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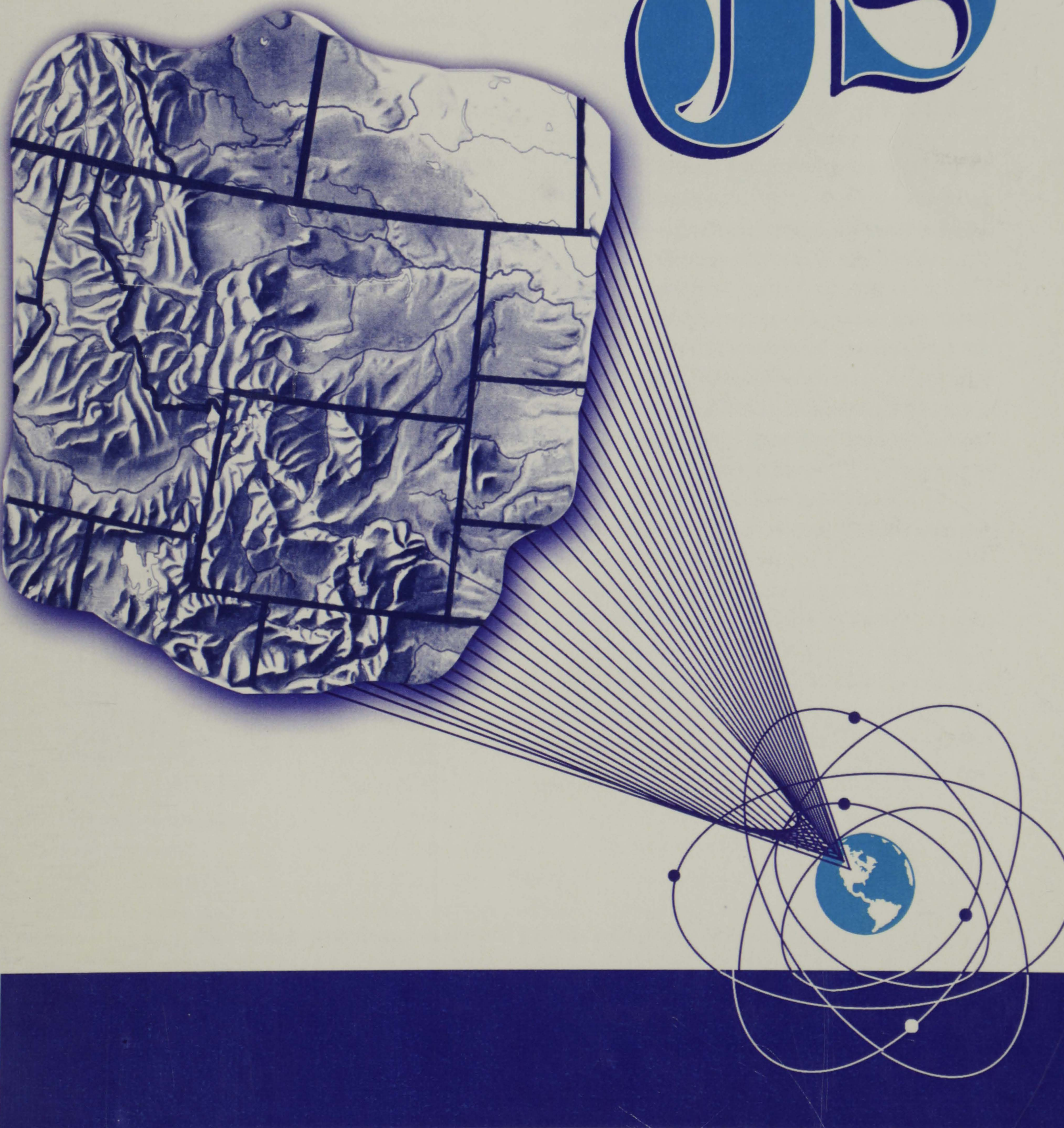

INTERMOUNTAIN JOURNAL OF SCIENCES

The Intermountain Journal of Sciences is a regional peer-reviewed journal that encourages scientists, educators and students to submit their research, management applications, or view-points concerning the sciences applicable to the intermountain region. Original manuscripts dealing with biological, environmental engineering, mathematical, molecular-cellular, pharmaceutical, physical and social sciences are welcome.

Co-sponsors/publishers include the Montana Academy of Sciences, the Montana Chapter of The Wildlife Society, and the Montana Chapter of The American Fisheries Society. This journal offers peer review and an opportunity to publish papers presented at annual meetings of the co-sponsor organizations. It is the intent of the governing bodies of the co-sponsor organizations that this journal replace printed proceedings of the respective annual meetings. Therefore, it is the policy of the editorial board that presenters at annual meetings of the co-sponsors be given priority in allocation of space and time of publication, although submission of other manuscripts for review and publication without regard to membership is encouraged.

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Manuscripts are submitted to the Editor-in-Chief (EIC) for initial consideration for publication in the IJS. This review shall include, but not be limited to, appropriateness for publication in this journal, correct formatting, and inclusion of a letter of submittal by the author with information about the manuscript as stated in the "Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*" (Dusek 1995). This cover letter must also include a statement by the author that this paper has not been submitted for publication or published elsewhere. The EIC notes the date of receipt of the manuscript and assigns it a reference number, IJS-xxxx. The EIC forwards a letter of manuscript receipt and the reference number to the corresponding author. The corresponding author is the author who signed the submittal letter.

Three hard copies of the submitted manuscript, with copies of the "Guidelines and checklist for IJS referees" attached are forwarded to the appropriate Associate Editor. The Associate Editor retains one coy of the manuscript and guidelines for his/her review, and submits a similar package to each of two other reviewers. A minimum of two reviewers, including the Associate Editor, is required for each manuscript. The two other reviewers are instructed to return the manuscript and their comments to the Associate Editor, who completes and returns to the EIC a blue "Cover Form" and all manuscripts and reviewer comments plus a recommendation for publication, with or without revisions, or rejection of the manuscript. This initial review process is limited to 30 days.

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Each manuscript that is rejected for publication is returned by the EIC to the corresponding author along with the reasons for rejection. The author is also advised that the manuscript may be resubmitted, provided all major criticisms and comments have been addressed in the new manuscript. The new manuscript may be returned to the initial review process if deemed appropriate by the EIC. If the manuscript is rejected a second time by either the EIC or the Associate Editor and reviewers, no further consideration will be given for publication of the manuscript in IJS. The corresponding author will be notified of this decision.

