

# Ungulate foraging areas on seasonal rangeland in northeastern Oregon

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## Abstract

In much of the west, seasonal rangeland provides important foraging opportunities for wild and domestic ungulates during times when forage is often limited. We studied the use of foraging areas by Rocky Mountain elk (*Cervus elaphus nelsonii* Bailey), mule deer (*Odocoileus hemionus hemionus* Rafinesque), and cattle grazing the same seasonal rangeland in northeastern Oregon. We determined the potential for ungulate use to overlap and the influence of vegetation and terrain features on that use. Vegetation and terrain features of plant communities in the *Festuca-Agropyron* and *Agropyron-Poa* Associations were inventoried on a 1,844 ha study area of privately owned seasonal rangeland to define characteristics of ungulate foraging areas. Slope, aspect, elevation and, edge between bunchgrass and forested vegetation types, were evaluated from topographic quadrats. Observations of ungulate distribution on the study area were also obtained. A Geographical Information System using map overlays intersected spatially defined plant communities and terrain features with location of ungulates. Indices of ungulate preference for plant communities and terrain features were established. Discriminant analysis was used to determine which features were most likely to influence ungulate selection of foraging areas. Terrain features having greatest influence on ungulate selection of foraging areas were, distance to the ecotonal edge between steppe and forest communities, and elevation. Cattle preferred foraging areas comprised of Idaho fescue-annual grass plant communities located at medium distance from the forest edge and on moderate elevation. Elk preferred foraging areas comprised of bluebunch wheatgrass-annual grass and Idaho fescue-bluebunch wheatgrass near the forest edge at higher elevations. Mule deer preferred buckwheat-bluegrass scabland plant communities at medium distance from the forest edge at higher elevation. Probability of ungulates using similar foraging areas was highest for elk and cattle and least for elk and mule deer.

**Key Words:** mule deer, elk, cattle, diet overlap, preference, selection, Geographic Information System

Seasonal rangeland associated with interior valleys of the Pacific Northwest provides foraging opportunities at critical times for wild and domestic ungulates (Skovlin and Vavra 1979). Before settlement, habitat for large wild ungulates in the region was relatively complete (Vavra 1993). With settlement, ungulate winter habitat on valley floors was converted to agricultural land, livestock grazing became the dominant use of all rangeland, and timber was harvested from forested uplands. These activities have changed the matrix of vegetation and terrain features comprising ungulate habitat (Cronyn and Workman 1994).

Seasonal rangeland now provides critical late fall, winter, and spring forage for Rocky Mountain elk (*Cervus elaphus nelsonii* Bailey) and mule deer (*Odocoileus hemionus hemionus* Rafinesque). Domestic livestock often graze seasonal rangeland in spring and early autumn. In 1982, we initiated a 3-year case study to determine the influence of vegetation and terrain features on selection and overlap of foraging areas by Rocky Mountain elk, mule deer, and cattle. Although this was a case study and limited to a relatively small area, information obtained on ungulate use of seasonal rangeland in this area is a valuable aid for planning and managerial decision-making by administrators and users of seasonal rangeland (Vavra 1980, Powell et al. 1986).

## Materials and Methods

The study area of 1,844 ha was privately owned seasonal rangeland on the northern exposure of the Blue Mountains in northeastern Oregon. It was typical of seasonal rangeland occurring throughout the Blue Mountain Region of Oregon, Washington, and Idaho. In this area, grass steppe vegetation of the Columbia Basin Geological Province intergrades with forest vegetation of the Blue Mountain Geological Province (Franklin and Dyrness 1973) to form seasonal rangeland providing important foraging areas for wild and domestic ungulates (Vavra 1980).

Dominant perennial grasses were Idaho fescue (*Festuca idahoensis* Elmer), bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), Sandberg's bluegrass (*Poa sandbergii* Vasey), Kentucky bluegrass (*P. pratensis* L.), prairie junegrass (*Koeleria cristata* Pers.), and pinegrass (*Calamagrostis rubescens*

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Buckl.). Annual brome grasses (*Bromus mollis* L., *B. brizaeformis* Fisch. & Mey, *B. tectorum* L.) were common and dominated ecologically disturbed sites. Several perennial forbs (*Achillea milifolium* L., *Hieracium albertium* Farr, *Astragalus conjunctus* Wats.) were common on all grass steppe sites. Woody shrub species (*Rosa woodsii* Lindl., *Symphoricarpus albus* (L.) Blake) occurred along stream drainages in grass steppe, and as understory components in forest communities. Forest vegetation adjacent to the study area was dominated by seral stands of Douglas fir (*Pseudotsuga menziesii* (Mirbel) Franco) and ponderosa pine (*Pinus ponderosa* Dougl.) with an understory of pinegrass or elk sedge (*Carex geyrei* Boott). Previous studies in the Blue Mountain Region have developed synecological and successional relationships for vegetation and soil types characterizing the study area (Poulton 1955, Daubenmire 1970, Tisdale 1982, Johnson 1982).

