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Slope Use by Cattle, Feral Horses, Deer, and Bighorn Sheep[2]

Abstract

Patterns of slope utilization by cattle (*Bos* spp.), feral horses (*Equus caballus*), Rocky Mountain mule deer (*Odocoileus hemionus hemionus*), and California bighorn sheep (*Ovis canadensis californiana*) were monitored to compare their distributions to the topographic compositions of their respective habitats. The hypothesis that each species utilized slope classes in proportion to the topographic compositions of their respective habitats was rejected ($P < 0.01$). Bighorn sheep activities were not impaired by slopes of up to 80%. Cattle, horses, and deer demonstrated negative curvilinear responses to increasing slope with initial site avoidance exhibited on 20, 30, and 40% slopes, respectively. Where large expanses of level topography were available, cattle and horses made less use of steep slopes than their counterparts inhabiting more rugged terrain. These data demonstrate that cattle, horses, and deer should not be expected to make random use of forage resources in rugged terrain.

Introduction

An awareness of the distribution and movement patterns of large herbivores is particularly valuable to managers charged with allocating resources or assessing the impacts of utilization by large herbivores. The arrangement of food, water, and shelter, and their concurrent interactions with topographic features obviously influences the distribution of animals and their simultaneous use of an area's resources. Slope gradient may also be a major determinant of herbivore distribution in rugged terrain. With the exception of cattle (*Bos* spp.), few data are available describing the upper limits of slope use by large herbivores.

Cattle favor the relatively level ground associated with drainages, basins, and ridgetops (Glendening 1944, Blood 1961, Demarchi 1965, Julander and Jeffery 1964, Mueggler 1965, Phillips 1965, Cook 1966, Mackie 1970, Patton 1971, Gillen 1982, Barrett 1982). In general cattle limit their use of hillsides when grades approach 30% (Blood 1961, Patton 1971, Gillen 1982, Van Vuren 1982). Upslope presence of palatable forage (Gonzalez 1964, Cook 1966, Bryant 1982), salt (Champline and Talbot 1926, Skovlin 1965), or water (Skovlin 1965), however, may encourage additional utilization of hillsides.

Feral horses (*Equus caballus*) have an affinity for ridgetops or elevated terrain (Pellegrini 1971, Welsh 1975, Miller 1980, Keiper and Berger 1982); however, no one has attempted to quantify their use of hillsides. Pellegrini (1971) noted horses avoided steep hills, and that they rapidly traveled over unavoidable rough terrain.

Most workers report mule deer (*Odocoileus hemionus hemionus*) show little response to topographic variation (Demarchi 1965, Mackie 1970, Barrett 1982). Some observers report, however, that slope indirectly affects distribution of deer through its impact on snow accumulation and persistence (Wilkins 1957, Loveless 1967, Gilbert *et al.* 1970, Dusek 1975) or microclimate and vegetation patterns (Julander 1966, Loveless 1967, Mackie 1970).

Although bighorn sheep (*Ovis canadensis*) habitat is synonymous with rugged cliffs and highly dissected terrain (McCann 1953, Harris 1956, Russo 1956, McCullough and Schneegas 1966, Todd 1972, Jones 1980), few workers have addressed their use of rugged topography. Demarchi (1965) reported a positive correlation between the frequency of sightings of bighorn and increasing degree of slope, but provided no

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information on the topographic composition of the study area. Shannon *et al.* (1975) found bighorn were neutral or may have discriminated against slope. They suggested the use of slopes was related to associated abiotic or biotic features rather than to slope per se.

In this project we monitored the frequency of use of slopes by cattle, feral horses, Rocky Mountain mule deer, and California bighorn sheep (*Ovis canadensis californiana*) from April 1979 through March 1981. Our goal was to establish thresholds of slope use for horses, deer, and bighorn sheep, and to supplement the information available for cattle. We first tested the hypothesis that each herbivore utilized slope classes in proportion to their availability. When this hypothesis was rejected, we further examined the data to detemine which slopes were favored or avoided.

Study Area

The study was conducted approximately 65 km south of Vale, Oregon, on a 375 km² area administered by the Bureau of Land Management. The area included three designated pastures, of roughly 62, 31, and 219 km², and an adjoining 63 km² unit to the south which contained a portion of the bighorn sheep range. Pasture boundaries consisted of 4-wire stock fencing, the east shoreline of the Owyhee Reservoir, and some natural barriers. Approximately 73% of the study area was within 1600 m of permanent water sources.