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The identity of all reviewers shall remain anonymous to the authors, called a blind review process. All criticisms or comments by authors shall be directed to the EIC; they may be referred to the ME or the Editorial Board by the EIC for resolution.

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Each manuscript submitted by an Associate Editor shall be reviewed by the EIC and a minimum of two other reviewers with expertise in the subject being addressed. Each manuscript submitted by the EIC shall be forwarded with the necessary review materials to the Chairman of the Editorial Board of IJS who will serve as the EIC for that manuscript.

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Commentary

Submissions concerning management applications or viewpoint concerning current scientific or social issues of interest to the Intermountain region will be considered for publication in the ' ommentary' Section. This ection will feature conci e well-written manuscripts limited to 1 500 words. Commentaries will be limited to on per issue.

Submissions will be peer reviewed and page charges will be calculated at the ame rate as for regular articles.

Literature Cited

Dusek, Gary L. 1995. Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*. Int. J. Sci. 1(1):61-70.

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Elk Responses to Humans in a Densely Roaded Area

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Abstract

Despite several studies that demonstrate general responses of elk (*Cervus elaphus*) to roads and people, land management agencies continue to struggle with management of off-highway vehicles, recreation, and roads. The Black Hills National Forest has a greater road density (3.2 km/km^2) than any other national forest. We used Global Positioning System (GPS) telemetry collars to quantify responses of elk to human activity by quantifying their movements during the 2000 and 2001 big game hunting seasons in the Black Hills, South Dakota. Three hunting seasons, 1 month each, occurred consecutively from 1 September to 30 November and included limited entry archery elk, limited entry firearm elk, and limited entry firearm deer (*Odocoileus* spp.). We used the number of licenses issued times the average days hunters were in the field to quantify human activity. Average distance/hr between successive locations increased during the 10-day interval that began on the opening date of the archery elk season ($P \leq 0.10$) compared to the previous 10 days in late August. Movements by elk following the opening of the firearm elk season were similar to those during the last 10 days of September, but greater ($P \leq 0.10$) than movements during the last 10 days of August. Elk movements during 10 days after the opening of the firearm deer season (1 November) were greater ($P \leq 0.05$) than both the last 10 days of August and the last 10 days of October. Movements increased on the opening weekends of hunting seasons and the day after Thanksgiving, which is a traditional day for hunting deer in the Black Hills. Individual animals selected habitats differently ($P < 0.01$) but also selected ($P < 0.10$) habitats different from those available within 500 m of locations for each 10-day interval only from 22 August through 31 October. Elk dispersion patterns relative to roads varied with the hunting season. During the archery season, elk were closer to primary and secondary roads than before the season. During the firearm elk and firearm deer seasons, elk moved away from primary and secondary roads. Based on foraging models, elk may require 0.5 hr of additional foraging time to accommodate greater movements resulting from human activity. In light of an increased demand for outdoor recreational opportunities, our study provided additional support for land management agencies to develop travel management policies that provide elk with areas of little human disturbance.

Key words: Black Hills, *Cervus elaphus*, elk, GPS telemetry, habitat selection, human activity, off-road vehicles, road density, South Dakota

Introduction

Others have documented a negative relation between roads and elk (e.g., Lyon 1979, Rowland et al. 2000) based on a premise that hunting quickly conditions elk to avoid people and roads (Christensen et al. 1991, Wertz et al. 1996). Greater hunter access and greater road densities increase the probability of elk mortality during hunting seasons (Unsworth et al. 1993). Even

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moderate disturbance to elk from limited-entry hunting seasons in Custer State Park, South Dakota, resulted in a redistribution of elk to areas that minimized contact with hunters (Millspaugh et al. 2000). However, in the absence of negative reinforcement, elk are not affected by people and may be attracted to areas where they are protected (Shultz and Bailey 1978, Thompson and Henderson 1998).

Behavioral response of elk to human activity is multi-faceted and likely specific to conditions of the area. For example, extent of security (Hillis et al. 1991) and topography can mitigate some negative responses to human disturbance (Edge and Marcum 1991). Elk respond differently to different recreational disturbances (Wisdom et al. 2004). Responses of elk to human activity include increased use of cover (Irwin and Peek 1983), increased movements (Cole et al. 1997), and avoidance of roads (Rowland et al. 2000). Ward and Cupal (1979) noted that humans on foot and the close-range discharge of a firearm resulted in increased heart-rates of elk. A single disturbance event/day can elicit a flight response by elk (Wisdom et al. 2004).

Although understanding the effects of human disturbance is important to manage elk populations, estimating elk response to disturbance, such as recreation, may be difficult because timing may constrain occurrence of human activity to weekends or hunting seasons. Before Global Positioning System (GPS) technology, episodes of monitoring elk distribution from radio telemetry also varied (e.g., Lyon and Canfield 1991) that potentially led to underestimating the effects of disturbance on elk; obtaining adequate sample sizes without disturbing elk and eliciting a response to the researcher also can be difficult. Development of GPS technology allows obtaining frequent locations of animals in a systematic manner without disturbing them. We studied the effects of human activity on the dispersion patterns and habitat selection by individual elk during three hunting seasons from 1 September to 30 November 2000 and 2001 in the Black Hills, South Dakota. We hypothesized that elk, in response to human disturbance, would increase movements, seek areas with relatively high cover, or avoid roads.

Study Area

We monitored instrumented elk in the Limestone Plateau area of the central Black Hills of western South Dakota (Fig. 1). Elevation ranged from approximately 1800 m in the southern part of the study area to 2040 m in the north. Annual precipitation averages 51-61 cm (Orr 1959). Ponderosa pine (*Pinus ponderosa*) is the dominant vegetation type, comprising 78 percent of the area. White spruce (*Picea glauca*) and quaking aspen (*Populus tremuloides*) occur on mesic sites and north-facing slopes and comprise 5 percent and 4 percent of the area, respectively. Aspen in this area is seral to both ponderosa pine and white spruce (Hoffman and Alexander 1987). Meadow and grassland vegetation types comprise 12 percent of the area and several uncommon vegetation types comprise the remainder of the study area.

