Diet Overlap and Social Interactions among Cattle, Horses, Deer and Elk in the Cascade-Siskiyou National Monument, southwest Oregon.

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ABSTRACT

This paper examines fecal composition and movement patterns of cattle, horses, deer, and elk to determine the potential for competition between native and non-native ungulates. Fecal analysis of deer, elk, horse, and cattle scat in the Cascade-Siskiyou National Monument show similar composition and seasonal trends identified in the literature. Seasonal variation of plant fragments and seeds found in fecal composition studies includes: for cattle (June through October) an increase in use of forbs through the progression of the grazing season with a concomitant decrease in use of grasses; for deer, a high forb use from April through August with a reciprocal use of shrubs; for elk, a high use of shrubs during July and August, high use of tree foliage during the winter months, and high use grass during the early growing season (April and May). Horses showed a consistent high use of grasses through the entire year Total average overlap of diet between cattle and native ungulates is 6% (min=0%; max=53%) for deer and 13% (min=0%; max=54%) for elk. The average percent similarity between samples of individual ungulates range from 31% (min=5%; max = 83%) for elk, 30 % for cattle (min=0%; max=95%), and 27% (min=0%; max=98) for deer. Average individual species dietary composition by month indicates that late season cattle grazing is most similar to winter grazing by elk and early summer and fall grazing by deer. While approximately twenty individual plants were commonly used by deer, elk and livestock, diets were dissimilar enough to conclude that competition for forage and browse resources were unlikely within the Monument area. Observations of the presence or absence of native ungulate scat and bedding sites, relative to cattle use at seeps and springs, indicated reduced sign by elk and deer in areas used by cattle. Deer and elk favored soil complexes, likely because such complexes support complex vegetation structure and composition thereby yielding several resource needs (browse, forage, and hiding cover). Telemetry data and observations indicated little interaction occurred between deer and cattle away from water-sources. Telemetry data and observations indicate that elk move away from cattle to different habitats at the onset of cattle presence, but do not necessarily vacate larger pastures with livestock presence. The avoidance of cattle by elk in the summer, but subsequent intermingling of elk with livestock on private lands during the fall and winter may indicate a preference for segregation overcome by browse/forage constraints during the fall and winter months.

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INTRODUCTION

The Cascade-Siskiyou national Monument is inhabited by Roosevelt elk [*Cervus elaphus roosevelti* (probably a hybrid of Rocky Mountain (*Cervus elaphus nelsoni*)] transplants and native Roosevelt elk) (Harper 1987) and muledeer (*Odocoileus hemionus hemionus*), blacktail deer (*Odocoileus hemionus columbianus*) or hybrid mule and blacktail deer (due to the overlap in species home range). Potential dietary overlap, seasonal forage consumption, species distribution patterns, and social interactions between wild ungulates and domestic livestock can lead to wildlife management issues. In this study, fecal analysis, utilization measurements (forage and browse), native ungulate locations (radio telemetry data and visual observations) relative to patterns of livestock are used to evaluate potential interactions between native and non-native ungulates in the vicinity of the cascade-Siskiyou national Monument (Figure 1). The literature summarizes many studies examining diet and competition for resources between livestock and native ungulates.

Forage Consumption and Dietary Overlap

Fecal analysis, although having some limitations, has been frequently used to determine food habits of numerous herbivores (Nelson and Leege 1982). In particular, fecal analysis has been used to study elk diets (Korfhage 1974, 1980), deer and domestic cattle (Hansen and Reid 1975), and Horses (McInnis and Vavra 1987).

Studies that have evaluated livestock forage utilization on open ranges show that cattle favor green grass over forbs and shrubs (Miller and Krueger 1976, Hall 1985, Mohammad et al 1996, Kingery et al. 1996). Cattle diet composition of grass, forb and shrub varies by season (Hansen and Reid 1975, Currie et al 1977, Stuth and Winward 1977, Mohammad et al 1996, Kie and Boroski 1996, Grings et al 2001), even within the same pasture (Mohammad et al. 1996). Diets comprised a higher percent grass composition during the late summer with forbs showing higher use by livestock in the early summer (Dusek 1975). The relative consumption of tree/shrub and riparian vegetation varies by grazing season (Willms et al 1980, Fitzgerald and Bailey 1984, Fitzgerald et al 1986, and Green and Kauffman 1995). Browsing of shrubs by cattle, particularly upland shrubs, usually occurs when more palatable food is depleted from the

available range (Hansen and McCulloch 1955, Fitzgerald and Bailey 1984, Kovalchik and Elmore 1992, Green and Kauffman 1995, Mohammad et al. 1996).

Numerous elk food habit studies have been conducted and are summarized by Kufield (1973), Nelson and Leege (1982), and recently updated by Cook (2002). Forage preference are highly variable by both Roosevelt (*Cervus elaphus roosevelti*) and Rocky Mountain elk (*Cervus elaphus nelsoni*), dependent on vegetation type, seasons, years, forage availability, and phenology. In general, studies indicate that elk typically favor grasses and forbs from early spring into mid summer and begin adding shrubs in late summer and fall in addition to dried grass and grass regrowth (if available) through fall and winter (Nelson and Leege 1982). Roosevelt elk diets constitute more than 75 per cent browse in western Oregon (Harper 1971).

Mule (*Odocoileus hemionus hemionus*) and black tailed deer (*Odocoileus hemionus columbianus*) are known to be browsers. Many studies have shown that mule deer diets contain predominantly forbs in the spring and summer and browse in the winter (Cowan 1947, Mackie 1970, Hansen and Reid 1975, Hobbs et al. 1983).

The literature suggests that horses are predominantly grazers with grasses comprising the highest percentage of their diets. McInnis and Vavra (1987) found that feral horses in eastern Oregon were predominantly grazers and that grasses comprised 88 % of their pooled seasonal diets and that there was little variation in total grass consumption among most seasons.

Competition for food between large herbivores involves several factors (Nelson 1982, Vavra et al. 1989), the most important of which are diet similarity, consumption equivalence, range overlap, timing of forage use, forage height, quantity and quality and density of competing species. Competition between elk and cattle is more intense than with any other large herbivores in the western United States (Cooperrider 1982). Competitive interaction between elk and cattle is greatest on winter and spring/autumn ranges (Nelson 1982, Wisdom and Thomas 1996). Because of a high percentage of grass in the diets of both cattle and elk, (Skovlin and Vavra 1979) identify a high likelihood of competition between elk and cattle in summer and fall grazed areas in Oregon. Because of their dietary and general habitat differences, elk and mule deer apparently do not seriously affect one another (Miller, 2002).

Interactions Between Deer, Elk and Cattle

The use of radio telemetry for tracking wild ungulates has proven effective for determining distribution, seasonal movement patterns and migration (Pederson et al. 1979). A wide range of spatial interactions between deer and cattle have been reported. Loft et al (1991) found that female deer changed their habitat selections in the presence of cattle, particularly in meadow and aspen areas. Many studies find that deer avoid livestock (Stewart et al. 2002, Coe et al 2001, Ragotzkie and Bailey 1991 Compton 1988, Wallace and Krausman 1987, Austin and Urness 1986, McMahan 1966, Ellisor 1969. Others found that deer dispersion remained unchanged with cattle (Skovlin et al 1968). Loft et al (1991) found that deer favored riparian areas in areas ungrazed by livestock and used upland shrubs more in habitats where livestock were present.

Similar patterns of interaction have been detected between elk and cattle. Coe et al.(2005), found that when cattle were introduced to a pasture, elk moved away from favored habitats and instead spent more time foraging at higher elevations and on steeper slopes where livestock were absent. Several authors observed less elk use in areas grazed by livestock, compared to ungrazed areas, or observed elk vacate areas with the onset of cattle grazing (Stevens 1966, Yeo et al 1993, Coe et al 2001, Mackie 1970, Clegg 1994). Dalke et al (1965) found that the presence of cattle at salt licks discouraged the presence of elk, and also altered the pattern of elk use through the area occupied by cattle. Several authors found that livestock grazing can affect native ungulate use during the same or later season (Anderson and Scgertzinger 1975, Skovlin et al 1983, Austin et al 1983). In some studies, large ungulates displaced smaller species, with deer being displaced by elk, and elk being displaced by cattle (Stewart et al. 2002).

Competition for Resources

While social interactions and diet overlap between native and non-native ungulates have been used to indicate competition, proof of competition between species is more difficult (Kie et al 1991, Coe et al 2001). Proof usually requires a confluence of factors: proof that diets between competing species overlap; a condition of insufficient and essential food supply exists; and that no alternative food source exists (Coe et al 2001). The consideration of individual species

availability, as well as the percent occurrence is important (Petrides 1975). Some studies suggest that native and non-native ungulates compete with each other (Yeo et al. 1993; Hobbs et al. 1996; Stewart et al. 2002; Findholt et al. 2005; Coe et al. 2001, Dusek et al 1975), and others find mutual benefits (Anderson and Scherzinger 1975; Frisina 1992). Studies show dietary overlap between wild and domestic ungulates, but the significance or importance of the overlap is not always clear (Miller and Krueger 1976, Stuth and Winward 1977, Wallace and Krausman 1987). Some studies have found both cattle and elk have deficiencies in areas where they share resources (Cook et al. 2004; Holechek et al 1982). Changes in native ungulate behavior associated with cattle presence include: longer feeding bouts (Kie et al 1991) and larger home range size incorporating steeper terrain (Loft 1988).

