hrs day$^{-1}$ (Craighead et al 1973, Collins and Urness 1983) it will be able to ingest 5 kg DM day$^{-1}$ as long as total standing crop on the site is 200 kg $ha^{-1}$ or greater. All pastures, except 2 in Winter 1992-93, exceeded this minimum. However, as standing crop decreases, the animal must spend increasing amounts of time foraging, which increases its energy expenditure and exposure to predators.

**Forage Quality**

Summer sheep grazing increased the forage quality during Fall 1992 by increasing the CP offered to grazing ungulates. This is noteworthy because forage quality in fall influences the ability of wild ungulates to enter winter with adequate body reserves. Data were inconclusive as to the effects of summer sheep grazing on forage quality during the winter. That is, few positive or negative effects were apparent in winter. Summer sheep grazing generally decreased forage quality during the spring by increasing fiber content and decreasing CP.

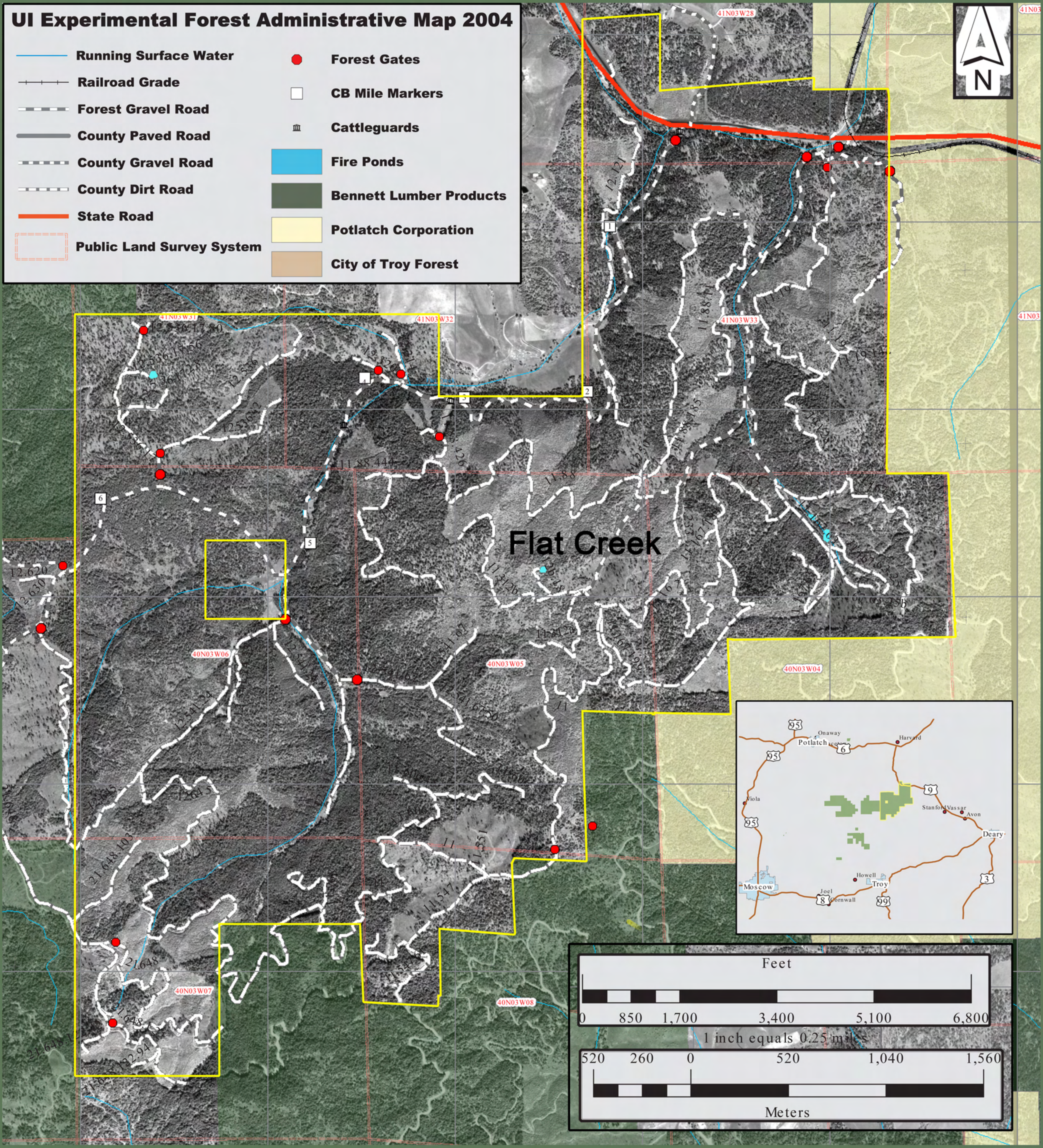
Results for individual species generally supported the conclusions for the composited data for each season. Each of the individual species analyzed comprised about the same percentage of each pasture's composition (8-11%), so an individual species did not dominate, or drive the results. One possible reason why forage quality was not greater in the grazed pastures in spring relates to the increased production of herbs mentioned previously. With reduced shrub canopy, the forbs and grasses probably initiated growth earlier in the spring. If so, the herbs would have been more advanced phenologically at the time of sampling in the spring, and the amount of structural carbohydrates and lignin would have been greater.

Elk and white-tailed deer require a minimum of 5 % CP for maintenance (Robbins 1990). All treatments in all seasons were able to supply CP at this level, except the 744 kg $ha^{-1}$ RSC treatment in Winter 1991-92, and the 731 and 1042 kg $ha^{-1}$ RSC treatments in Winter 1992-93 (Tables 7,8,9).

During spring, healthy adult white-tailed deer and elk require 12 % CP to meet the nutritionally demanding time of late gestation and early lactation (French et al. 1956, Murphy and Coates 1966, Robbins 1990). All treatments in all seasons met this requirement, except the 731 and 1042 kg $ha^{-1}$ RSC treatments in Spring 1993 (Tables 7,8,9). It is important to note, however, that CP data were comprised of several plant species, including some that may not be readily selected by white-tailed deer or elk. Deer and elk are selective feeders and will almost always select plant species and plant parts that are higher in nitrogen, but lower in fiber than what is present in the standing crop as a whole (Arnold 1981).

## Conclusions

Prescribed sheep grazing intensities used in this study improved forage quality available to elk and white-tailed deer in fall, but not in winter and late spring. Forage quantity was decreased in all seasons. The different responses of vegetation to environmental conditions and grazing treatments in different seasons stresses the fact that a "cookbook" approach to managing wildlife habitat is improper. The use of grazing animals has the capacity to greatly alter wildlife habitat, improving it for some while degrading it for others (Severson and Urness 1994, Mosley 1994). Management goals and objectives must be defined clearly, and prescribed grazing treatments administered judiciously with these goals and objectives in mind. Management goals, skills, and diligence will determine the kind and extent of habitat alteration that will occur when livestock grazing is used as a management tool.


UI Experimental Forest Administrative Map 2004
Running Surface Water
Railroad Grade
Forest Gravel Road
County Paved Road
County Gravel Road
County Dirt Road
State Road
Public Land Survey System
Forest Gates
CB Mile Markers
Cattleguards
Fire Ponds
Bennett Lumber Products
Potlatch Corporation
City of Troy Forest
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Flat Creek
Feet
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850
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