The Black Hills National Forest has an average road density of 3.2 km/km^2 (T. Mills, GIS Specialist, Black Hills National Forest, personal communication); road density in our study area was 2.3 km/km^2. Forest travel policy allows motorized vehicle travel on and off roads throughout

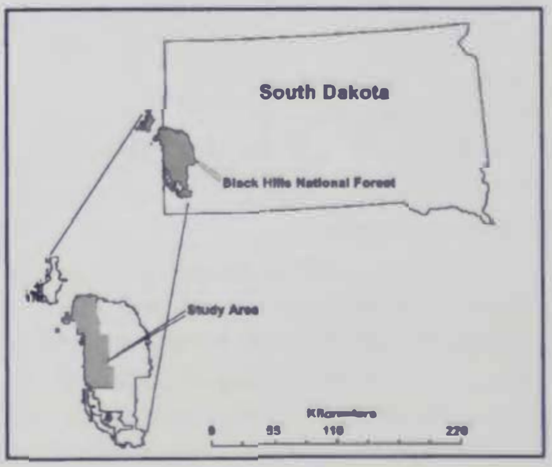

Figure 1. Map of South Dakota showing location of Black Hills National Forest and study area within the Black Hills National Forest boundary.

the forest except for special management areas (USDA Forest Service 1996). Our study area included 1133 km^2 (64%) of hunt unit 402 in the Black Hills of South Dakota.

METHODS

Human Activity

We estimated human activity by multiplying the number of licenses times the average number of days spent hunting. We used statistics compiled by South Dakota Department of Game, Fish, and Parks (SDGFP) for the archery elk, firearm elk, and firearm deer seasons and from post-season mail surveys (Smith 2001). Permits for archery elk, firearm elk, and firearm anterless/spike deer licenses were specific to Hunt Unit 402. However, branch-antlered firearm deer licenses were issued for the entire Black Hills area. We estimated the number of deer licenses in Hunt Unit 402 by back calculating from hunter success rates and from estimates of harvest of branch-antlered deer in the unit to which we then added the antlerless/spike deer permits. During 2000, 73 archery elk licenses were issued and hunters averaged 10.8 days in the field; 344 firearm elk licenses were issued and hunters averaged 6.3 days in the field; and approximately 2848 deer licenses were attributed to this unit and hunters averaged 2.5 days in the field. During 2001, 80 archery elk licenses were issued and hunters averaged 12.4 days in the field; 410 firearm elk licenses were issued and hunters averaged 6.7 days in the field, and approximately 2480 deer licenses were associated with this unit and hunters averaged 2.8 days in the field.

GP Telemetry

In February 2000, we used a net gun fired from a helicopter to capture four female elk from different herd groups. We equipped each elk with a GPS telemetry unit affixed to a vinyl collar and programmed to collect locations at 2-hr intervals from 22 August to 30 November. An electro-magnetic mechanism in each collar released the collar on 1 December 2001, collars were retrieved, and data were downloaded. During March to early April 2001, we captured 2 adult females and 2 yearling males using modified collapsible clover traps (McCullough 1975, Thompson et al. 1989). These collars released on 1 March 2002 at which time we retrieved the collars and downloaded the data.

More individuals with GPS collars would have been desirable. At the time of our study, GPS telemetry on animals was just emerging as a reliable technique to monitor animal distribution. Earlier in our study we had four collars and associated equipment from a different manufacturer costing > $25,000, all of which failed. We determined that strategy of obtaining multiple locations over short intervals from a few animals was better than standard radio telemetry on many more animals. Straight line distances between successive locations obtained by radio telemetry would have underestimated movements by elk in areas with very high road densities and repeated disturbance.

Mature male elk may differ from females in their response to roads (Marcum and Edge 1991). Yearling males were regularly observed with females and calves. As 2 year-olds, males segregated from cows and calves wandering movements were observed. Consequently, we believe these animals represent movements similar to those of females with GPS collars.

Analyses

Data from the GPS units in 2000 were differentially corrected using data from a base station about 16 km south of the study area. Selective availability of GPS satellites was discontinued and data from 2001 were not differentially corrected. We analyzed and present data obtained only during the daylight hours that coincided with the period of human activity. Euclidean distance between successive locations was calculated and standardized by calculating distance/hr between successful locations. We assigned locations to 10-day intervals from 22 August to 30 November; the interval 21 October to 31 October was 11 days, so the beginning of each hunting season was the first day of a 10-day interval. We displayed data for elk movements using box-and-whisker plots for 10-day intervals and for days within 10-day intervals. Because box-and-whisker plots display characteristics in the distribution of elk movements, they are useful for statistical tests for differing distributions. A control was not possible in this study, so we compared elk movements associated with increased human activity from hunters to elk movements before any hunting seasons (22-31 Aug) and the interval immediately before the firearm hunting seasons (21-30 Sep and 21-31 Oct, respectively). Because some movements might have been associated with seasonal activities of elk, we also compared movements for 10-day intervals before and after each hunting season opened. Consequently, we tested hypotheses that (1) elk movements during 10-day intervals of a hunting season did not differ from movements during 22–31 August, and (2) elk movements during 10-day intervals during the firearm seasons did not differ from the 10-day interval before the firearm seasons. Our data exhibited skewed distributions and we used multiple response permutation procedure (MRPP, Mielke and Berry 2001) to test for differences in distribution of elk movements among 10-day intervals. Multiple comparisons were made using the Peritz closure method (Petrondas and Gabriel 1983). These tests maintained experiment-wise error protection for determination of significant differences in the multiple range tests among 10-day intervals. Exact *P*-values are only available in the omnibus tests; we set significance of multiple range tests at predetermined α-levels. Consequently, we ran the procedure at $\alpha \leq 0.05$ and $\alpha \leq 0.10$ and reported the results accordingly.

We mapped and classified vegetation on private lands in the study area to vegetation structural stages described by Buttery and Gillam (1983) using 1:24,000 digital ortho-quad maps and 1:24000 aerial photographs. Ocular estimates of vegetation structural stage on private lands were referenced with vegetation structural stages of adjacent USDA Forest Service lands classified in the Resource Information System (RIS) for 4- to 32-ha land units. GIS coverage of the RI data was then edited to include private lands. We used ArcInfo (Environmental ystem Research Institute 2001) to create 500 m buffers around each point, and intersected these with the GI vegetation coverage. For analyses, we combined overstory canopy cover and diameter-at-breast height (DBH) categories of aspen and white spruce vegetation types because they comprised ≤ 5 percent of the area; ponderosa pine was combined across DBH categories into three overstory canopy cover categories (0-40%, 41-70%, and > 70%; Buttery and Gillam 1983). To evaluate whether elk selected for dense forest cover in response to human disturbance, we combined ponderosa pine > 70 percent overstory canopy cover and white spruce into a dense forest category. We then used a Design III model (Manly et al. 1993) to test the hypotheses that elk selected habitats randomly during each 10-day interval. Selection ratios resulting from these tests > 1 are indicative of preference while selection ratios < 1 are indicative of avoidance relative to availability in this study.