Topography ranged from well-eroded, gently-rolling hills to mountainous ridges, cliff rock, and canyons. Elevations ranged from 809 m, pool level of Owyhee Reservoir, to 1687 m. Major plant communities supported overstories dominated by Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) or low sagebrush (*Artemisia arbuscula*). Herbaceous layer dominants included bluebunch wheatgrass (*Agropyron spicatum*), Sandberg's bluegrass (*Poa sandbergii*), and cheatgrass (*Bromus tectorum*).

Historic overgrazing by large numbers of horses (up to 2500 in the 1940's), long-term seasonal use by livestock, and occasional wildfires have affected the distribution of plant communities on the area. Bluebunch wheatgrass, a large and palatable perennial bunchgrass, was most prevalent on slopes in excess of 20%. Cheatgrass and Sandberg's bluegrass, two species typically characterizing abused rangelands, were dominants in drainages and large basins where slopes were generally less than 20%. Wyoming big sagebrush and low sagebrush did not exhibit any systematic patterns of distribution. Detailed maps and descriptions of major plant communities are provided by Ganskopp (1984).

Feral horses and bighorn sheep were year-round residents. The total number of horses in the three pastures increased from 133 to 168 during our study. Bighorn sheep occupied a small portion of the largest pasture and the adjoining 63 km² area to the south. The herd consisted of about 100 animals.

Deer and cattle were seasonal occupants of the area. Approximately 200 to 300 deer wintered on the area from October through April. Cattle grazed the three pastures from April through October on a deferred rotation basis during both years of study. Their use totaled 1600 AUMs in 1979 and 3900 AUMs in 1980. Mean livestock density for the three pastures was 0.75 cows/km² in 1979 and 1.8 cows/km² in 1980.

Methods

The last two weeks of each month were devoted to surveying the study area in an attempt to plot the location of as many animals as possible. Binoculars and a 20 to 40X spotting scope facilitated long-range searching for large herbivores. Movement about the area was accomplished with four-wheel drive vehicles and by foot. Incidental sightings were also recorded and only animals initially unaware of our presence were utilized as data sources. We did not knowingly record duplicate observations of a recognized group or individual within a 24-hour period.

Percent slope of observation sites was measured with a clinometer. If more than one animal was involved, the measurement was made on an area deemed representative of the group. Each sighting was treated as a single observation, regardless of the number of animals involved. A coordinate grid, superimposed on a 1:63360 map of the study area, allowed documentation of sighting locations.

Because horses and bighorn sheep were year-round residents of the area, their data reflect a relatively uniform distribution of observations

over the two-year period. The only exception occurred in January, 1981, when three weeks of continuous fog hindered our searches for bighorn sheep. Our data for cattle and deer are strictly seasonal. Cattle were herded to the area in April and removed in late October each year. A few deer were continuously on the area, but their presence was most pronounced between October and April. Eighty-nine percent of our observations of deer were made during this period.

Visual examination of maps depicting sighting locations of the four herbivores revealed that cattle, horses, and bighorn sheep were either confined to, or chose to occupy only certain portions of the study area. Sightings of mule deer were well dispersed over the entire study area. Based on these distribution patterns, we defined the geographic boundaries of each herbivore's habitat. Consequently, our data depict only the habitat characteristics of areas frequented by each species.

Because cattle respected the fences and natural boundaries of the pastures, we assumed they occupied three distinct habitats on the area. Data were tallied by pasture with the assumption that an entire pasture was available for their use.

Horses on the area were easily identified by referencing sketches of distinguishing characteristics. Mean home range size (minimum convex polygon) was 12 km^2 with no seasonal shifts in home ranges occurring (Ganskopp and Vavra 1986). Six distinct herds of horses were identified during the study. Because bands and bachelors composing each herd appeared to restrict their movements voluntarily, we outlined the outermost coordinates of each herd with a minimum convex polygon (Southwood 1966), and assumed the circumscribed area constituted the available habitat of each herd. Three small herds (each supporting < 15 animals) were not included in this analysis.

Deer were observed throughout the study area. Total number of deer sighted was 1467 with 1157 animals classified to sex and age. Buck to doe ratios averaged 13.5/100, and fawn to doe ratios averaged 71.4/100. Because individual deer could not be identified or linked to a specific unit of land, we assumed the entire area was available for their use.

Bighorn sheep occupied a relatively restricted area in the more rugged southern portion of the study area. A minimum convex polygon, circumscribing 73 km^2, was used to define their habitat. Bighorn could be found at any location or elevation within their range throughout the duration of the study. Total number of bighorn sighted was 811 with 691 animals classified to sex and age. The lamb to ewe ratio averaged 54.1/100, and the ram to ewe ratio averaged 59/100.