Terrain of the study area was characterized by flat-topped ridges with steep side-hills and narrow stream drainages on the open grass steppe study area. Terrain at the ecotone, between grass steppe and forest vegetation, was characterized by several broad ridgelines perpendicular to streams draining the study area. Elevation of the study area ranged from 1,036 m to 1,341 m.

Climate was continental with low precipitation, warm to hot summers and relatively cold, dry winters. Most precipitation occurred as snow during winter, and rain during spring. Fall precipitation was common, and substantial growth of perennial grass species often occurred. Yearly precipitation during the 3 years of the study was normal and averaged 442 mm.

#### Temporal and Spatial Distribution of Herbivores

Observations of ungulate use of foraging areas were obtained between March 1982 and August 1984. Ungulate observations between December and May were obtained on foot or horseback due to snow or unstable ground conditions. Between May and December, ungulate use was obtained from a vehicular route along the same ridgelines traversed by foot or horseback between December and May. Observations were obtained only during daylight hours, emphasizing early morning and evening. Mid-day observations were generally obtained in conjunction with ongoing study activities. Except for narrow canyon bottoms, higher elevation ridgelines allowed almost total observation of the grass steppe portion of the study area.

An observation of ungulate grazing use consisted of all animals that formed a cohesive group engaged in foraging. If any animals in the group were grazing at the time of observation, even though movement was continuous or some animals in the group were engaged in non-foraging activities, the observation was recorded as being a valid indication of ungulate selection of a foraging area. Total observations of wild ungulates were 125 groups for Rocky Mountain elk and 137 groups for mule deer. A total of 143 group observations of cattle were made.

#### Plant Community and Terrain Characteristics

Vegetation was classified by plant communities using measurement techniques described by Daubenmire (1968). Grass steppe communities available to ungulates for foraging were mapped on 1:24,000 scale aerial photos. Seventy-three macroplots of 0.05 ha were proportionally distributed by plant community and, within each macroplot, 20 microplots with area of 0.2 m<sup>2</sup> were sampled to determine basal cover and plant frequency.

Terrain features were evaluated using statistics obtained from USGS topographic quadrangles. These included: 1) eleven gradients of slope between 0 and 62.5% in intervals of 6.2%; 2) eight directions of aspect (N,E,S,W,NE,SE,SW,NW) with direction determined from the right angle of contour lines; 3) thirteen classes of elevation with each class representing a 31 m increment in elevation; and 4) nine distance intervals of edge (the distance from any point on the study area to the edge formed by the juncture of grass steppe and forest vegetation).

#### Ungulate Selection of Foraging Areas

Locations of ungulates, boundaries of plant communities, and boundaries of classes of terrain features were recorded on 1:24,000 scale aerial photography, and subsequently transferred to 19 cm scale USGS topographic quadrangles. Topographic quadrangles of the study area were overlaid with a grid dividing the study area into 0.54 ha pixels. Digitized information files were created by assigning coded numbers to pixels in which ungulates had been observed and to pixels within boundaries of plant communities and classes of terrain features.

A Geographic Information System (GIS) was used to intersect ungulate grazing locations with plant communities and terrain features. The overlay function of the Map Analysis Package (MAP) computer algorithm (Unpublished data, Tomlin) associated ungulate locations with spatially defined plant communities and terrain features to characterize ungulate foraging areas.

Statistics describing plant communities and terrain features at the intersection with ungulate location were used to determine significant association between ungulate locations, vegetation, and terrain features (Sheehy et al. 1987). Ratios were used to develop selectivity indices indicating ungulate preference for plant communities and terrain features (Krueger 1972). The proportion of ungulate locations occurring within a plant community or terrain feature, and the proportion of that plant community or terrain feature within the study area, were used to develop a ratio indicating ungulate preference for the plant community or terrain feature.

Chi-square analysis with independence assumption was used to test for significant association of ungulate locations with plant communities and specific terrain features (Remington and Schork 1970). Rejection of the null hypothesis indicated that a significant association existed between ungulate locations and foraging areas. Confidence intervals for determining ungulate association with specific foraging areas were obtained (Neu et al. 1974). Foraging areas selected by an ungulate in greater proportion than found in the study area were classified as preferred. Those areas selected in proportion to availability on the study area were classified as desirable. Foraging areas selected in proportion lower than occurrence were classified as undesirable. Foraging areas not selected by ungulates irrespective of availability on the study area were classified as avoided.

Discriminant Function Analysis was used to determine the spatial characteristics of seasonal rangeland that most influenced ungulate selection of foraging areas (Hudson 1976, Hanley and Hanley 1982). Groups in the discriminant function were locations of Rocky Mountain elk in the winter and spring, mule deer in the winter and spring, and cattle in summer and in fall. Discriminating variables were plant communities, slope, aspect, elevation, and distance to edge. A stepwise selection procedure was used to select the variables most useful in determining the

discriminant functions accounting for the greatest proportion of total variance within and between groups. Variable importance was chosen by the criterion of minimizing Wilks lambda-U, a measure of group discrimination, to maximize the overall univariate F ratio for the test of differences among group centroids (Klecka 1975).