We adopted the road classification used by the Black Hills ational Forest of primary (> 35 vehicles/week), secondary (7 - 35 vehicles/week), and primitive (< 7 vehicles/week) roads in the tudy area. We then generated 2290 random points with a uniform distribution across the study area using Animal Movements (Hooge et al. 1999) in ArcView 3.2 (Environmental Research Systems Institute 1998). Because elk were distributed farther from primary roads than secondary roads and farther from secondary roads than primitive roads (Benkobi et al. 2004), we assumed that the effects of roads on dispersion of elk were hierarchal. Therefore, we constructed buffer strips in ArcMap (Environmental Research Systems Institute 2001) around primary and secondary roads at distances that use and availability intersected (350 m for primary roads and 240 m for secondary roads, unpublished data, Rocky Mountain Research Station, Rapid City, SD). Before calculating the distance from random points to the nearest secondary road, we clipped the 350-m buffer around primary roads from the GIS coverage. Likewise, before calculating the distance from random points to the nearest primitive road, we clipped the buffers around primary and secondary roads from the coverage. We used Tukey's bi-weight method (Mosteller and Tukey 1977) to estimate average ± SE of distances to roads. We then constructed 95-percent confidence intervals around average distances from elk and random points to the various road categories. The distance of elk to roads during each 10-day interval was compared individually to the distance of random points to roads so as not to exceed the degrees of freedom for statistical tests.

Results

We obtained 2779 daytime GPS locations within our study area boundary. We censored 47 daytime GPS locations because they occurred outside the study area where we did not have GIS vegetation classification. GPS telemetry success rates, e.g., percent attempted locations that were successful, averaged 87 percent during our study and varied from 82 percent in late August to > 90 percent in November.

Human activity averaged 890 hunter-days during archery elk seasons, 2457 hunter-days during firearm elk seasons, and 7032 hunter-days during firearm deer seasons. Thus, each successive hunting season resulted in approximately a three-fold increase in human disturbance.

Elk movements

Archery Season.—Movements between successive daytime locations of elk differed ($P \leq 0.10$) between the 10-day interval from 22-31 August, before the archery season, and the 10-day interval from 1-10 September after the archery season opened (Table 1, Fig. 2). Before the archery season, elk were relatively sedentary in their behavior. From 1-10 September, movements of elk that exceeded the median increased substantially and were probably what the MRPP test was sensitive to. Box and whisker plots of hourly movements for days within 10-day intervals showed that elk rarely moved more than 500 m in an hour before the archery season. The median and average distance between elk locations before the archery

Table 1. Average distance per hour between elk locations from GPS telemetry in 10-day intervals from 22 August to 30 November.

Season	Distance (m) between locations				Different from	
Dates	x		SE	Median	22-31 Aug[1]	last 10 days of previous season[2]
22 – 31 August	120	±	7.4	66	NA	
Archery Elk						
1 – 10 September	162	±	13.1	74		
11 – 20 September	119	±	9.3	57	NS	
21 – 30 September	153	±	11.9	73		
Firearm Elk						
1 – 10 October	176	±	13.4	90		NS
11 – 20 October	172	±	17.1	80		
21 – 31 October	126	±	10.9	58	NS	
Firearm Deer						
1 – 10 November	188	±	18.1	79	**	**
11 – 20 November	132	±	13.2	67	NS	
21 – 30 November	224	±	22.8	115	**	

[1] Results from MRPP test (Mielke and Berry 2001) using the Peritz closure method (Petrondas and Gabriel 1983) of movements by elk for 10-day intervals during hunting seasons with movements from 22 - 31 August. * = significance at $\alpha \leq 0.10$, ** = significance at $\alpha \leq 0.05$.
[2] Results from MRPP test (Mielke and Berry 2001) using Peritz closure method (Petrondas and Gabriel 1983) of movements by elk for the 10-day interval after the season opened with the previous 10-day interval. * = significance at $\alpha \leq 0.10$, ** = significance at $\alpha \leq 0.05$.

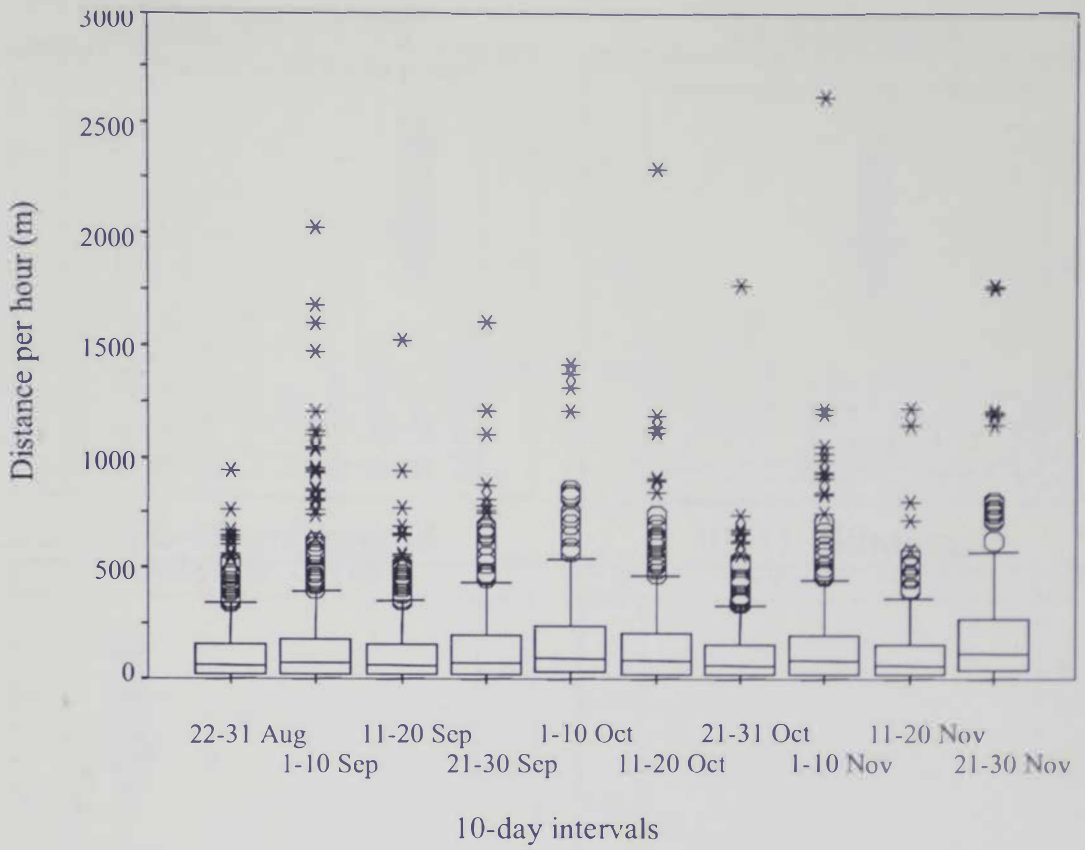

Figure 2. Box-and-whisker plots of distance per hour between GPS locations of elk for 10-day incremental periods from 22 August to 30 November of 2000 and 2001. Boxes represent the inner two quartiles above and below the median (indicated by a horizontal line) and whiskers are 1.5 times the inner quartile distance. Outliers are labeled with a circle and extreme values are labeled with an asterisk. To better show the differences between boxes the scale of distance per hour was limited to 1750/m hour. This resulted in elimination of 5 extreme data points.