Outlines of the study area and the various habitats were transferred to U.S. Geological Survey topographic maps. Map scale was 1:24000 with 12.19 m between contour intervals. A sample of 1545 randomly selected points were described to derive the topographic composition of the habitats. Distance between adjacent contour lines bracketing each point was measured and converted to horizontal distance. The vertical distance between contour intervals was divided by the horizontal distance between contour lines and multiplied by 100 to yield percent slope.

Data were compiled for each herbivore and habitat in 10% intervals ranging from 0 to 80+ % slope. Chi square analysis of homogeneity ($P < 0.05$) was used to test the null hypothesis (H_0) that the proportion of use of slope classes was equivalent to the occurrence of the classes in the polygon, pasture, or designated habitat. If H_0 was rejected, simultaneous confidence intervals for differences between percentages (Snedecor and Cochran 1967, Marcum and Loftsgaarden 1980) were derived to determine which classes were occupied at significantly ($P < 0.02$) greater than expected levels (a positive preference rating), were utilized roughly in proportion to their occurrence (a zero preference rating), or were utilized at less than expected levels (a negative preference rating).

When simultaneous comparisons are conducted within several categories, the probability that all comparisons have reached a correct conclusion is a function of the total number of comparisons made and the probability level selected for each individual comparison. The probability that all comparisons have reached a correct conclusion $= 1 - N P$ where: N is the number of categories and P is the probability level selected for the individual comparisons. If the number of categories is large and a conventional significance level of $P = 0.05$ is employed, the probability that all comparisons have reached a correct

conclusion becomes quite small. This problem may be overcome to some degree by using a more conservative significance level (i.e., $P = 0.01$). One does not wish to be so conservative, however, that real differences between percentages may go undetected, and unconventional probability levels are occasionally used as a compromise in this procedure. Because some of our data contained as many as nine categories, a probability level of $P < 0.02$ was selected for detecting differences between percentages. With nine categories there is a 0.88 probability that all of our tests have reached a correct conclusion. Neu *et al.* (1974) and Marcum and Loftsgaarden (1980) provide a more detailed discussion of the statistical processes.

Data were also pooled for each species and equations predicting the proportion of observations expected on sites with increasing slope derived through regression analysis (Neter and Wasserman 1974). F tests for comparison of two regression lines ($P < 0.05$) were conducted with all possible interspecific combinations to examine the hypothesis that patterns of slope use were identical among any of the four species (Neter and Wasserman 1974).

Results

Respective mean slopes of sites utilized by cattle, horses, deer, and bighorn were 5.8, 11.2, 15.7, and 42.5%. Data for cattle, horses, and deer were skewed in favor of relatively gentle topography, so means should be viewed with some caution. The hypothesis that each herbivore utilized classes of slopes in proportion to the topographic compositions of their respective habitats was rejected in all cases ($P < 0.01$).

Two hundred twenty-two observations of cattle were recorded, with an average group size of 14.6 animals. The greatest slope on which cattle were observed involved one sighting on a 70% grade. All other observations were on slopes of less than 40%. Patterns of slope use by cattle generally reflected those reported in the literature (Table 1). Cattle favored slopes in the 0-9% category in all pastures and appeared indifferent to slopes in the 10-19% category in pastures A and C. They avoided slopes exceeding 20% in all three pastures.

Cattle demonstrated some variation in their patterns of use among the three pastures. This is best evidenced by comparing pastures B and C which depict the extremes of topography available to these animals. Topography in pasture B was relatively gentle with a mean slope of 19%. The mean slope of pasture C was 37%, and cattle in this pasture were more often observed on the steeper slopes. This suggests that cattle inhabiting rugged terrain will make more use of steep slopes than cattle confined on more level topography. Conversely, cattle having access to large expanses of gentle topography are less likely to venture upslope than their counterparts occupying more rugged areas.

Feral horses were observed on 394 occasions, with a mean number of 4.7 animals per observation. One group of horses was observed on a 100% slope with all other observations on slopes of 50% or less. Horses generally demonstrated an affinity for high benches and gently sloping ridgetops. Typically they rapidly traversed rugged or steep topography to gain access to elevated but relatively level terrain.