The association between discriminating variables at the foraging area and ungulate use was determined by the MacArthur and Levins (1967) equation formulated as the "R" (range overlap) equation by Nelson (1985):

$$R_{12} = \frac{n=1 \sum [U_{h1}, U_{h2}]}{n=1 \sum [U_{h1}]}$$

where  $R_{12}$  equals the probability of ungulate 2 having an identical distribution pattern as ungulate 1 in s-number of vegetation and terrain strata;  $U_{h1}$  equals the proportion of time which ungulate 1 spends in stratum "h"; and  $U_{h2}$  equals the proportion of time which ungulate 2 spends in stratum "h".

The "R" equation was used to determine the probability of ungulate overlap in use of preferred, desirable, undesirable, or avoided foraging areas. "Stratums" were plant communities or terrain features for which ungulate preference was determined from observations of ungulate use relative to availability of the stratum on the study area. The "R" equation determined the probability that ungulate use of a foraging area would overlap according to preference of each ungulate single plant community or terrain feature "stratum." An iterative process using the "R" equation determined the probability that ungulate use would overlap if the most important discriminating variables (as determined from Discriminant Analysis) together influenced ungulate selection. The most discriminating variable initially determined the total foraging area for each ungulate in each preference class. At each iteration, each successively less discriminating variable determined the availability of the foraging area to each ungulate depending upon whether ungulate selection of a foraging area was influenced by single or multiple discriminating variables.

## Results and Discussion

### Ungulate Use

Seasonal rangeland of the study area was used by at least one of the three ungulates in every season, but with little direct temporal overlap (Fig. 1). Cattle used the study area primarily in late spring-early summer and in the fall with the duration of fall use dependent upon weather conditions. Generally, by late December, cattle had moved to lower elevation winter ranges and feed-grounds because of snowfall and cold temperature. When on the study area, cattle were confined to specific pastures with movements made according to grazing management strategies of the livestock owner. Average use by cattle of the study area between 1982 and 1985 was 1,280 AUM's per year.

Highest use by elk occurred during winter and spring seasons (Fig. 1). Elk use increased each month from December to April, but declined abruptly in May, when elk moved off the study area. The temporal and spatial pattern of elk use of seasonal rangeland appeared related to availability of forest communities. Elk moved from forest communities to grass steppe rangeland in late afternoon along several travel corridors, which provided cover and foraging opportunities. They usually returned to forest communi-

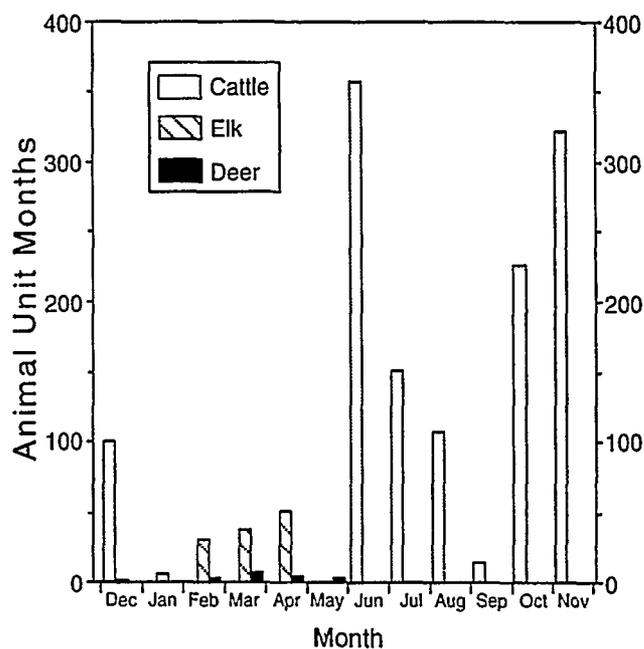


Fig. 1. Monthly ungulate use (AUMs) of the northeastern Oregon study area.

ties by mid-morning of the following day. After mid-May, elk use of grass steppe rangeland of the study area was limited to a few summer resident elk. Elk use of the study area, calculated as 2 adult cow elk per AU equivalent, averaged 134 AUM's per year.

Mule deer wintered near agricultural land at an elevation lower than the study area. Coincidentally, deer use of the study area peaked in March with the increased availability of early season bunchgrass and forbs (Fig. 1). Use of the study area in late winter and early spring appeared to be influenced by weather, as it affected the availability of spring forage growth. Most grazing by deer in late winter and early spring was concentrated on open grass steppe rangeland. Deer use of the study area, calculated as 5 adult doe per AU equivalent, averaged 21 AUM's per year.