season were 66 m and 120 m, respectively. Median distance between elk locations increased to 75 m and the average distance increased to 163 m the first 10 days of the archery season. The first weekend after the season opened was marked by increases in the spread of inner and outer quartile ranges above the median, but significant differences in these movements among days within the 10-day interval were not evident (Fig. 3). The 10-day interval from 11-20 September suggested a return to movement patterns observed before the archery season began ($P \geq 0.7$). Elk movements during the last 10 days of September exceeded ($P \leq 0.10$) those before the archery season began. The increased spread in the box-and-whisker plot the day before the firearm elk season was noteworthy. It occurred during the last weekend of the archery season.

Firearm Elk Season.—Movements (distance/hr) between successive elk locations during 1–10 October were similar ($P \geq 0.45$) to those during the last 10 days of the archery season (Table 1). Increased movements the last day of the archery elk season may have influenced this observed pattern. Elk movements from 1-10 October exceeded ($P \leq 0.10$) those from 22-31 August. Elk movements increased on the opening day of firearm elk season, and the first and second weekends of the season (Fig. 4). During the second 10-day interval of October, elk movements remained greater than 22-31 August ($P \leq 0.10$), but movements of elk the last 11 days of October were not different from late August ($P \geq 0.79$). Nonetheless, movements by elk increased during the last weekend of the season.

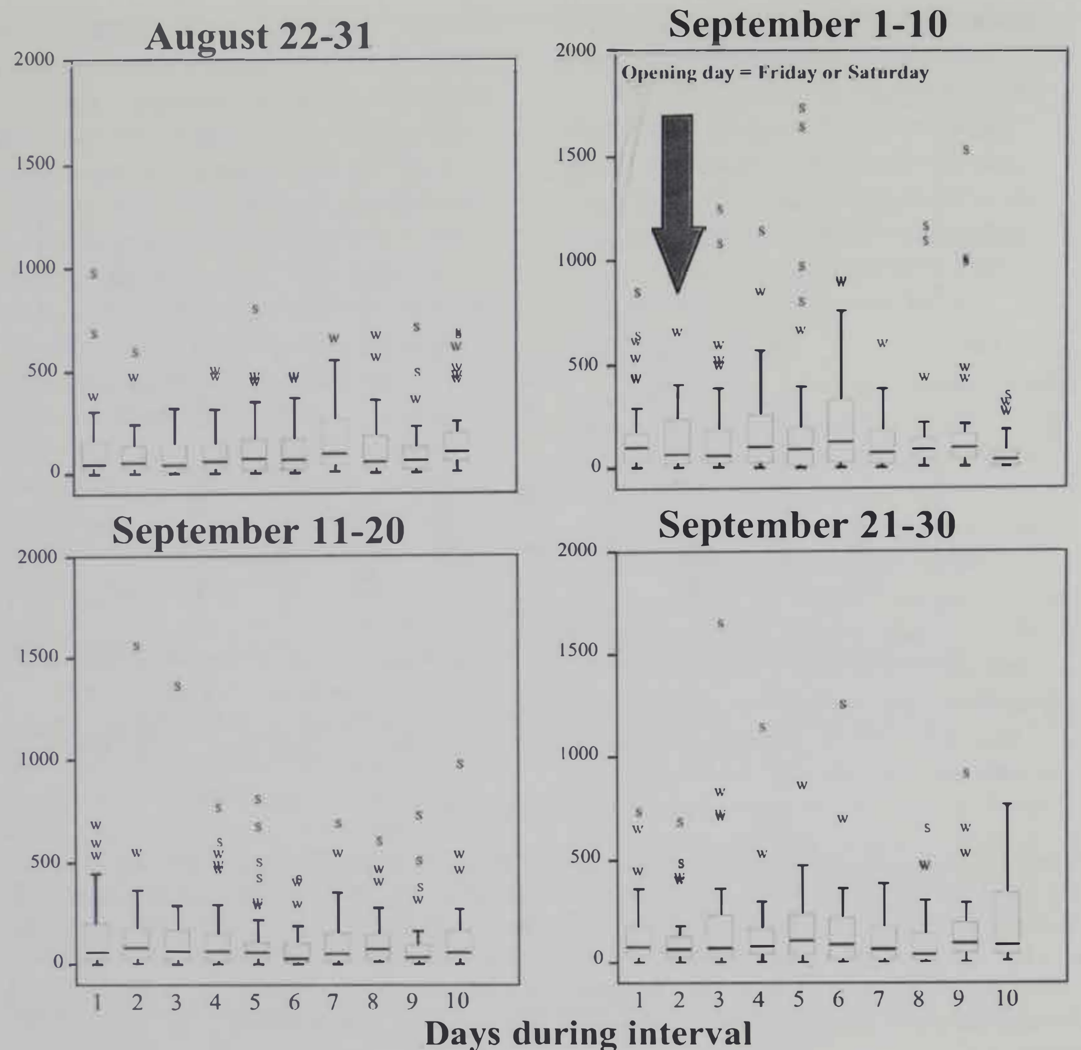

Figure 3. Box-and–whisker plots of distance per hour between successive GPS telemetry locations of elk from 22 August to 30 September of 2000 and 2001. Boxes represent the inner two quartiles above and below the median (indicated by a horizontal line) and whiskers are 1.5 times the inner quartile distance. Outliers are labeled with a w and extreme values are labeled with an s. Opening day of the archery elk season was a Friday or Saturday and the arrow indicates the first weekend.

Firearm Deer Season.—Elk movements after the opening of the firearm deer season on 1 November were greater ($P \leq 0.05$) than movements the last 10 days of the firearm elk season and greater ($P \leq 0.05$) than movements from 22-31 August (Table 1, Fig. 5). During the middle of the firearm deer season, elk movements were similar ($P \geq 0.97$) to those from 22-31 August. Movements by elk the last 10 days of the firearm deer season were greater ($P \leq 0.10$) than movements from 22-31 August. Average distance/hr between successive elk locations during this period exceeded that of any other 10-day interval during our study. We also observed a marked increase in dispersions of elk movements the day after Thanksgiving, a traditional day for deer hunting in the Black Hills.