A Restatement of Objectives

The objectives for the data analysis were to: 1). examine the relative percent similarity in diet between livestock (cattle and horses)and native ungulates (deer and elk), 2) identify seasonal variation in use of vegetation life-forms/functional groups and individual vegetation species by all ungulates, 3) identify individual vegetation species important as forage to cattle, deer and elk, 4) Identify social interaction between cattle, deer and elk, and 5) determine the potential for competition between native and non-native ungulates on the Monument.

STUDY AREA DESCRIPTION

The Cascade – Siskiyou National Monument in Southwest Oregon (Figure 1) is an area rich in plant species and communities attributed to the convergence of three major ecoregions (Pater et al. 1997). Soils vary in their origin from restricted alluvial deposits, volcanic ash deposition, and derivation from eroded magma. Individual stands of vegetation can be dominated by any of 5 conifers, 7 hardwoods, or 10 shrubs interspersed across short distances. Coarse patterns of tree and shrub distribution are dependent on the effects of elevation, slope, and aspect on precipitation and consequent redistribution of water. As well as the rugged topography, patterns in soil texture facilitate smaller scale change in shrub and herbaceous composition (Hosten et al. 2007a, b). For example, high clay content favors a herbaceous dominated

understory free of evergreen shrubs (Hosten et al. 2007b). Common low elevation plant communities include Oak/wedgeleaf ceanothus/grass, Douglas-fir forest, wedgeleaf ceanothus/grass, and Mountain Mahogany-oak/fescue. Many of these sites fall within areas classified as deer winter range and are generally grazed by livestock in the spring and summer. Higher elevation sites are classed as deer summer range and are grazed by livestock through the summer and fall. Summer range habitats include white fir forest, semi-wet meadow, steep mountain grassland, Douglas-fir forest, mixed fir forest, mixed conifer forest. Dry meadows are interspersed throughout these communities depending on soil depth or the presence of argillic soil horizons. Past timber harvest on public lands creates a patchwork of plant community developmental stages and native ungulate habitat across the landscape.

Pellet count studies (Montgomery et al. 1981) within the monument and adjacent lands indicate that blacktail and mule (or hybrids) deer start moving up from winter rangelands (1800) feet to summer rangelands (over 6000 feet) by mid May. Buckbrush is the most important browse available (December - January) during the snow months when access is restricted at high elevation. Clearcuts and riparian zones receive more use by does during the fawning season (late June, early July) likely because of adequate cover and high quality forage (especially in riparian areas). Partial cut, mixed conifer forest showed highest use by deer in the summer range. Old growth sites provided important thermal cover during the winter, but little forage. Mosaics of diverse vegetation structure and composition showed more use than larger more homogenous stands of vegetation.

Field personnel collecting radio collar data on elk observed that elk moved to outlying areas when cattle were released into meadows and springs, and elk were never observed closer than 400 m from cattle (Bigman 1995). Field biologists noted that elk were frequently observed in large numbers in logged over areas during the course of the study, browsing lichens from the branches of felled trees (Bigman 1995). However, other collared elk apparently fled from the recently cut areas, perhaps in response to noise and activity from vehicles and machinery (Bigman 1995).

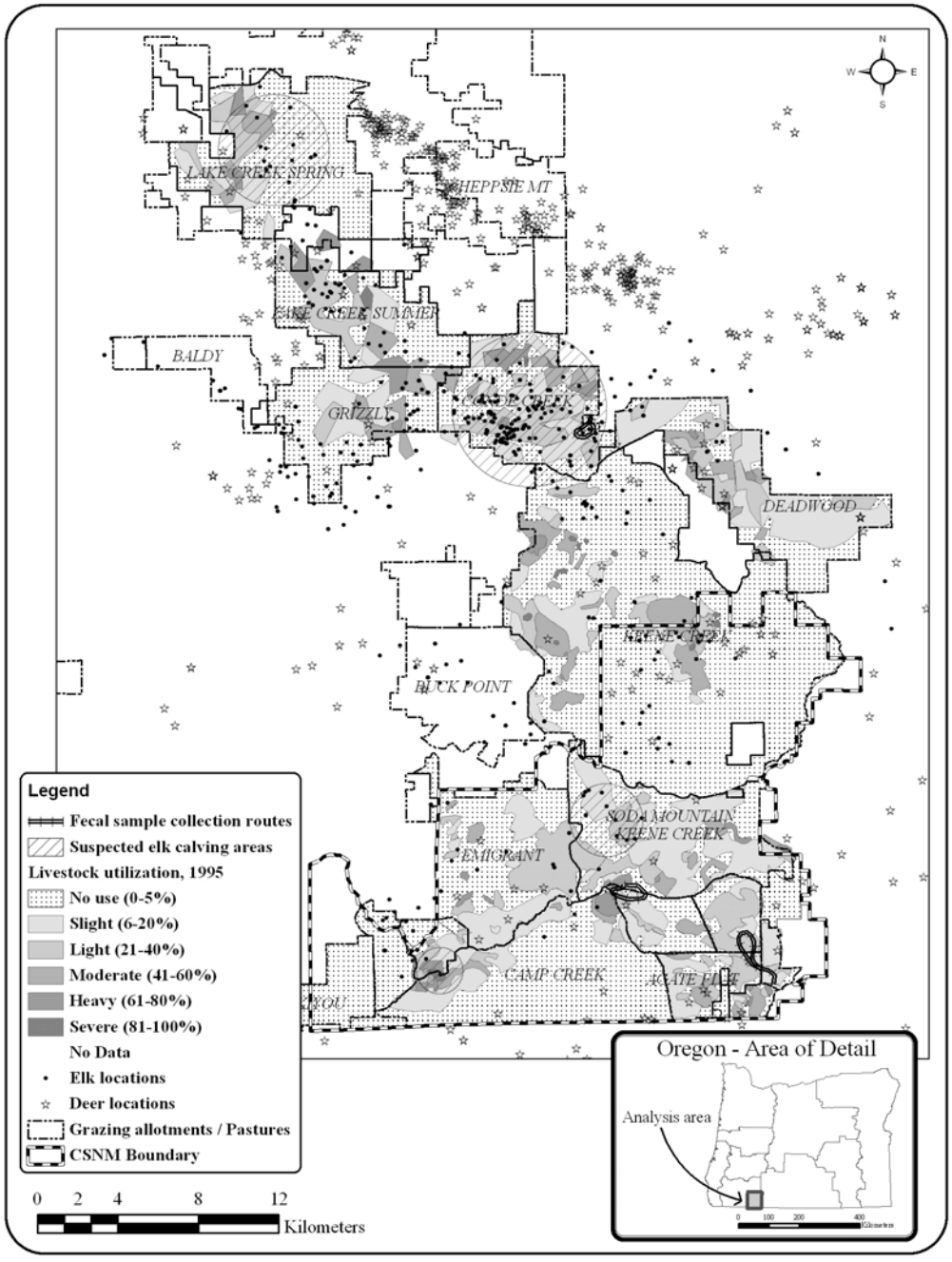

Figure 1. Study location, deer and elk locations on a background of cattle utilization and Allotment/pasture boundaries. Note that several fecal analysis pellet collection sites have not been accurately located.

METHODS

Deer, Elk, Horse and Cattle Fecal Composition and Seasonal Variation of Diets.

Fecal samples from elk, deer, horses and cattle were randomly collected throughout the study area in 1980. Standard fecal collection protocols and analytical procedures as defined by Colorado State University fecal analysis lab were followed. Collection sites were selected across the landscape representing different plant communities. Multiple pellets were collected from individual locations and were pooled as samples to reduce variability and increase local representation. Fresh, recently deposited fecal material, was collected in order to closely establish the time of forage consumption. Individual samples were prepared for microscope analysis. A percent composition of plant epidermal fragment present in each sample was determined and plant species were identified down to genus and sometimes species.

Fecal data were entered into a spreadsheet to create a matrix depicting samples and vegetation species identified in the fecal material. This allowed for the calculation of similarity indices inherent in the use of plant community analytical techniques, such as ordination. Analysis was conducted at different levels of biological organization - individual plant species and vegetation life-forms. While individual sample values were used in the analysis by ordination, averaging by month was completed for the subset of samples that included species/life-from of interest. Sorting was used to identify individual plant species utilized by cattle, horses, elk and deer. Sorting was based on the average percent composition of samples and relative percent occupancy within the total number of fecal samples collected over the study area.

Interactions Between native Deer, Elk and Cattle

Deer and elk location data were acquired by both telemetry and visual observation by the Oregon Department of Fish and Wildlife (Bigman 1995). Fifteen female elk were fitted with radio collars in 1992, and located periodically through 1995, (by day, time of day and season) by radio telemetry. Six hundred twenty two female elk locations were recorded in four years of data collection. Similarly, five hundred and forty deer locations were established using telemetry within the analysis area.