### Characteristics of Vegetation

Vegetation of the study area was 74.3% grass steppe and 25.7% shrub, meadow, riparian, and talus garland communities. Six bunchgrass plant communities in the bluebunch wheatgrass-bluegrass, and Idaho fescue-bluebunch wheatgrass Associations characterized grass steppe of the study area (Table 1). Communities in the bluebunch wheatgrass-bluegrass Association were bluebunch wheatgrass-Sandberg's bluegrass, bluebunch wheatgrass-annual grass and strict buckwheat-bluegrass scabland. Communities in the Idaho fescue-bluebunch wheatgrass Association were Idaho fescue-bluebunch wheatgrass, Idaho fescue-annual grass and Idaho fescue-biscuit scabland. Talus garland communities on steep slopes, meadow, shrub, and riparian plant communities also occurred on the study area but were of limited extent. Riparian communities were limited to stream drainages formed by steep canyon walls that provided little foraging opportunities for ungulates. However, elk used canyon ripari-

Table 1. Dominant plant species (% frequency) of seasonal rangeland plant communities in the northeastern Oregon study area.

	Plant Communities <sup>1</sup>					
	Feid/Agsp (%)	Feid/A. Grass (%)	Feid/Mound (%)	Agsp/Posa (%)	Agsp/A. Grass (%)	Erst/Poa (%)
<b>Perennial Grass</b>						
<i>Festuca idahoensis</i>	96.0	89.0	85.0	7.0	23.0	30.0
<i>Agropyron spicatum</i>	90.0	83.0	77.0	73.0	43.0	83.0
<i>Poa sandbergii</i>	57.0	46.0	1.0	61.0	23.0	7.0
<i>Poa leibergii</i> Scrien.	32.0	T	3.0	31.0	40.0	65.0
<b>Annual Grasses</b>						
<i>Bromis mollis</i>	42.0	95.0	19.0	21.0	8.0	97.0
<i>Bromus brizaeformis</i>	8.0	13.0	9.0	5.0	10.0	30.0
<i>Bromus tectorum</i>	10.0	23.0	59.0	62.0	17.0	15.0
<i>Festuca megalura</i> Nutt.	1.0	0.0	0.0	23.0	23.0	0.0
<b>Forbs</b>						
<i>Achillea millifolium</i>	39.0	30.0	64.0	16.0	27.0	3.0
<i>Erigonum heracleoides</i> Nutt.	4.0	11.0	5.0	T	23.0	T
<i>Lomatium cous</i> (Wats.) Coult & Rose	20.0	T	9.0	T	0.0	0.0
<i>Lomatium leptocarpum</i> . (T. & G.) Coult. & Rose	23.0	3.0	0.0	8.0	0.0	8.0
<i>Astragalus conjunctus</i>	42.0	17.0	0.0	12.0	0.0	2.0
<i>Balsamorhiza serrata</i> Nels. & Macbr.	7.0	5.0	T	6.0	0.0	33.0

<sup>1</sup>The definition of plant community acronyms are as follows: Feid/Agsp is the Idaho fescue-bluebunch wheatgrass plant community; Feid/A. Grass is an Idaho fescue plant community with a high proportion of annual grasses, especially annual brome grasses; Feid/mound is an Idaho fescue plant community associated with loessal "mima" mounds; Agsp/Posa is a bluebunch wheatgrass-Sandberg's bluegrass plant community; Agsp/A. Grass is a bluebunch wheatgrass plant community with a high proportion of annual grasses; and Erst/Poa is a strict buckwheat/bluegrass plant community.

an communities for forage and thermal cover when adverse weather conditions prevailed on the study area.

Idaho fescue and bluebunch wheatgrass dominated plant communities in the Idaho fescue-bluebunch wheatgrass Association. Bluebunch wheatgrass and Sandberg's bluegrass dominated plant communities in the bluebunch wheatgrass-bluegrass Association (Table 1). Annual brome grasses, such as soft chess and cheatgrass, had high occurrence in all plant communities, especially in Idaho fescue and bluebunch wheatgrass plant communities which were in degraded ecological condition (Sheehy 1987). The Idaho fescue-bluebunch wheatgrass and bluebunch wheatgrass-Sandberg's bluegrass plant communities were in high seral condition with high frequency of native perennial grasses and forbs.

Plant communities in higher seral condition is a characteristic of foraging areas grazed by wild ungulates in winter and early spring. A secondary forage component available to wild ungulates was cured plant material from the previous summer's growing season. Observations of winter and early spring grazing by wild ungulates indicated wild ungulates valued fall growth of perennial grasses. Nutritive value of fall growth of Idaho fescue, bluebunch wheatgrass, and Sandberg's bluegrass is known to be high compared to standing crop from the previous growing season (Sheehy 1987). In early spring, grass steppe plant communities had a "flush" of rapid growth as annual brome grasses, annual forbs, some early perennial forbs, and perennial bunchgrasses responded to warming temperatures. All plant communities, except for Idaho fescue-annual grass, had increased new growth of standing crop available for ungulate grazing by early spring.