The 0-19% classes in each herd received + or 0 preference ratings, indicating that slopes within this range were favored or utilized indifferently by horses (Table 1). The 20-29% category was avoided by herds 1 and 2 but used roughly in proportion to its occurrence by herd 3. Mean slopes of the habitats occupied by herds 1, 2, and 3 were 20, 24, and 34%, respectively. Like cattle, horses inhabiting rugged terrain appeared willing to utilize steeper slopes than their counterparts on more level topography. Horses in all three herds avoided slopes in excess of 30%.

One hundred seventy-two observations of deer were recorded on the area, with the average group numbering 8.5 animals. The steepest grade on which deer were detected was 75%. Like cattle and horses, deer favored relatively level topography (Table 1). They were most often observed on slopes in the 0-9% category which received a (+) preference rating. Grades between 10 and 39% appeared to have no effect on their movements, as categories in this range received (0) preference ratings. Categories in excess of 40% were utilized at significantly ($P < 0.02$) lower frequencies than their availability would suggest and received (−) preference ratings.

Bighorn sheep were observed on 121 occasions with a mean group size of 6.7 animals. Bighorn frequented grades approaching 150%,

TABLE 1. Habitat availability (%) and use (%) by cattle, horses, deer, and bighorn sheep. Categories with a (+) preference rating were utilized at greater than expected levels ($P < 0.02$). Categories having a (0) preference rating were utilized in proportion to their occurrence. Categories with a (−) preference rating were utilized at less than expected levels ($P < 0.02$).

	Percent slope								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Cattle									
Pasture A availability	11	20	19	13	10	8	9	4	6
Use	79	18	3						
Preference rating	+	0	−						
Pasture B availability	23	36	24	11	2	1	3		
Use	82	15	3						
Preference rating	+	−	−						
Pasture C availability	16	17	13	14	12	10	9	3	6
Use	70	20	5	5					
Preference rating	+	0	−	−					
Horses									
Herd area 1 availability	13	31	29	14	3	3	4	1	2
Use	30	58	12						
Preference rating	+	+	−						
Herd area 2 availability	27	30	24	10	4	3	1	0	1
Use	43	41	11	4	1				
Preference rating	+	0	−	−	0				
Herd area 3 availability	13	16	19	20	12	7	5	3	5
Use	43	20	23	5	5	4			
Preference rating	+	0	0	−	−	−			
Deer									
Availability	15	18	14	14	11	9	9	3	7
Use	47	18	13	10	4	3	2	3	
Preference rating	+	0	0	0	−	−	−	−	
Bighorn sheep									
Availability	12	10	8	13	12	16	14	5	11
Use	17	8	5	8	15	11	15	14	7
Preference rating	0	0	0	0	0	0	0	+	0

but most were sited on slopes of 110% or less. The mean slope for all points sampled within the bighorn sheep habitat was 44%, while the slope of the areas actually utilized by the sheep averaged 42.5%.

The hypothesis that bighorn sheep utilized slopes in proportions equivalent to the topographic composition of their habitat was marginally rejected ($P < 0.01$). Examination of the preference ratings for each of the nine slope categories (Table 1) revealed the bighorn deviated significantly ($P < 0.02$) from our expected pattern of use in only one instance (the 70-79% category). Because this category received a (+) preference rating, and all other categories were frequented at expected levels, we concluded that slopes between 0 and 80% did not impair the movements and activities of bighorn.

Second-order equations provided best fit of data relating percent slope (independent variable) to percent of observations of herbivores in each category (dependent variable). Significant response functions ($P < 0.05$) were obtained for cattle ($Y = -6.0X + 0.09X^2 + 96.4$, $r^2 = 0.95$), horses ($Y = -1.9X + 0.02X^2 + 54.4$, $r^2 = 0.96$), and deer ($Y = -1.5X + 0.01X^2 + 45.9$, $r^2 = 0.89$) but no significant relationship was derived for bighorn sheep (Figure 1). Our attempt to fit a second-order polynomial to the bighorn sheep data produced an r^2 of 0.22 and an F value of 0.98. This again suggests that slopes between 0 and 80% had no effect on the habits of bighorn sheep.

Our F tests for all possible interspecific comparisons of two regression lines rejected the hypothesis that patterns of slope use were identical among cattle, horses, and deer ($P < 0.01$). Although each equation proved to be unique, we do not intend to infer that a clear spatial separation existed between the various species.

Discussion

Slopes between 0 and 19% received either (+) or (0) preference ratings in our analysis of all four herbivores. These same slopes supported 94% of our observations of cattle, 79% of the horses, 66% of the deer, and 25% of the bighorn sheep. It is obvious that cattle, horses, and deer exerted the majority of their demands on the resources occurring within these bounds. Bighorn sheep, with their greater tolerance or preference for steep slopes, were much less dependent on the resources of relatively gentle terrain.