Deer and elk locations were considered in the context of spatial variables including: edaphic, topographic, biotic, and land management activities. Edaphic factors include classification as a complex (USDA 1993). Topographic variables included elevation, slope, and aspect, all derived from existing digital elevation data. Biotic variables examined were ecological class (conifer forest, grazeable forest, range site and potential vegetation categories all derived from the Natural Resource Conservation Service soil surveys (USDA 1993). The potential affect of land management activities were examined using distance from roads, distance from water sources, and 1995 maps of utilization defining the utilization level congruent with the landscape pattern of livestock use. Distance from road and water were calculated in 100 meter distance increments from roads and water sources (perennial streams, ponds, lakes, or springs). These variables were all defined in GIS as ARCGIS grids. Data was collated for each deer and elk observation by intersecting observations with the library of grids, resulting in a spatially explicit dataset of response variable (deer and elk locations) and predictor variables (the values of all edaphic, topographic, biotic, and management variables.

The above defined variables of interest at deer and elk locations were analyzed temporally on a month to month basis as well as pooled together to examine changes in distribution consequent to movement of cattle from pasture to pasture. Categorical variables were tested for significance using chi-squared tests. The actual number of observations within polygons defining variables of interest were compared to expected values derived from proportions of the analysis area falling in each class multiplied by the total number of observations within the area of interest. Continuous variables such as elevation and slope were grouped by month of observation and compared with t-tests. Significance threshold was 0.10 unless otherwise specified.

To test whether cattle presence affected elk distribution at the pasture level, elk observations in each pasture were designated as “before cattle grazing,” “during cattle grazing,” or “after cattle grazing” based on the month and day of observation in relation to the dates of permitted grazing in the BLM grazing leases. Numbers of elk observations in each category were compared using chi-squared tests to expected values derived from proportions of time between first and last elk observation in each pasture. Elk observations within potential

vegetation types (USDA 1993) within individual pastures were compared before, during, and after cattle grazing to determine if cattle presence caused a shift in elk habitat selection. Deer observations in grazing allotments were insufficient to conduct a similar analysis. Spatial analyses at a range of spatial scales was designed to lead to an understanding of ungulate movement at the largest scale (the entire area of analysis), between pastures and allotments, and also between NRCS potential vegetation classes within individual pastures.

A second dataset allows an examination of cattle, elk and deer interaction at mid elevation seeps and springs within a mixed conifer matrix. During an inventory of springs and seeps, surveyors made note on data sheets of evidence of cattle, deer, or elk. Evidence of presence for all ungulates included visual sighting of animals, footprints, scat, or bedding areas. The number of seeps or springs where elk and deer where observed, with and without cattle present, are compared with chi-squared tests.

RESULTS

Dietary Overlap Between Cattle, Elk, and Deer

A total of 15 plant species show greater than 4% fecal composition by any individual ungulate occurring on the CSNM (Table 1). Only nine individual plant species show an average percent fecal composition greater or equal to 4% for any native or non-native ungulate. Of the plant species showing higher utilization by more than one ungulate, only six species (*Poa spp.*, *Bromus spp.*, *Eleocharis spp.*, *Elymus spp.*, and *Stipa spp.*, and *Symphoricarpus spp.*) include cattle as an important consumer. This indicates limited opportunity for competition between livestock and native ungulates based on individual species. Two species (*Carex spp.* and *Symphoricarpus spp.*) that show high use by cattle occurs on restricted riparian habitat. While *Carex spp* does not show high use by native ungulates based on an average of all samples, it is possible that high fall use by livestock may prohibit fall and spring use by native ungulates.

Table 1. List of plant species showing greater than 4% fecal composition by one or more native and anon-native ungulates occurring on the Cascade-Siskiyou national Monument.

Plant species	Life-form	Cattle	Deer	Elk	Horse	Instances of ungulate use >= 4%
Poa spp	grass	6.6	0.1	4.1	6.2	3
Bromus spp	grass	23.9	0.8	1.8	16.1	2
Ceanothus cuneatus	shrub	2.3	36.7	7.2	0.1	2
Eleocharis	grasslike	4.9	0.3	0.5	7.7	2
Elymus spp	grass	4.4	0.2	0.5	5.2	2
Fragaria sp	forb	1.4	5.9	18.6	0.0	2
Oryzopsis-misidentified	grass	3.1	0.1	6.3	12.7	2
Stipa spp	grass	6.9	0.1	0.6	23.7	2
Taxus sp	tree	0.3	8.0	10.7	0.0	2
Amelanchier spp	shrub	0.1	4.7	0.2	0.0	1
Carex spp	grasslike	12.6	0.1	1.5	1.2	1
Festuca spp	grass	2.6	0.3	2.5	7.2	1
Calocedrus decurrens	tree	0.0	3.7	5.7	0.1	1
Potentilla spp	forb	0.9	4.5	0.7	0.0	1
Pseudotsuga menziesii	tree	0.4	3.7	4.1	0.2	1
Quercus spp	tree	1.3	5.3	3.9	0.4	1
Symphoricarpos spp	shrub	1.5	3.3	12.3	0.0	1
Verbascum sp	forb	4.6	0.3	0.7	1.6	1
Vicia spp	forb	0.7	0.8	9.6	0.0	1

Seasonal Variation by Life-form (Figures 2a-h)

Forbs *(figure 2a):* Cattle and horse fecal samples indicated relatively low use (<5%) of forbs through the grazing season. Deer fecal samples indicated use of forbs throughout the grazing season with highest use during the early summer (>40%) and tapering off as winter nears. Elk fecal materials examined indicated relatively high and bimodal use of forbs across the year. Values ranged from approximately 75% during the early summer and 40% during the winter to a low of less than 10% during the spring.

Sedges *(figure 2b):* Fecal analysis indicated use of sedges by deer and elk was low (<5%). Cattle and horses fecal samples showed moderate percent utilization of sedges early in the grazing season (particularly cattle), tapering off after April and remaining low to the end of the grazing season.

Grasses *(figure 2c):* Horse fecal material showed consistent and high (>75%) use of grasses throughout the year. Cattle fecal samples showed a high use of grass throughout the

grazing season, but tapering off sharply in October. Deer fecal samples showed minor use of grass early in the spring and late in the fall. Grass epidermal fragments found in elk fecal material indicated use of grasses throughout the season by elk, but particularly during the early summer.

Wetland plants *(figure 2d):* Epidermal fragments of wetland associated plants, identified in the fecal material, varied considerably throughout the year, perhaps a reflection of the relative scarcity and uneven distribution of this habitat within the project area. Utilization of numerous wetland species for forage by horses and cattle occurred early in the spring (25% and 45% respectively) and late in fall (20% and 45 % respectively). Deer fecal samples showed little wetland use (5%), and only in the early spring. Elk fecal samples also indicated low composition of wetland plants through the summer and fall.

Shrubs *(figure2e):* Fecal samples indicated shrub use by livestock appeared insignificant in the spring, gradually increasing to over 5% later in the grazing season. Deer fecal material showed consistent high use of shrubs throughout the year, with highest frequency of shrub fragments appearing in fecal material in winter months. Elk fecal material indicated moderate shrub use through most of the year with high use during the late summer. Horse fecal material showed very little use of shrubs.

Trees *(figure 2f):* Deer and elk fecal material indicated that they are the only major users of tree foliage use through the year. Deer show a bimodal fecal composition with high tree foliage use in the early spring (45%) and fall (50%). Elk fecal composition by trees is unimodal with a high (50%) tree foliage content in the fall. Horses show slight use of trees, particularly through fall, winter and early spring.