By late spring, when wild ungulates generally migrated off the study area to summer rangeland at higher elevation, or to lower elevation agricultural land, standing crop on these plant communities had increased between 191 to 487% from early winter availability, irrespective of winter and spring use by wild ungulates (Sheehy 1987).

## Terrain

Terrain of the study area had a major influence on ungulate use. Features such as slope, aspect, and elevation in combination with soils and climate were major determinants of community structure and location. Terrain was also a major factor influencing occurrence of specific communities along the grass steppe and forest ecotone.

Maximum slope encountered was 62.5%. Plant communities dominated by Idaho fescue had slope ranging between 0 and 25.0%. Bluebunch wheatgrass dominated communities tended to occur on slope ranging between 6.3 and 31.2%. Ninety-three percent of the area of bluegrass scabland plant communities occurred near, or on ridgetops having minimal slope.

Terrain had all aspect directions and horizontal aspect with near proportional distribution of all aspect direction, except south and horizontal. Plant communities dominated by Idaho fescue had highest occurrence on north and east aspects. Plant communities dominated by bluebunch wheatgrass had highest occurrence on east, south, and west aspects. The strict buckwheat-bluegrass scabland plant community was proportionally distributed on all aspects except south.

Elevation ranged from 1,005 to 1,341 m. Highest spatial occurrence of all plant communities was between 1,098 and 1,311 m of elevation. The bluebunch wheatgrass-Sandberg's bluegrass plant community occurred at all elevations, while plant communities dominated by Idaho fescue tended to occur most at higher elevations.

Edge formed by the grass steppe and forest boundary was a dominant characteristic. Although all plant communities contributed to edge, communities dominated by bluebunch wheatgrass and Idaho fescue had greatest area adjacent to the forest boundary. Other communities dominated by annual grasses, bluegrasses, and perennial forbs were located at greater distance from the forest boundary.

### Factors Influencing Ungulate Selection of Foraging Areas

The frequency that a plant community or terrain feature occurred, compared with the frequency that a plant community or terrain feature was grazed by an ungulate, indicated that foraging areas were not selected randomly. Chi-square analysis of the frequency of ungulate occupancy suggested that selection of foraging areas by all ungulates was influenced ( $P < 0.01$ ) by plant communities, aspect, and distance from edge. Cattle and elk selection of foraging areas were influenced ( $P < 0.01$ ) by elevation. Selection of foraging areas by mule deer and elk were influenced ( $P < 0.01$ ) by slope.

**Cattle Foraging Areas.** Foraging areas preferred by cattle were Idaho fescue-annual grass communities on higher elevations at moderate distance from the forest edge (Table 2). Desirable foraging areas were bluebunch wheatgrass-annual grass, Idaho fescue-

**Table 2.** Cattle selection of vegetation and terrain features on seasonal rangeland in northeastern Oregon.

Preference	Plant community <sup>1</sup>	Slope (%)	Aspect	Edge distance (m)	Elevation (m)
Preferred	Feid/A.Grass			367-976	1251-1280
Desirable	Agsp/A. Grass	0-50.0	All	245-366	1190-1250
	Feild/Agsp				1281-1311
	Feid/Mound				
	Agsp/Posa				
Undesirable	Erst/Poa	>50.0		123-244 977-1281	1068-1189 1312-1341
Avoided	None			0-122 1281-1891	<1005 1005-1067 >1341

<sup>1</sup>The definition of plant community acronyms are as follows: Feid/Agsp is the Idaho fescue-bluebunch wheatgrass plant community; Feid/A. Grass is an Idaho fescue plant community with a high proportion of annual grasses, especially annual brome grasses; Feid/mound is an Idaho fescue plant community associated with loessal "mima" mounds; Agsp/Posa is a bluebunch wheatgrass-Sandberg's bluegrass plant community; Agsp/A. Grass is a bluebunch wheatgrass plant community with a high proportion of annual grasses; Erst/Poa is a strict buckwheat/bluegrass plant community; and None indicates that no plant communities were avoided entirely.

cue-bluebunch wheatgrass, Idaho fescue-biscuit scabland, and bluebunch wheatgrass-Sandberg's bluegrass communities which occurred across a broad array of edge distances and elevations. Undesirable foraging areas were strict buckwheat-bluegrass scabland communities occurring at lower elevations. All aspects were desirable to cattle as foraging areas. Foraging areas that were close to, or at greatest distance from forested communities, or that were at highest or lowest elevation of the study area, were avoided by cattle.