Daytime elk movements the last 10 days of August averaged 1348 m/day. Daytime movements by elk increased 467 m/day for the first 10 days following the opening of archery elk on 1 September. After the opening of firearm elk season, daytime elk movements increased 566 m/day compared to the end of August. Daytime elk movements increased 544 m/day during the

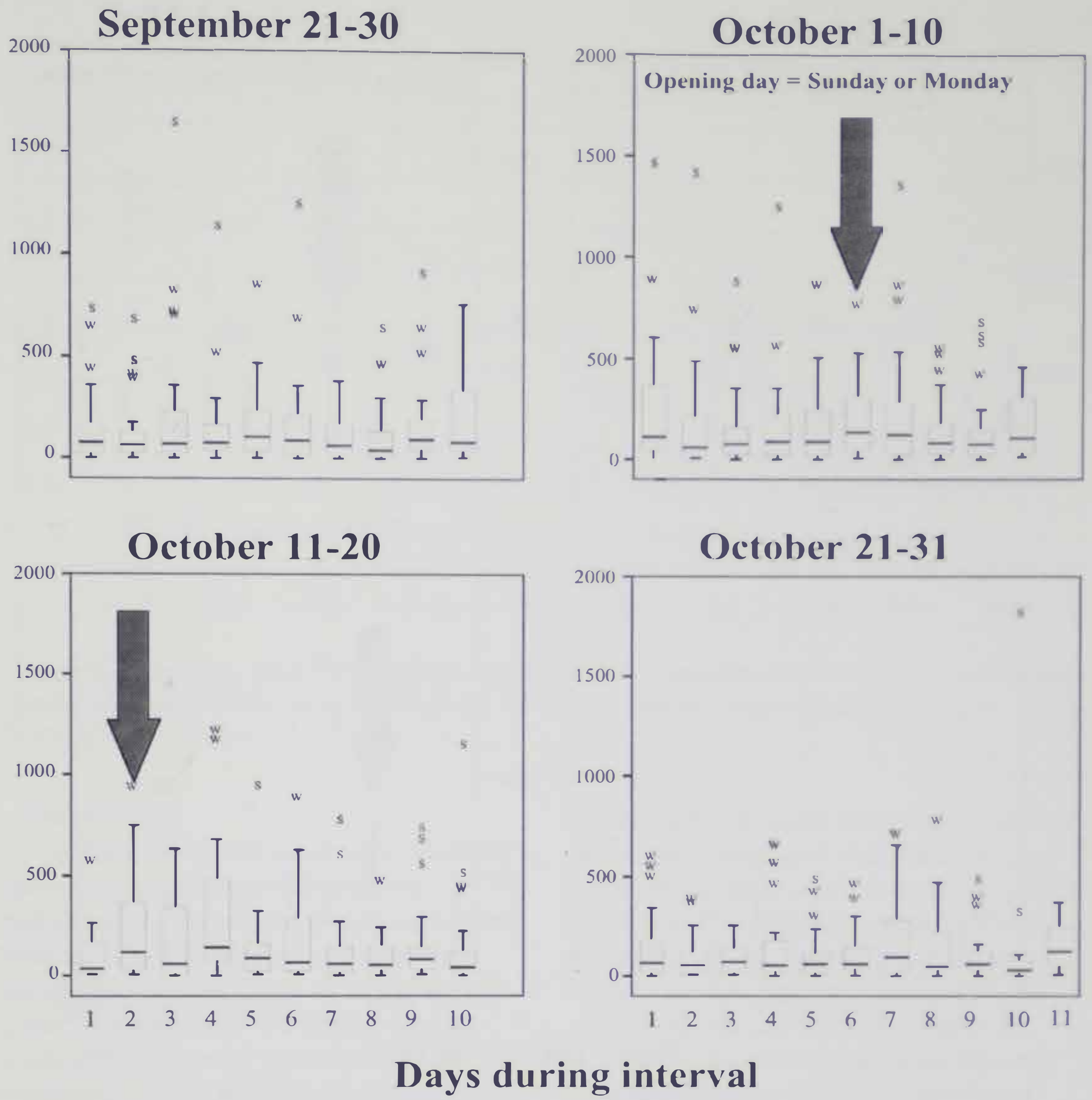

Figure 4. Box-and–whisker plots of distance per hour between successive GPS telemetry locations of elk from 21 September to 31 October of 2000 and 2001. See Figure 3 for explanation of box and whisker plots. Opening day of the firearm elk season was a Sunday or Monday and arrows indicate the first two weekends.

first 10 days of the firearm deer season when compared to the last 10 days of August, but increased 761 m/day during the last 10 days of November.

Dispersion of elk relative to habitat and roads

Elk selected habitats differently ($P < 0.10$) from habitats within 500 m of their locations during the 10-day intervals from 22 August thru 31 October. For the three 10-day intervals during November, patterns of habitat selection were not different from those available ≤ 500 m away ($P = 0.11$, 0.12, and 0.25, respectively). Habitat selection differed ($P < 0.01$) among animals during each 10-day interval. Although we can make few conclusive statements regarding the selection of habitats, a few patterns were evident: (1) the selection ratio for grasslands was positive prior to the opening of the archery elk season but was negative from 1 September through 30 November, and (2) we observed a clear pattern of declining selection ratios for grassland habitats associated with increasing human disturbance (Fig. 6). The selection ratio exhibited by elk during daylight