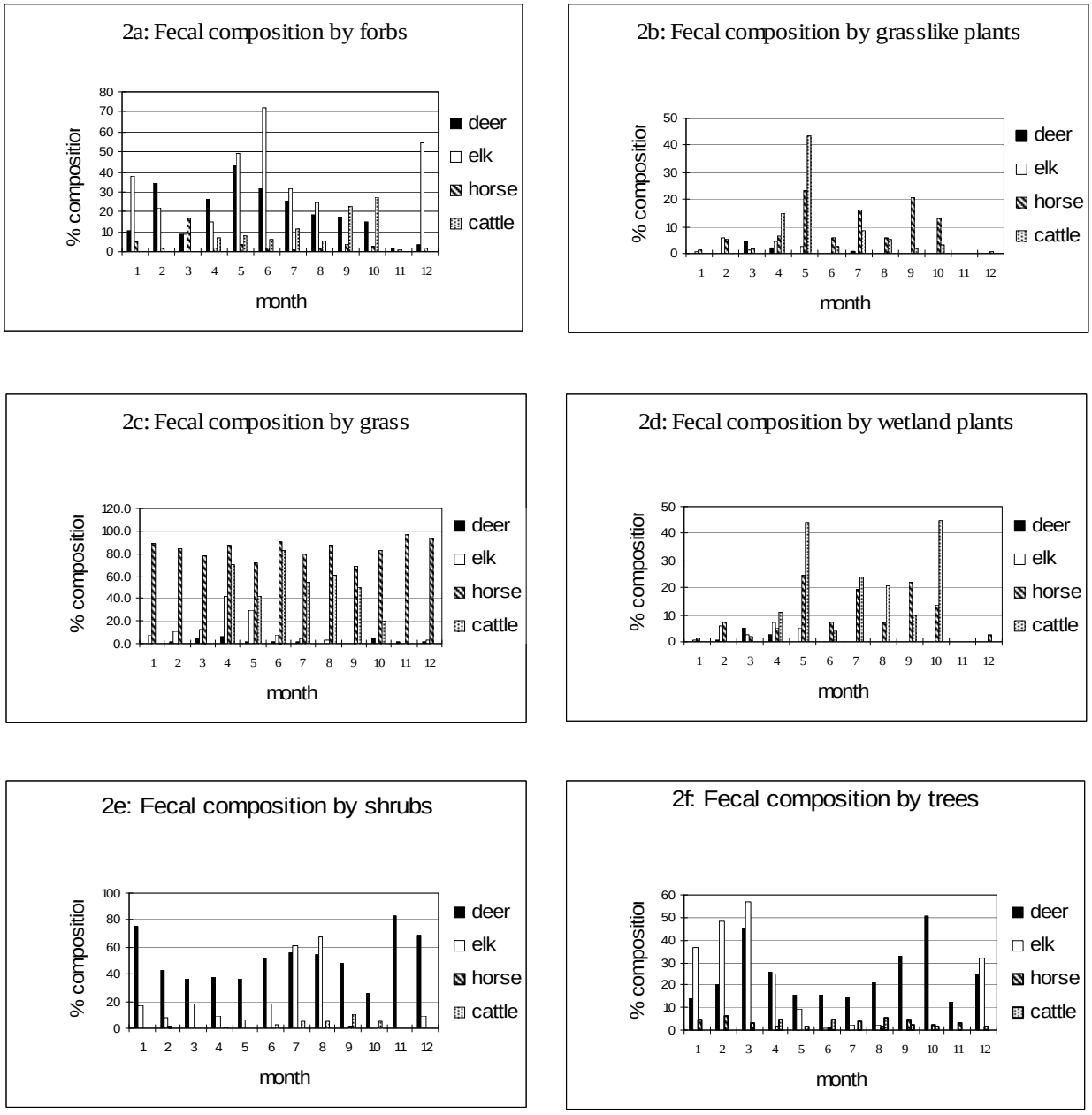

Figure 2. Seasonal variation of percent life-from fecal composition of deer, elk, horse, and cattle scat

Average Percent Composition by Individual Plants (Figure 3a-h)

Fragaria sp *(Figure 3a):* Cattle show a low use (<5%) of *Fragaria* throughout the grazing season. Deer show moderate use of this plant throughout the year, with clear seasonal high during the summer. Elk show the highest fecal composition by *Fragaria* following the same pattern as deer, but with a mid season high of over 40%.

Vicia sp*(Figure 3b):* All ungulates except elk show very low use of *Vicia*. Elk show strong seasonal use of *Vicia* peaking over the mid winter at over 30%.

Carex spp *(Figure 3c):* All ungulates except livestock show a low fecal composition by *Carex,* with a tendency for higher composition during the spring and early summer. Cattle use appears to increase through the grazing season, with a high of over 30% at the end of the grazing season.

Bromus spp (Figure 3d): All ungulates except deer appear to make at least moderate use of *Bromus*. Elk, Livestock and horses show increasing use of *Bromus* with a seasonal high (>40%) during the early summer (June, July).

Stipa sp*(Figure 3e):* Cattle and horses make use of *Stipa* while other ungulates show minimal fecal composition. Cattle make low use of *Stipa* (<10%) peaking during the mid summer, while horses show higher fecal composition with peak use during the winter.

Festuca spp *(Figure 3f): Festuca* appears important to elk in the early spring (April) and to livestock through the spring and summer grazing season. While average fecal composition of *Festuca* in horse scat shows variability due to the low number of samples, it appears important through the year.

Ceanothus cuneatus *(Figure 3g):* Cattle show low use of buckbrush, peaking during November at approximately 5% composition. Elk show moderate use with highs (approximately 10 %) during the spring and midsummer. Deer show a strong winter preference for buckbrush resulting in seasonal high of over 60 % fecal composition

Quercus sp *(Figure 3h):* All ungulates except horses show at least a low use of *Quercus* with a short and moderate seasonal high. Elk show a moderate composition by *Quercus* in the late winter/early spring. Deer show a more prolonged and moderate use through the summer with a peak in November. It is not known if acorn and leaf fragments were identified separately.

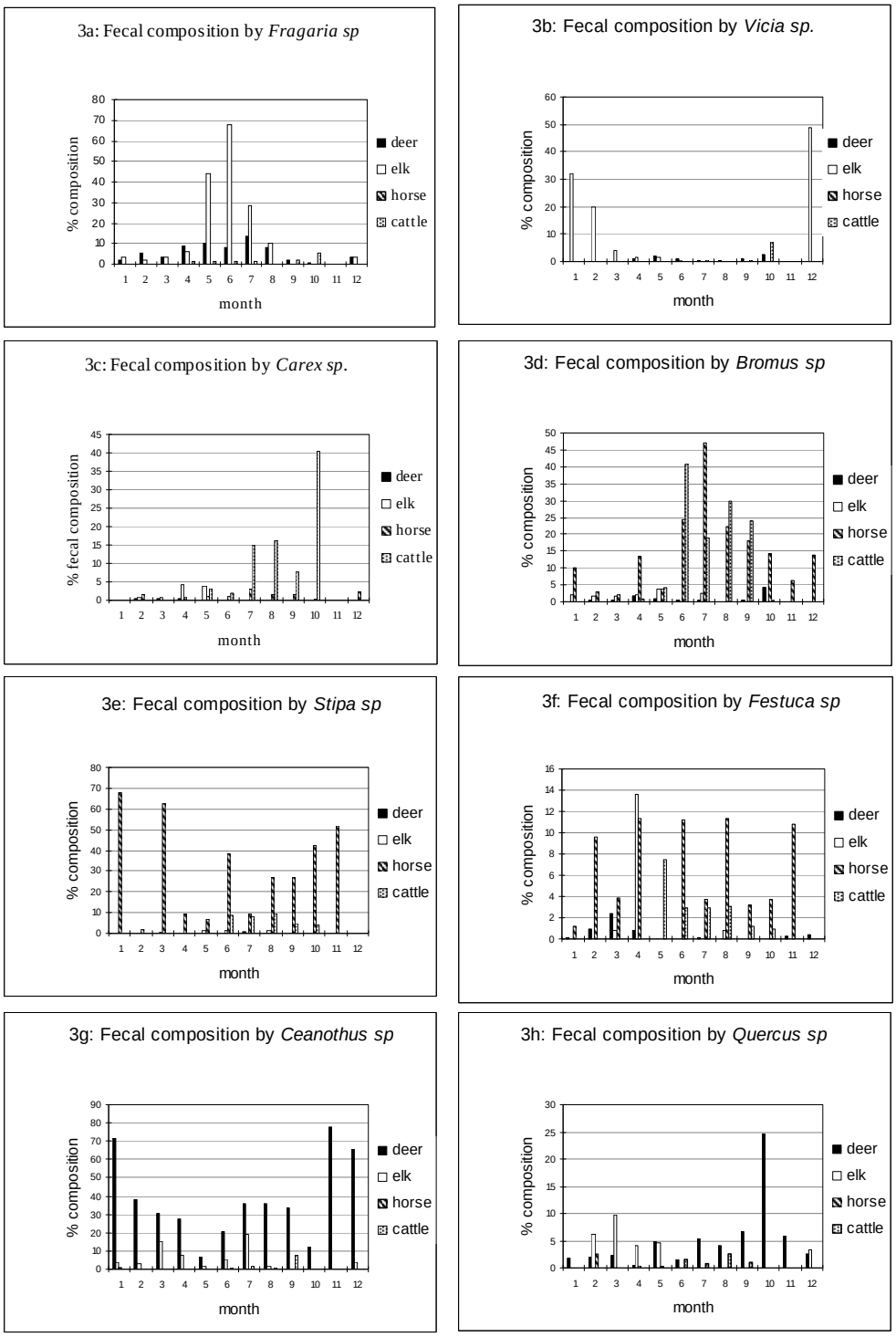

Figure 3. Seasonal variation of plant species found in fecal composition of deer, elk, horse, and cattle scat.

Seeds (Figure 4): The pattern of percent seed composition within fecal samples is similar for all ungulates examined. Composition increases gradually over the growing season as plants flower and set seed. A sudden drop in seed composition indicates an end to the availability of seed for ingestion. The order of maximum seed composition within fecal samples increases with horse (1.8%), elk (2.5%), deer (3.2%), and livestock (4.2%).

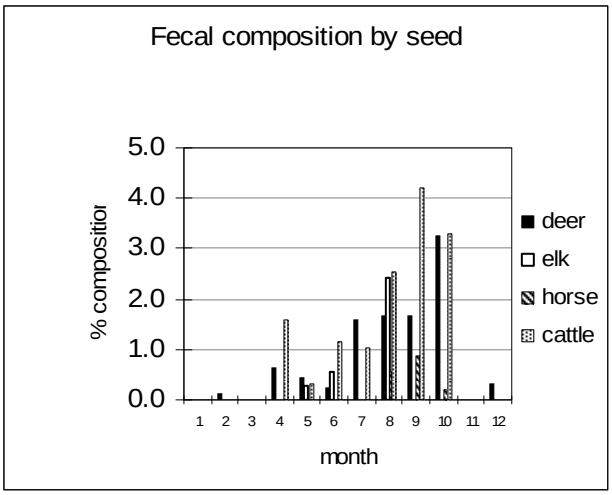

Figure 4. Percent fecal composition of seed for deer, elk, horse, and cattle.