**Elk Foraging Areas.** Foraging areas preferred by elk were bluebunch wheatgrass-annual grass and Idaho fescue-bluebunch wheatgrass communities occurring at higher elevations near the forest edge (Table 3). Desirable foraging areas were strict buckwheat-bluegrass scabland communities at moderate elevations near the forest edge. Undesirable foraging areas were Idaho fescue-annual grass, Idaho fescue-biscuit, and bluebunch wheatgrass-Sandberg's bluegrass communities occurring on low to moderate elevations, and at greatest distance from the forest edge. Elk avoided foraging areas in plant communities at lower elevations, and at greatest distance from the forest edge. Elk preferred

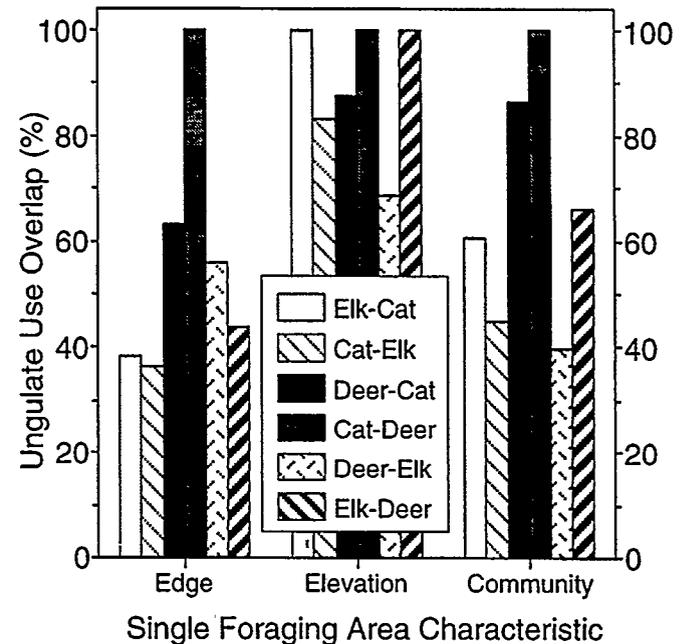
**Table 3.** Elk selection of vegetation and terrain features on seasonal rangeland in northeastern Oregon.

Preference	Plant community <sup>1</sup>	Slope (%)	Aspect	Edge distance (m)	Elevation (m)
Preferred	Agsp/A.Grass Feid/Agsp	0.0	SE,S,W	0-244	1220>1341
Desirable	Erst/Poa	6.3-18.7	N	245-366	1190-1219
Undesired	Feid/A.Grass Feid/Mound Agsp/Posa	0.1-6.2 18.8-37.7	NE,E, SW,NW	1098-1189	
Avoided	None	37.8-62.5		1282-1891 >1891	<1005 1005-1097

<sup>1</sup>The definition of plant community acronyms are as follows: Feid/Agsp is the Idaho fescue-bluebunch wheatgrass plant community; Feid/A. Grass is an Idaho fescue plant community with a high proportion of annual grasses, especially annual brome grasses; Feid/mound is an Idaho fescue plant community associated with loessal "mima" mounds; Agsp/Posa is a bluebunch wheatgrass-Sandberg's bluegrass plant community; Agsp/A. Grass is a bluebunch wheatgrass plant community with a high proportion of annual grasses; Erst/Poa is a strict buckwheat/bluegrass plant community; and None indicates that no plant communities were avoided entirely.

level terrain as foraging areas, while foraging areas with slopes >37.7 % were undesirable or avoided. Elk generally preferred foraging areas with southerly or westerly aspects.

**Mule Deer Foraging Areas.** Preferred foraging areas for mule deer were strict buckwheat-bluegrass scabland plant communities at any elevation which were at moderate distance from the forest edge (Table 4). Desirable foraging areas were Idaho fescue-bluebunch wheatgrass, Idaho fescue-annual grass, Idaho fescue-biscuit, and bluebunch wheatgrass-Sandberg's bluegrass communi-



**Fig. 2.** Probability of ungulate use overlap if a single characteristic of a foraging area influences ungulate selection.

**Table 4.** Mule deer selection of vegetation and terrain features on seasonal rangeland in northeastern Oregon.

Preference	Plant community <sup>1</sup>	Slope (%)	Aspect	Edge distance (m)	Elevation (m)
Preferred	Erst/Poa			367-671	>1341
Desirable	Feid/Agsp	0-37.7	N,SE	123-366	1190-1311
	Feid/A. Grass		W,NW	672-976	
	Feid/Mound Agsp/Posa				
Undesired	Agsp/A. Grass	31.3-37.7	NE,E, S,SW	0-122 977-1586	1037-1189 1312-1341
Avoided	None	37.8-62.5		1586-1891 >1891	<1005 1005-1036