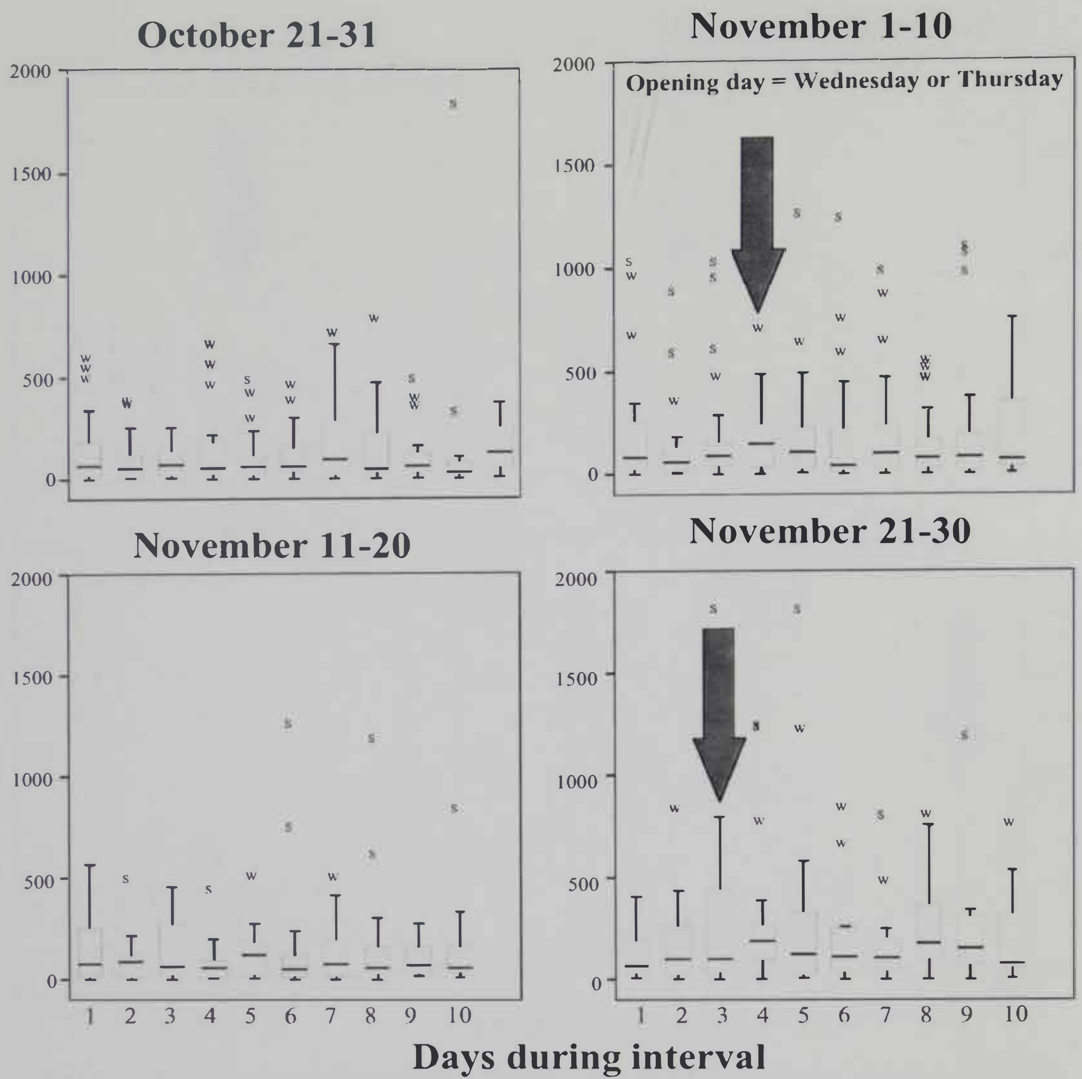

Figure 5. Box-and–whisker plots of distance per hour between successive GPS telemetry locations of elk from 21 October to 30 November of 2000 and 2001. See Figure 3 for explanation of box and whisker plots. Opening day of the firearm deer season was a Wednesday or Thursday and the arrows indicate the first weekend and the day after Thanksgiving.

periods was always positive for dense forest habitat (ponderosa pine or white spruce with > 70% overstory canopy cover).

After eliminating the effects of primary and secondary roads, elk were farther from primitive roads than random points within the study area for all 10-day intervals except 1-10 October (Table 2). Elk were farther from secondary roads through the period of 1-10 October after which elk dispersion patterns were indistinct relative to secondary roads. Elk locations relative to primary roads were similar to those for primitive roads in that elk were increasingly closer to primary roads during the 10-day intervals from 22 August to 10 October. After 11 October, the average distance of elk to primary roads increased through 30 November.

Discussion

Increased movement by elk coincided with increased human activity in the area followed by reduced movement similar to that before the hunting seasons. We believe that increased movement of elk following the opening of hunting seasons was a response to human activity and not to behavioral changes associated with fall

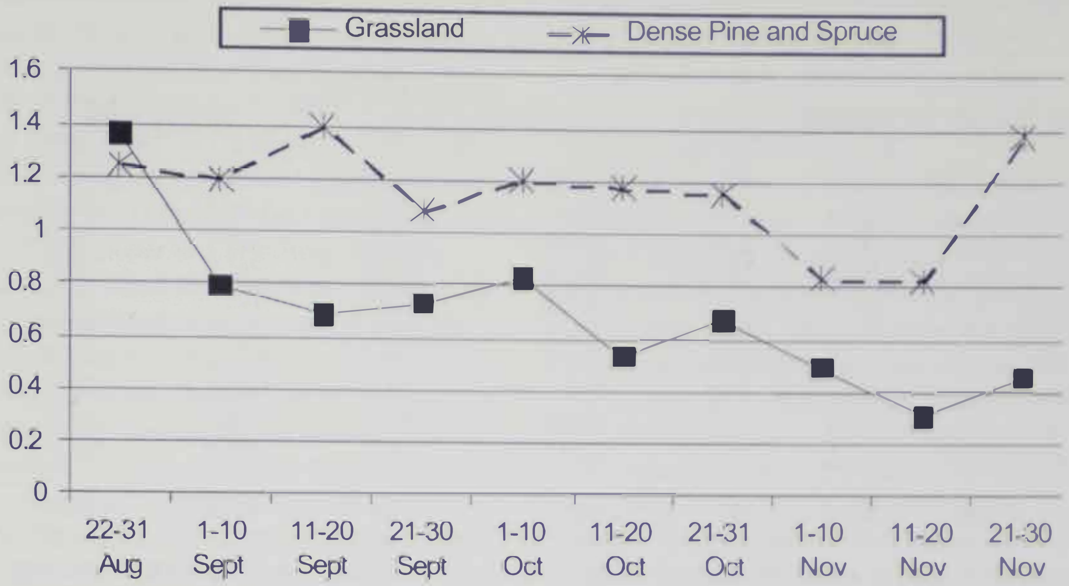

Figure 6. Selection ratios for grassland and dense forest (ponderosa pine > 70% overstory canopy cover and white spruce combined) for 10-day periods beginning in late August through 30 November.

rutting behavior.