Average Diet Composition by Month

Deer and horse diets are the least similar amongst all ungulates on the CSNM (Figure 5). Cattle and elk fecal composition are intermediate between deer and horse fecal composition, with elk fecal composition more similar to deer fecal composition, and cattle fecal composition more similar to horse fecal composition. The most closely associated average monthly fecal composition between livestock and native ungulates are late summer cattle diets and elk winter diets (December, January, February).

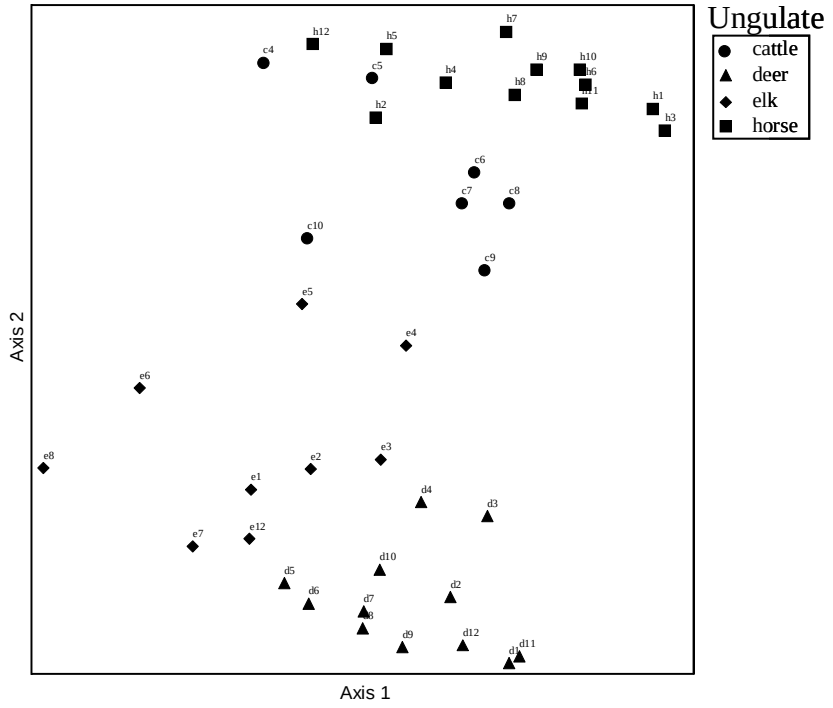

Figure 5. Ordination of average monthly fecal composition for cattle, deer, elk, and horse (sample label includes a number indicating month).

Species Richness

The ranked order for the average individual plant species richness (Table 2) in fecal samples is cattle (17.8; n = 45), elk (15.4; n = 12), horses (14.2; n = 25), and deer (13.1; n = 113). The average Shannon diversity for cattle elk and horses is similar (1.9, 2.0, and 1.8 respectively) and greater than for deer (1.4). Cattle use a greater number of species than native ungulates despite the relatively short grazing season for cattle. The disparate values for cattle, elk and horses may be reflected by the mode of bulk-grazing of larger animals versus selective food intake of fewer plant species by deer.

Table 2. Average species richness for cattle, deer, elk and horses.

	cattle	deer	elk	horse
Average Species Richness	17.8	13.1	15.4	14.2
Average Evenness	0.7	0.5	0.7	0.7
Average Shannon Diversity	1.9	1.4	2.0	1.8
Number of Samples	45	113	12	25

Interactions between native ungulates and cattle

Native Ungulate Response to Environmental Variables Across the Analysis Area

Telemetry data indicated that both deer and elk followed typical movement patterns identified in the literature. They moved from lower elevations in winter months to higher elevations in the summer (Figures 6 and 7). Slope use by both species followed an inverse pattern, with average slopes of observation points being steeper in winter and flatter in summer (Figures 8 and 9).

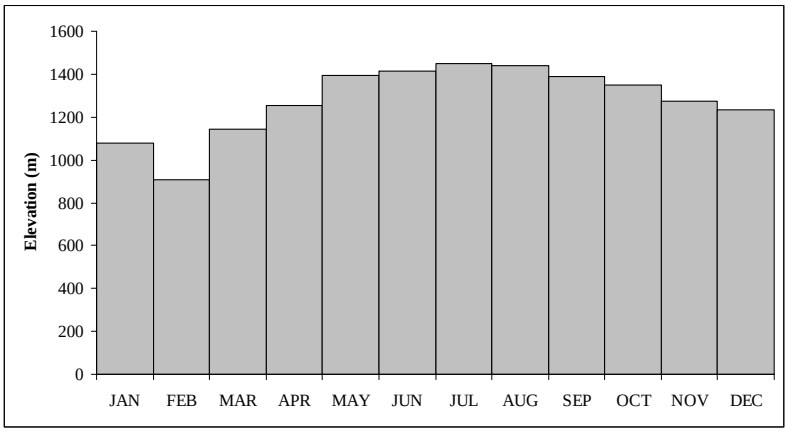

Figure 6. Average elevations of elk observation locations by month, 1992-1995.

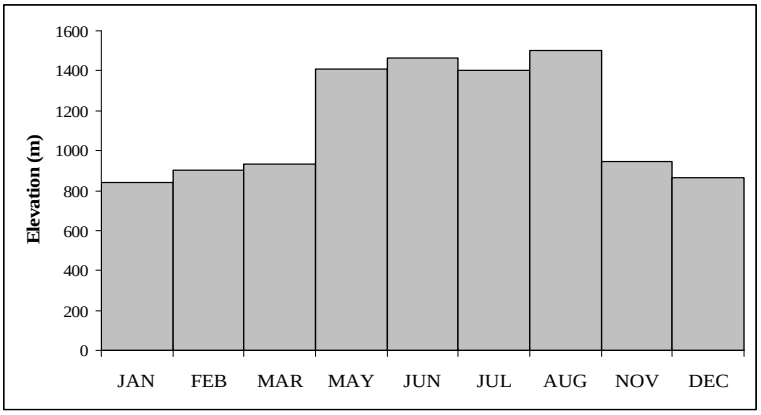

Figure 7. Average elevations of deer observation locations by month, 1994-1999.

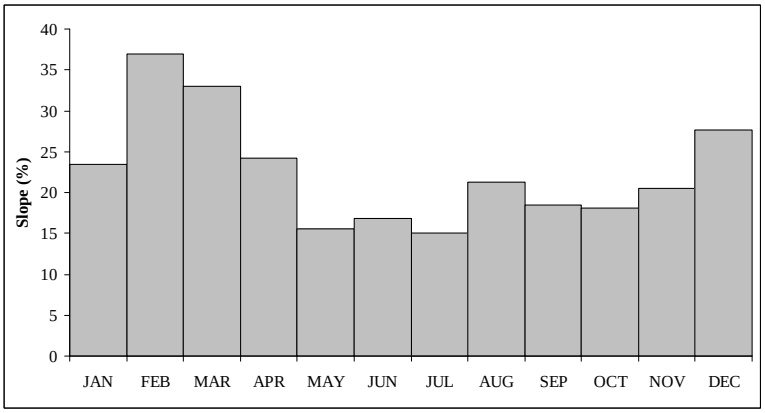

Figure 8. Average slope of elk observation locations by month, 1992-1995.

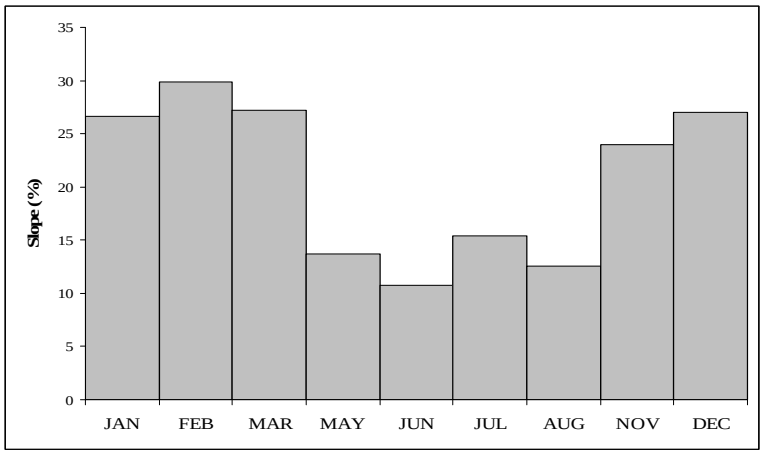

Figure 9. Average slope for deer observation locations by month, 1994-1999.

Native Ungulate Response to Management Variables Across the Analysis Area

Deer were observed less than expected 0 to 300 meters from roads, and more than expected farther than 300 meters from roads. In contrast, elk observations deviated significantly from expected values only in July, when more than expected fell within 300 meters of roads (Figure 10).

Throughout the analysis area, elk did not respond in any consistent way to distance from roads during winter months, but tended to occur more often than expected within 100 meters of roads in the summer months. This pattern changed immediately with the beginning of rifle hunting season in October, with fewer observations than expected within 100 meters of roads, and more than expected 200 – 600 meters from roads [Figure 10 (p=0.003)]. In November elk occurrence returned to the pre hunting season situation. Deer were observed more often than expected in the range of 300 – 1,000 meters from roads in winter months. In June deer were observed more often than expected within 100 meters of roads. September and October data were insufficient to determine distance from roads during early hunting season.