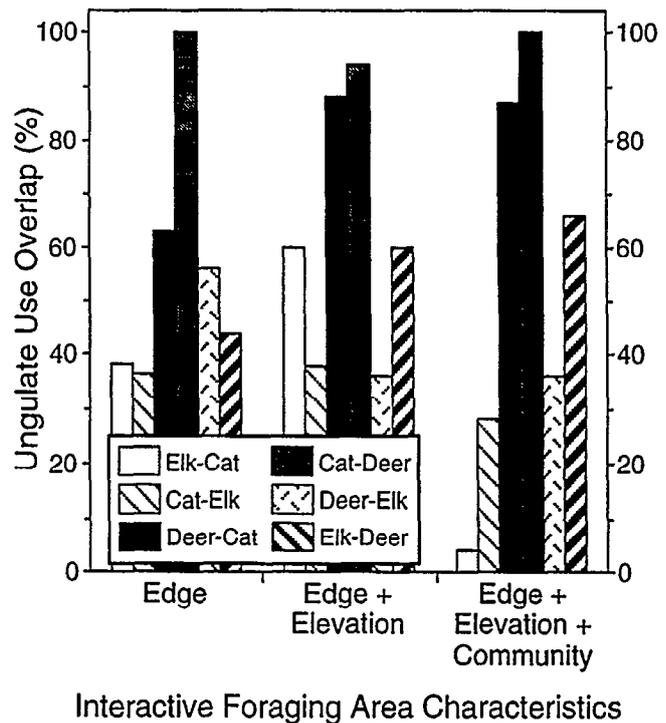
<sup>1</sup> The definition of plant community acronyms are as follows: Feid/Agsp is the Idaho fescue-bluebunch wheatgrass plant community; Feid/A. Grass is an Idaho fescue plant community with a high proportion of annual grasses, especially annual brome grasses; Feid/mound is an Idaho fescue plant community associated with loessal "mima" mounds; Agsp/Posa is a bluebunch wheatgrass-Sandberg's bluegrass plant community; Agsp/A. Grass is a bluebunch wheatgrass plant community with a high proportion of annual grasses; Erst/Poa is a strict buckwheat/bluegrass plant community; and None indicates that no plant communities were avoided entirely.

ties at higher elevations located at moderate distance from the forest edge. Undesirable foraging areas were bluebunch wheatgrass communities located at lower or higher elevation nearest or at greatest distance from the forest edge. Foraging areas avoided by deer were portions of all communities at lower elevations and at greatest distance from the forest edge. Deer preferred to forage on level terrain and terrain with southerly or westerly aspect.

**Ungulate Foraging Area Overlap.** The probability of ungulates selecting the same foraging area (on the study area) ranged from 38% to 100% if ungulate selection was based solely on distance to forest edge, or elevation, or plant communities as the discriminating variable (Fig. 2). Using distance to edge as the foraging area characteristic most influencing ungulate grazing, indicated deer and cattle had highest probability of use overlapping on the same foraging area. Using elevation the same way indicated all ungulates had high probability of use overlapping on the same foraging area. Using only plant community again indicated that deer and cattle had highest probability of use overlapping on the same foraging area.

Although specific features of seasonal rangeland may unilaterally influence ungulate selection of foraging areas, grass steppe of the study area was a composite of vegetation and terrain features. Discriminant Function Analysis, which interactively examined vegetation and terrain features, indicated that distance to edge and elevation were terrain features which most influenced ungulate selection of foraging areas in specific plant communities.

Distance of grass steppe communities from the forest edge was the first discriminant function, and accounted for 70% of all variation in ungulate selection of foraging areas. It also had the lowest Wilkes lambda U-statistic (0.80541), and the highest univariate F ratio (26.88) among the features tested. Elevation was the second discriminant function and accounted for 26.1% of all variation in ungulate selection of foraging areas. The third discriminant function was plant community, which accounted for 3.2% of all variation in ungulate selection of foraging areas. Slope and



**Fig. 3** Probability of ungulate use overlap if multiple characteristics of a foraging area interactively influence ungulate selection.

aspect appeared to have little or no interactive influence on ungulate selection of foraging areas.

Interactively combining discriminating variables changed the probability that ungulate use would overlap on foraging areas (Fig. 3). Elevation and distance to edge interactively decreased the probability of deer and elk use overlapping. The inclusion of plant communities with elevation and distance to edge as a composite discriminating variable decreased the probability of cattle and elk use overlapping on foraging areas. Elevation was the foraging area characteristic with highest probability of separating deer and elk. Plant community was the foraging area characteristic with highest probability of separating elk and cattle.

Although ungulate selection of foraging areas was influenced by terrain characteristics, plant communities appeared to be the most important foraging area characteristic determining ungulate use. This supposition was supported by ungulate preference for plant communities which indicated that ungulate grazing overlap would have: 1) little probability of occurring on foraging areas preferred by each ungulate; 2) increased on foraging areas desired by each ungulate; and 3) had highest probability of occurring on foraging areas undesirable to other ungulates.