These data clearly illustrate that in rugged terrain cattle, horses, and deer will limit their use of steep sidehills. Consequently, range managers and researchers need to consider the effects of varying topography on the distribution patterns of these animals.

Due to several factors, however, caution must be exercised when applying these results to other areas. Our first concern is that much of our data were of a seasonal nature. We recognize that

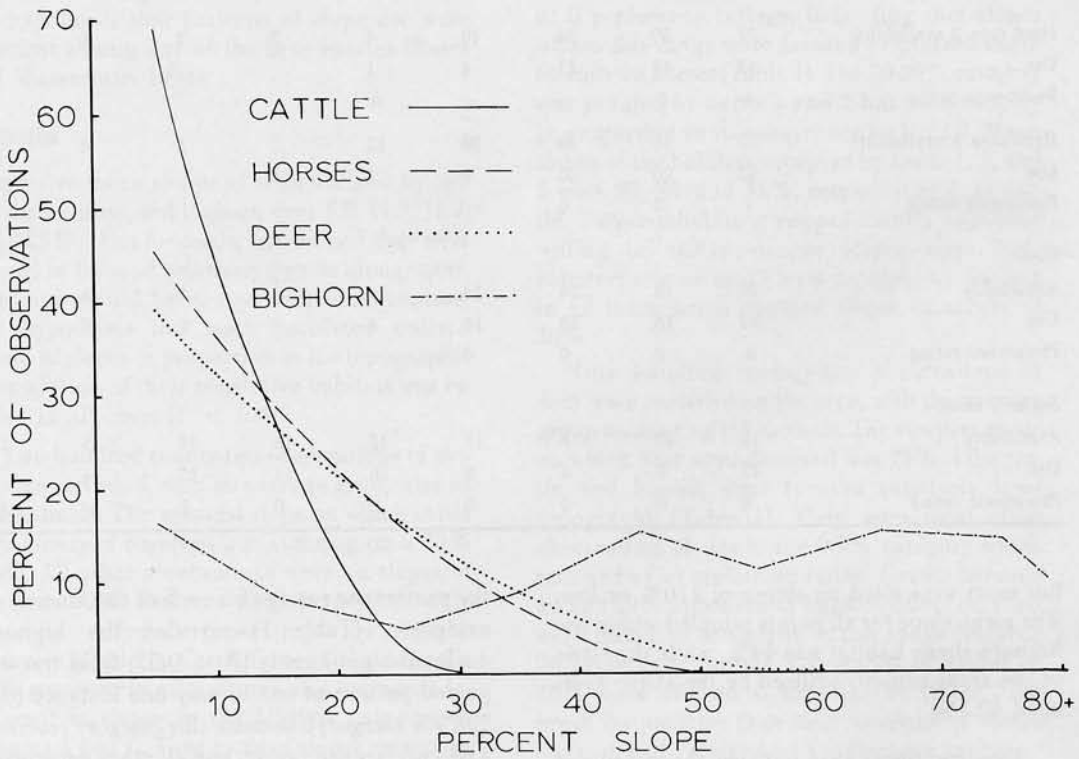

Figure 1. Relationship of slope gradient to the percent of observations of cattle, feral horses, deer, and bighorn sheep. Raw data are presented for bighorn sheep because a significant ($P < 0.05$) relationship could not be obtained with linear or quadratic models.

patterns of use are subject to change throughout the year. In this study, cattle in particular appeared more willing to utilize slopes in the early spring and late fall, than during the warmer summer months. Our sample numbers, however, were too small to address this hypothesis with any statistical confidence.

A second consideration is that our observations relate to populations having access to a common environment. We saw no aggressive behavior during interspecific encounters, but competitive processes or interspecific intolerances may have altered dispersion patterns to some degree (Berger 1985). If such competitive influences were present, our data may reflect an up-slope movement of one or more of the herbivores in question.

Our third concern focuses on the different patterns of use exhibited by cattle and horses when comparing relatively gentle and more rugged habitats. This suggests that quantitative expectations derived in one area may not necessarily apply in another. We recognize that each management unit provides a unique environment, and that patterns of animal movement are ultimately a product of several interacting environmental and animal factors. Although much more data must be acquired before these variations in utilization patterns can be described with any confidence, we should remain aware that topographic attributes may limit resource use by cattle, deer, and feral horses.

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