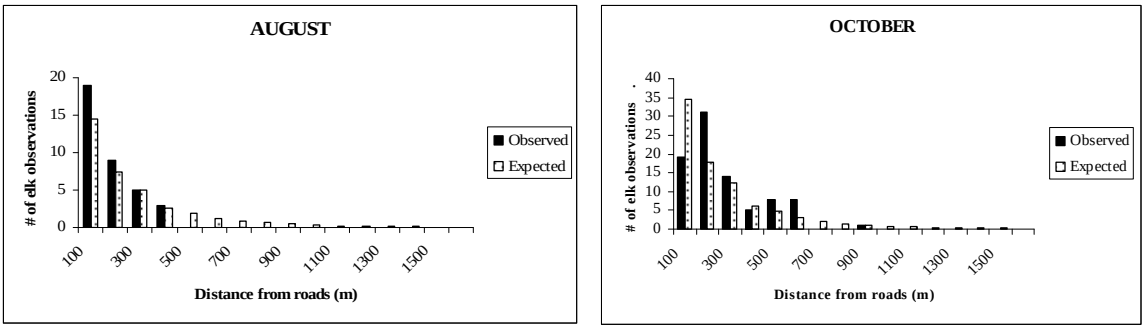

Figure 10. Actual and expected number of elk observations by road distance buffer for August and October for the entire analysis area.

Elk showed more consistent use patterns relative to 1995 cattle utilization areas. Elk were observed May - August less than expected in areas mapped as "no use (0 - 5%)" by cattle. Significantly more observations than expected occurred in "slight (6 – 20%)" and "light (21 – 40%)" cattle use areas in May and June, while July and August had more elk sightings than expected in "slight (6 – 20%)" to "heavy (61 – 80%)" areas (Figure 11). As the season progressed, elk were more likely to be observed in higher cattle utilization areas. The four months shown were the only ones significantly different from

expected values. No relationship between deer locations and 1995 cattle utilization areas was detected. Deer apparently used different habitat types than cattle, as only 19% of the deer observations fell within areas mapped as having cattle present in 1995. Deer observations were distributed nearly as expected (Figure 12). Only May differed significantly from expected values.

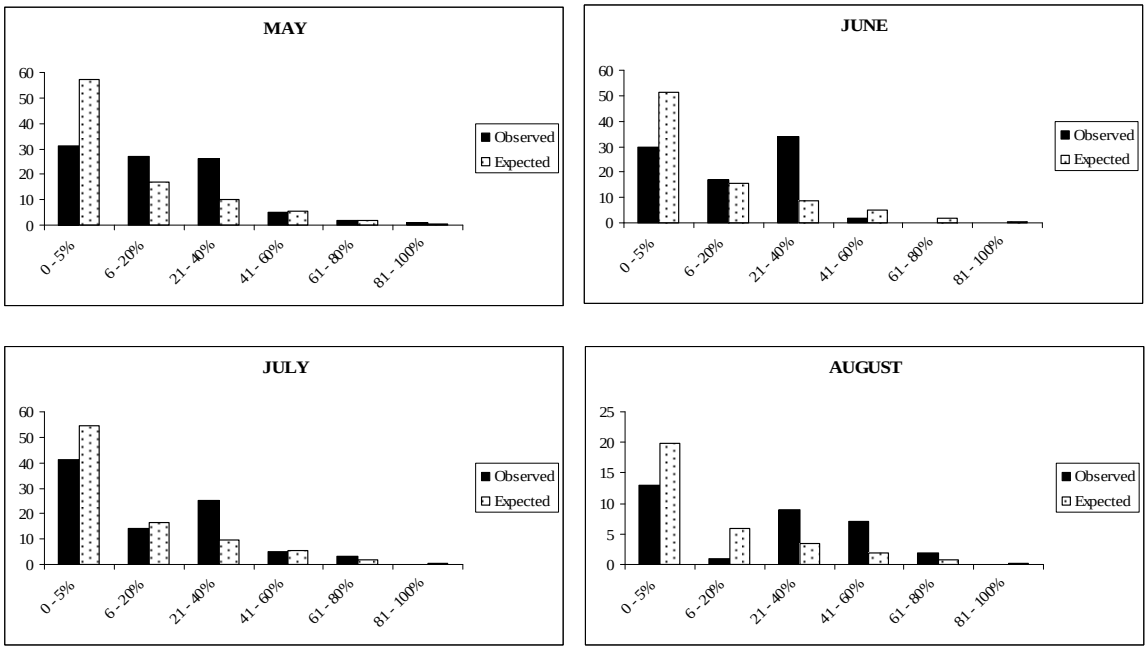

Figure 11. Actual and expected elk observations by 1995 cattle utilization class.

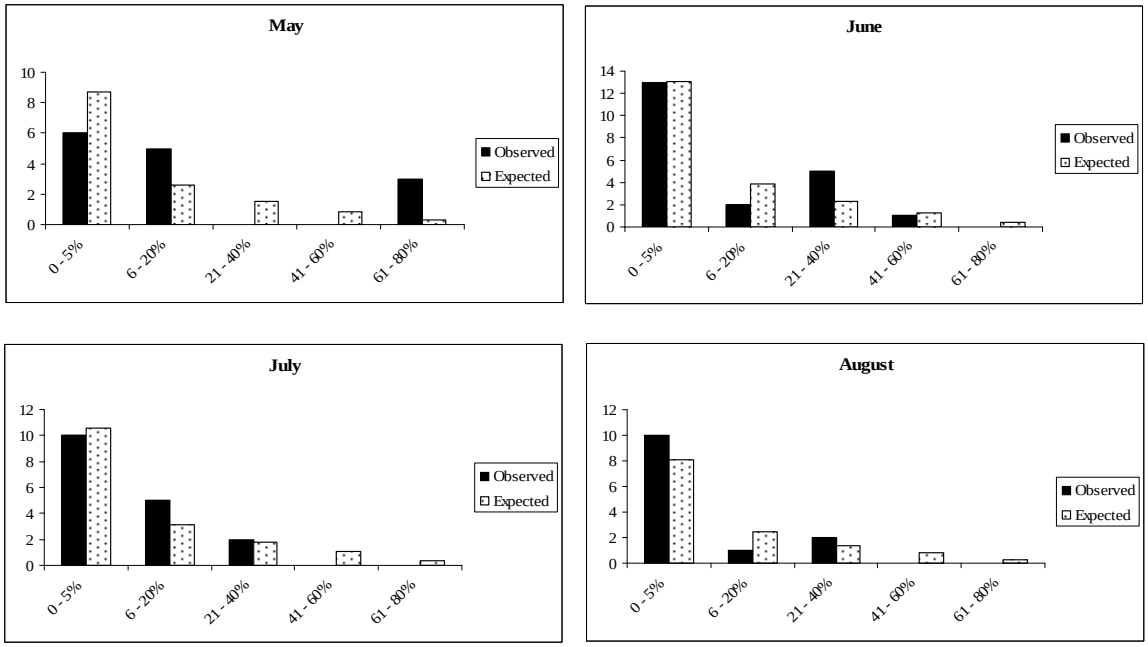

Figure 12. Actual and expected deer observations by 1995 cattle utilization class.

Interactions Between Elk, Deer and Cattle Within Individual Allotments

Keene Allotment (Figure 13f), Lake Creek Summer Allotment (Figure 13d), and Soda Mountain Allotment - Keene Pasture (Figure 13e) had more elk observations in them than expected when cattle were absent, and fewer than expected when cattle grazing the allotments. The result for Keen Pasture of the Soda Mountain Allotment was not significant. Conde Creek Allotment (Figure 13a) had more elk than expected prior to cattle grazing, and fewer than expected during and after. Grizzly Allotment showed a different pattern than the rest of the pastures examined, having fewer elk sightings than expected before, and more during and after cattle grazing (Figure 13b). Lake Creek Spring Allotment had fewer elk than expected before and during cattle grazing, but more than expected after cattle grazing, but the observed values did not differ significantly from expected (Figure 13c).