#### Behavioral Factors Influencing Ungulate Selection of Foraging Areas

Observations of ungulate use of the study area indicated elk were highly conscious of security afforded by forest cover. Except under special circumstances such as: cold and clear days, little or no wind, high visibility, and easy conveyance of sound; they selected foraging areas in plant communities within a certain distance of the edge between grass steppe and forest vegetation types. A major need of elk on winter range in the Blue Mountain

Region is the presence of forest vegetation capable of meeting security requirements near low stature herbaceous plant communities used as foraging areas (Leckenby 1984). Edge between grass steppe and forest vegetation types is highly correlated with elevation. Soil type may have also been a factor influencing elk selection of foraging areas because preferred or desirable plant communities were associated with soils capable of supporting body weight of animals during periods that spring freezing and thawing made deeper loessal soils unstable.

Mule deer selected foraging areas according to the presence of specific plants associated with bluegrass scabland and Idaho fescue plant communities on ridgetops. New growth of Sandberg's bluegrass is a preferred forage species during late winter and spring (Skovlin and Vavra 1979). While mule deer were also security conscious, changes in elevation afforded by relief of terrain appeared to satisfy security considerations. If mule deer were disturbed while grazing preferred plant communities, which were generally situated along ridgetops, they moved out of sight into drainages at lower elevation.

Cattle were less influenced by vegetation and terrain factors relative to use of this seasonal rangeland. More plant communities appeared to be considered as desirable foraging areas, and terrain factors appeared to have less influence on cattle selection of foraging areas. Cattle selection of foraging areas, as contrasted to elk and mule deer, was constrained by fences that separated the study area into different land ownership and pasture management units, and the need during late spring and summer grazing to obtain drinking water. Although the same plant communities and terrain features were present in pastures under different ownership, higher elevation pastures were comprised of different plant communities than lower elevation pastures. Without the inhibition to movement caused by fences, cattle selection of foraging areas may have been different.

Location of water is considered to be a major factor influencing cattle distribution and selection of foraging areas on seasonal and other rangeland (Roath and Krueger 1982). Ambient air temperature appeared to be a factor directly influencing cattle selection of foraging areas during summer because of the need to regulate body temperature. Temperature indirectly influenced cattle selection of foraging areas during late fall and early winter because of the decreased need for shade and water as a result of lower ambient air temperatures and the non-lactating status of the animals.

During summer cattle selected foraging areas in Idaho fescue plant communities, adjacent to grass steppe and forest edge, preferred by elk during the winter and spring. Utilization of vegetation standing crop in these plant communities during summer by cattle may have improved vegetation quality for elk and mule deer use in winter and spring, after fall precipitation promoted growth of preferred forage species. Cattle utilization of standing crop of foraging areas, in lower elevation plant communities in late fall, may have improved vegetation quality for subsequent cattle use in late spring and early summer the following year. Cattle are moved initially on to these communities when entering the study area. Temporal separation of ungulates on desirable foraging areas allowed growth of vegetation to occur between periods of grazing by cattle that improved vegetation quality for other ungulates.

Spatial separation of foraging areas and temporal separation of ungulate grazing were major factors reducing the potential for conflict among ungulates for preferred foraging areas. Other factors were security requirements of wild ungulates, constraints to

cattle movements imposed by fences and water, and shade needs of cattle during summer. Cattle also tended to utilize foraging areas at lower elevation in fall in a natural movement toward winter ranges and feeding areas.

Foraging areas with fall growth of Idaho fescue were highly preferred by elk. Foraging areas with fall or late winter growth of Sandberg's bluegrass were highly preferred by mule deer. Cattle and mule deer appeared to be more discriminating than elk in selection of preferred foraging areas, while elk appeared to be more discriminating than cattle and mule deer in selection of desirable foraging areas. Both mule deer and elk, compared to cattle, appeared to consider a wider array of plant community and terrain features as undesirable foraging areas.

In conclusion, temporal and spatial separation of ungulates on the study area reduced the potential for conflict over use of forage resources. Temporal separation was the most important factor alleviating the potential for conflict between domestic and wild ungulates. Spatial separation was a secondary factor alleviating the potential for conflict among all ungulates, especially between cattle and elk or mule deer. If ungulate grazing intensity was to increase, the potential for conflict between cattle and elk would be expected to increase before it would between mule deer and cattle, or mule deer and elk.

Although plant communities accounted for only a small percentage of the variation in ungulate selection of foraging areas, dietary evidence (Sheehy 1987) indicates vegetation was the primary factor influencing ungulate use of seasonal rangeland of the study area. Logic indicates that ungulates do not select plant communities, but select for specific plants according to an intrinsic value system relating to palatability and availability of plants within the composite of vegetation and terrain forming plant communities. Terrain features appear to be factors influencing location of plant communities and selection of specific foraging areas once the ungulate commits to the act of foraging.

Other studies corroborate that use by diverse ungulates tends toward partitioning of most intensively used habitat, both actual use as well as timing of use (Miller et al. 1981, Leege 1984). Large ungulates using seasonal rangeland in the Intermountain Region appear to prefer different vegetation although overlap does occur (Vavra et al. 1989).

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