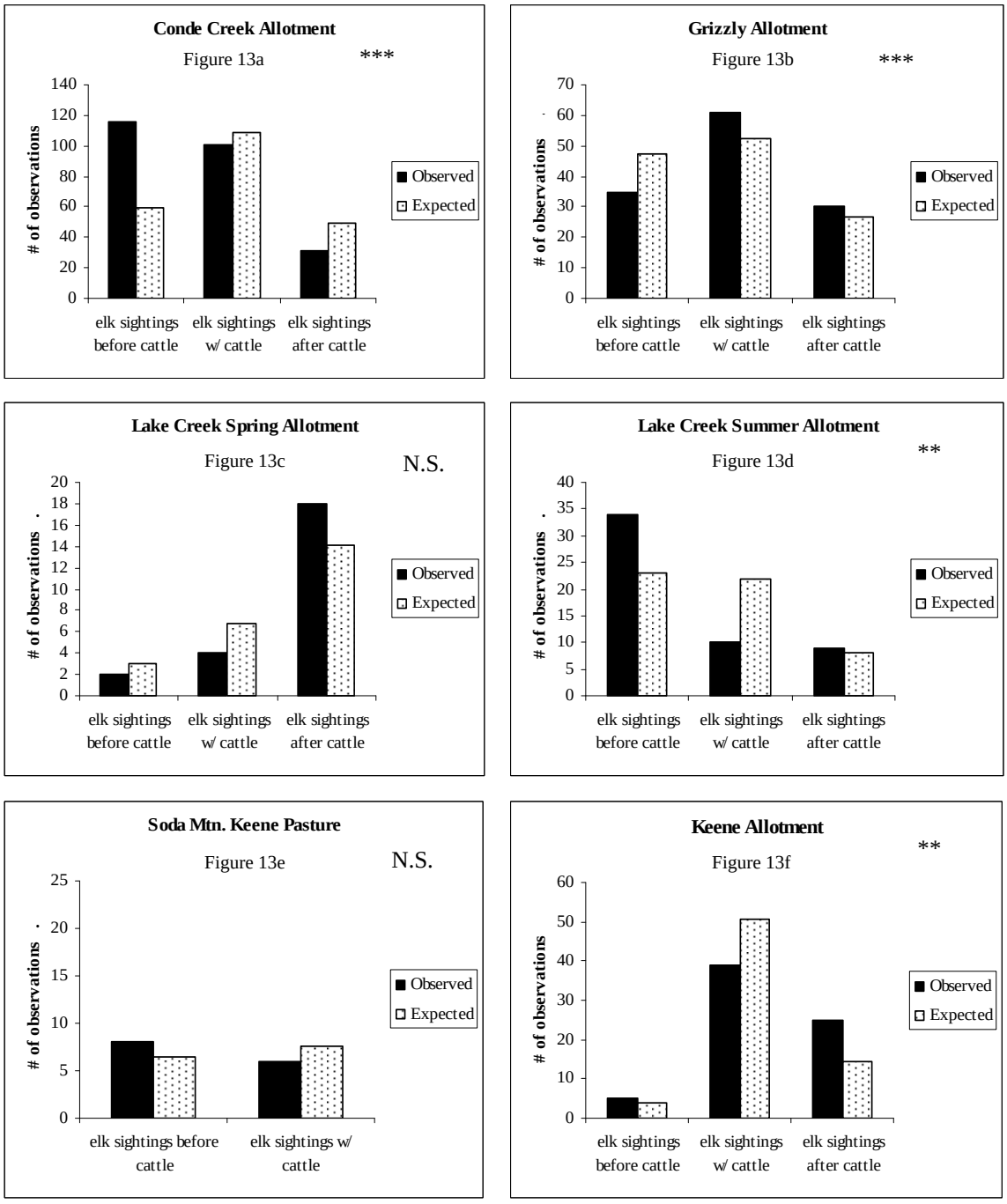

Figure 13. Actual and expected counts of elk observations within individual pastures (before, during, and after cattle grazing). Expected values based on proportions of total time between first and last elk observation. * <0.05, **<0.01, ***<0.001, N.S. = Not significant.

Grizzly and Lake Creek Spring Allotments show a displacement of elk to lower slopes by cattle, and a return to slopes occupied prior to the advent of grazing, though results are not statistically significant (Figure 14). Other allotments show a progression of average slope occupied by elk before during, and after grazing by livestock. Conde Creek Allotment and Keene Creek Allotments show a gain in elevation, while Lake Creek Summer Allotment shows a decline in slope occupied through prior, during, and post grazing (Figure 14).

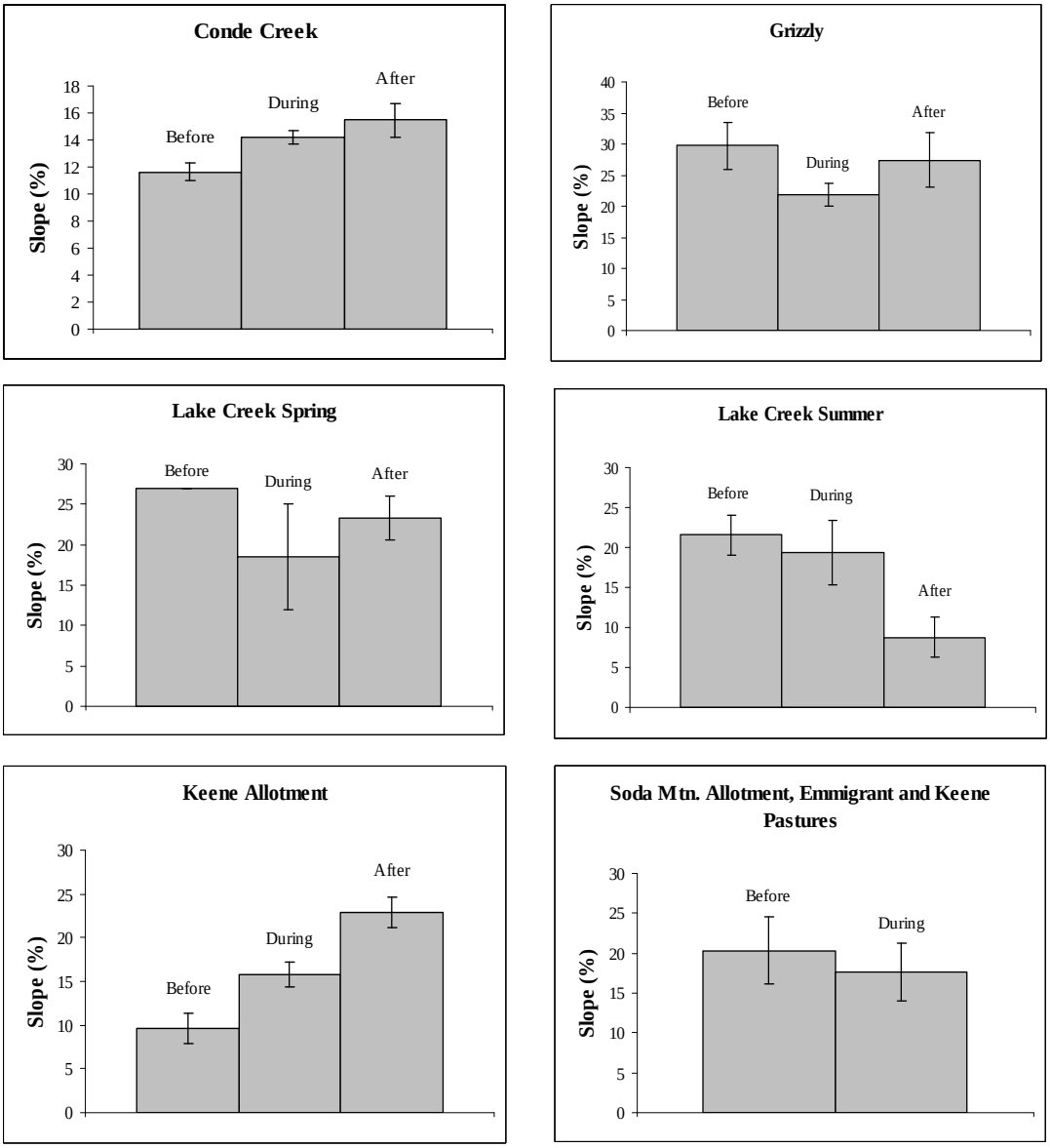

Figure 14. Average slope use by elk, by allotment before, during and after cattle grazing) (bars denote standard error).

Average elevation occupied by elk were are compared before, during, and after grazing by livestock (Figure 15). Three allotments (Conde Creek Allotment, Grizzly Allotment, and Keene Allotment) show a change in average occupied elevation with the advent of grazing, followed by a return to average elevation prior to grazing once livestock leave the allotment.

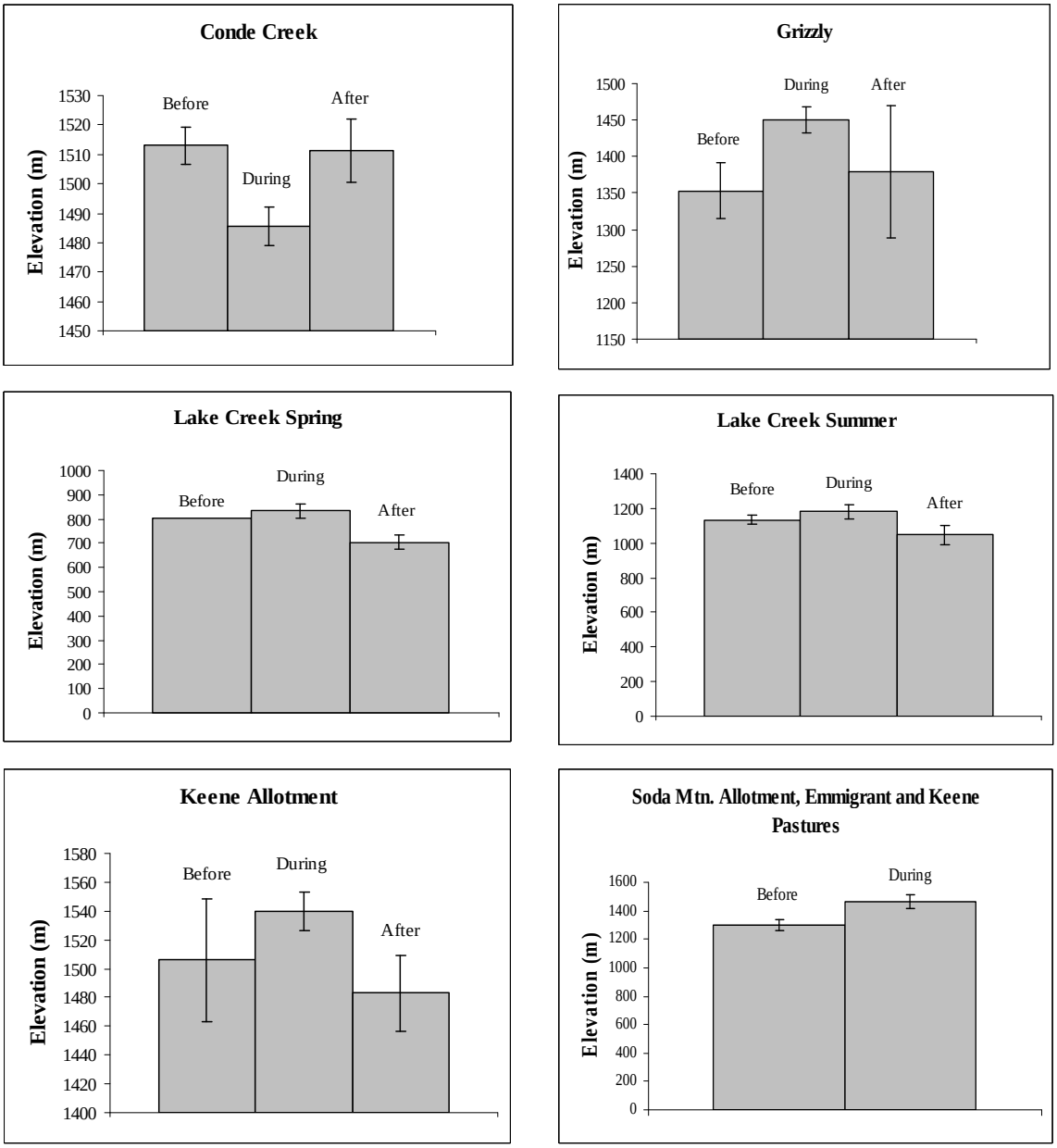

Figure 15. Average elevation use by elk, by allotment (before, during and after cattle grazing) (bars denote standard error).

Patterns of Deer and Elk Use at Seeps and Springs Relative to Livestock

Chi-square analysis showed less elk sign at springs used by cattle. While deer showed the same pattern of change, results were not statistically significant (Figure 16).

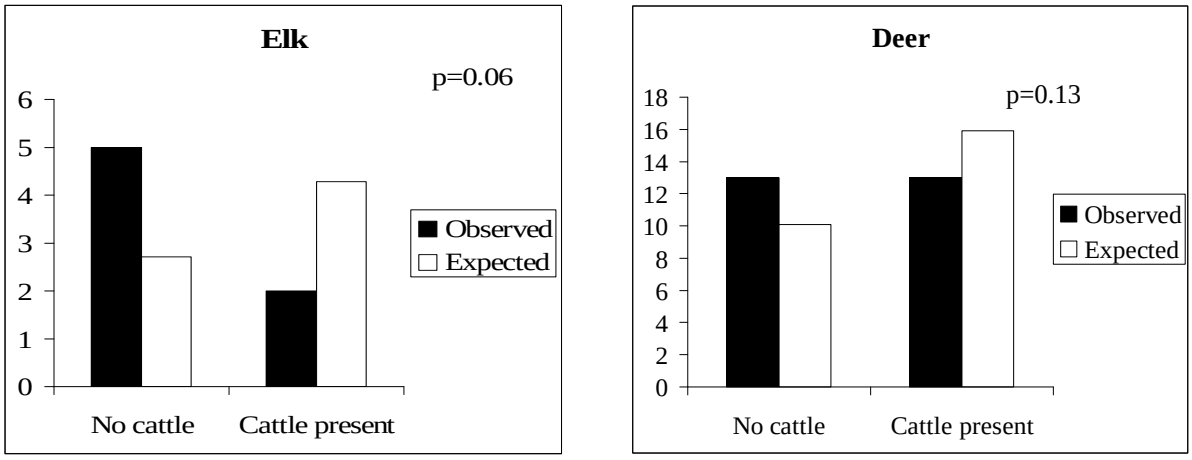

Figure 16. Deer and elk sign at high elevation springs relative to the presence/absence of sign from livestock.

DISCUSSION

Deer, Elk, and Cattle Fecal Composition and Seasonal Variation

Some epidermal fragments are not readily discernable from digested vegetation examined under the microscope. Fragments that are unidentifiable may be lumped into coarser categories due to their cell characteristics. Since individual plants may vary in their digestibility across the grazing season, their frequency of occurrence in fecal material may not be strictly proportional to the ingested phytomass. Despite these drawbacks, the fecal data analyzed in this study show many of the same dietary patterns identified in the literature. These patterns include the relative and seasonal use of individual plant species and life forms by both native and non native ungulates. Local deer are predominantly browsers throughout the year, but can show relatively high use of forbs in the winter and spring. Horses show consistently high use of grass through the year. Elk show a more variable diet, with high use of trees during the winter, forbs in the early summer, and shrubs during the late summer. Cattle show most consistent use of grass, but also utilize grasslike and wetland plants.

Cattle and elk diets are the most similar of the cattle versus native ungulate diets. In particular, late season (September and October) cattle fecal composition is most similar to spring fecal composition by elk (April and May).

The high presence of seed in cattle fecal material, relative to amounts in other ungulate species, implies active uptake rather than passive ingestion. It is not known if the seed resource is important to other ungulate species. It is possible that plants dependent on sexual reproduction may suffer a local setback due to reduced replenishment of the seedbank.

Of the individual plant species, wild strawberry (*Fragaria sp*) is the only upland forb whose epidermal fragments were commonly seen in fecal material of native ungulates and livestock Several grasses were used by both cattle and native ungulates, though none occur in limited habitats. Sedges (*Carex spp*) are the only species used by livestock that occur within limited habitat across the landscape.

Native Ungulate Response to Environmental Variables

Data suggested that animal use of elevation and slope is typical of what has been found in other studies. Animals tended to retreat to lower elevation winter ranges as deep snow blankets the high elevations. During winter months, elk and deer also tend to favor southerly slopes and open habitats during daylight to maximize incident solar radiation. In early spring, as forage becomes available and temperatures rise, deer and elk gravitate towards the lush forage and cool shade offered by north faces and conifer communities.

Elk are generally thought to keep away from roads (Rowland et al 2005). Through much of the region, roads carved out of forested and brush areas create a swathe of forage and shrub resprouts, perhaps explaining the favored use of roadsides by elk in the vicinity of the monument. Movement away from roads during the hunting season indicate displacement by the annual hunt.

Effects of Cattle Presence on Elk Distribution

Observations in three allotments most favored by elk when livestock were not present (Conde Creek, Lake Creek Summer, and Keene) suggested that elk were inclined to move to other areas such as Lake Creek Spring Allotment following the introduction of cattle. Several allotments (Grizzly, Lake Creek Summer, and Keene allotments) show counts of elk within potential vegetation types that changed with the advent of cattle

grazing, and then reverted to pre grazing levels following the cessation of the grazing season. This suggests that cattle do influence elk movements reflect a shift in habitual areas near favored meadows following cattle introduction. As summer progressed, elk tended to occur more frequently in high cattle use areas, and wet meadows, suggesting that as forage dried out and became scarce, elk were more willing to spend time near cattle. Past studies have made similar interpretations of elk increasingly spending time near cattle as summer progressed (Coe et al.2005; Nelson 1982).

Seeps and springs are widely used by many species of animals, particularly in the hot, dry months of summer. Observations from seeps and springs suggest that cattle may displace native ungulates, in particularly elk, from these areas.

CONCLUSIONS

Wetland plants are the only plant species used by cattle that occur on limited habitat. Since the collection of the fecal samples data, several lower elevation wetland areas have been fenced and show considerable improvement in terms of reduced cover by bare soil and increased cover by sedges or riparian shrubs (Hosten and Whitridge 2007). Historic use of buckbrush (*Ceanothus cuneatus*) by cattle was implicated in winter deer die-off (Hosten et al. 2007c). Changes in the timing of cattle grazing appear to have reduced use of buckbrush enough to alleviate competition for this shrub resource within the CSNM. Use of riparian shrubs by cattle increases towards the end of the grazing season at higher elevation (Hosten et al. 2007c), but there is no indication that this causes dietary shortfalls for native ungulates. History and studies in California chaparral (Biswell 1999) suggests that the lack of fire and consequent lack of fresh growth by key shrubs as browse, such as buckbrush (*Ceanothus cuneatus*), may play a more important role in maintaining the health of deer and elk through winter and spring. Urban sprawl, agricultural development and the consequent loss of winter habitat outside the CSNM are also more likely to be an issue than dietary constraints due to cattle grazing within the analysis area.

Studies of social interaction between cattle and native ungulates on the CSNM and extended analysis area suggest that native ungulates show lower visitation at seeps and springs frequented by livestock, or, change their behavior so as to reduce the number of bedding sites and scat. The disparate diet of deer in comparison to cattle is validated

by the apparent lack of social interaction with cattle away from water sources. Elk have a diet more similar to cattle and show several instances of displacement by cattle in uplands away from water- sources. Displacement of elk away from roads during hunting season indicate that cattle are not the only influence on elk movements. The fact that elk and cattle are observed on the same winter pastures on private land indicates that the tendency for elk to move away from cattle is overcome when forage and browse resources are constrained by winter snowfall.

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