Before 1 September, elk were relatively sedentary. In the days following the opening of the archery season, elk increased their movements, which might have been associated with recreation activities during Labor Day weekend. We believe that the increased movements by elk during the interval of 1-10 September did not result from human activities over Labor Day weekend because we detected significantly greater movements during the entire 10-day interval. Increased movements associated with the opening of the archery season were evident for ≥ 6 days. Conner et al. (2001) showed that elk behavior and movements were affected by archery hunters in Colorado. However, in Custer State Park, South Dakota, elk did not demonstrate significant behavioral responses to archery hunters in September (Millspaugh et al. 2000). The increased movements by elk during 21-30 September were likely influenced by scouting by firearm hunters and the end-of-season rush by archery hunters on 30 September.

The number of hunter-days that we recorded during the firearm elk season exceeded those during the archery season by about three times, and disturbance effects on elk movements lasted through the second weekend of the firearm season. In Custer State Park, South Dakota, elk avoided firearm hunters that was more notable in areas with less cover (Millspaugh et al. 2000). Increased movements by elk were also noted the day before the opening of the firearm elk season. Similar movement patterns by elk were noted before and after the firearm deer season. Opening of hunting seasons affected elk movements for about 6 days during the archery season, about 15 days during the firearm elk season, and about 10 days during the firearm deer season. Ward (1976), Hershey and Leege (1982), and Cassirer et al. (1992) noted effects of human activity and timber harvest on elk were often short term with elk returning to areas when the human activity ceased.

About 50 percent of our observations showed little or no movement between successive locations (lower quartile ranges) suggesting that elk remained nearly sedentary if undisturbed, perhaps in dense forest cover. We noted an increase in

Table 2. Average (± SE) distance (m) to the nearest primitive, secondary, or primary road of elk locations and random points for 10-day intervals between 22 August and 30 November of 2000 and 2001 in the Black Hills, South Dakota[1].

10-day interval	Classes of roads					
	Primitive roads[2]		Secondary roads		Primary roads	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
22 - 31 August	225.0	8.8A	2159.0	69.4A	1665.8	85.5
1 - 10 September	190.6	6.9A	2064.0	63.5A	1261.9	60.9B
11 - 20 September	198.9	7.8A	1898.7	64.8A	868.4	41.4B
21 - 30 September	185.2	7.3A	2233.5	77.5A	845.9	34.6B
1 - 10 October	166.2	7.7	2358.8	73.2A	708.0	36.4B
11 - 20 October	211.6	9.3A	1096.9	78.9B	918.2	52.6B
21 - 31 October	214.3	10.4A	1832.1	77.7A	1185.5	63.5B
1 - 10 November	210.2	9.4A	1314.1	80.5	1719.3	70.8
11 - 20 November	213.4	9.8A	1112.0	64.3B	2018.7	97.7
21 - 30 November	234.0	11.1A	1542.2	106.3	2456.0	109.5A
Random points	**145.0**	**3.1**	**1448.1**	**30.6**	**1854.2**	**34.9**

[1]Estimates of average distance in meters and SE were made using Tukey's bi-weight method (Mosteller and Tukey 1977).

[2]Average distance of elk locations for 10-day intervals within a column followed by letter A were significantly ($P \leq 0.05$) farther than random points from roads; averages followed by letter B were significantly ($P \leq 0.05$) closer than random points to roads.

the failure rate of GPS location attempts and the percent of locations that elk were bedded during October (unpubl. data, Rocky Mountain Research Station, Rapid City, SD). Percent of successful GPS locations was negatively correlated, ($r = -0.64$, $P = 0.05$) with the selection ratio for white spruce, suggesting that elk increasingly sought areas of dense forest, which would reduce success rates of GPS locations (Gamo et al. 2000). During periods of increased human disturbance, such as hunting seasons, elk seek areas that provide greater cover (Hurley and Sargent 1991, Lyon and Canfield 1991, Millspaugh et al. 2000). When dense forest comprised > 25 percent of the available habitat, the selection ratio exhibited by elk was > 1.0.

Increased movements by elk associated with human activity could contribute to weight loss by elk in the late fall or winter. An elk on a mixed forage diet weighing 259 kg (Parker et al. 1984) with estimated forage availability on our study area of 2283 kg/ha (unpubl. data, Rocky Mountain Research Station, Rapid City, SD) and forage digestibility of 45 percent (Hobbs et al. 1981) would require an extra 30-46 min/day of foraging during hunting seasons to compensate for energy expenditures associated with human disturbance. The increased foraging time would not be important except that the model (Parker et al. 1984) predicted that elk had to forage 17.75 hr/day to meet their basic needs of $70W_{kg}^{0.75}$. This foraging time requirement exceeded the theoretical foraging time limit of > 12-15 hr/day (Owen-Smith 1982, cited by Wickstrom et al. 1984).

Before the fall hunting seasons, elk selected open grassland habitats during daylight periods. Forage was more abundant in grasslands than other habitats (unpublished data, Rocky Mountain Research Station, Rapid City, SD). This pattern clearly changed once the hunting seasons began and elk avoided open grasslands during the day. Hourly movements by elk in the outer quartile ranges (upper whisker in Figs. 2-5) often were greater than the median projected for the entire day.

We believe that dispersion patterns of elk during hunting seasons relative to roads resulted from the types of equipment and methods used by hunters. Ward and Cupal

(1979) have shown that humans on foot and gunshots ≤ 300 m from elk elicit heart-rate and flight responses. Archery hunters are usually in the forest trying to get close to elk. Because of the limited opportunities for elk to avoid roads associated with the high density of roads, any disturbance on primary or secondary roads would probably push elk closer to a primitive road. In our study when the effects of primary and secondary roads were removed from the GIS, it was difficult to get > 150 m from a primitive road. By the second week of the firearm elk season, elk dispersion patterns relative to roads changed. "Road hunting" is common and types of habitat in which road categories occurred confounded any response by elk to disturbance on roads during firearm seasons. Primary roads were mostly in meadow drainages with low slope. Secondary roads occurred in narrower meadow drainages, valleys, and the forest, where visibility from these roads was less. Primitive roads were usually in forested areas. Although elk were closer to primary and secondary roads than random points, they remained > 700 m away and usually > 1 km from these roads. Effects of roads on elk dispersion patterns extend 400 m (Ward 1976) and likely farther (Hershey and Leege 1982, Rowland et al. 2000). Elk dispersion patterns relative to roads are not a simple matter of distance to the nearest road (Lyon 1983) and the response of elk to firearm hunters depends on the extent of cover (Lyon and Canfield 1991, Millspaugh et al. 2000). We attempted to separate road effects in a hierarchal manner from primary to primitive roads, but the repeated nature of disturbance, high road density, styles of hunting, and effective ranges of the harvest mechanisms used by hunters influenced elk dispersion patterns.

Management Implications

We could not use experimental controls to quantify the response of elk to human activity. If the response of elk to activity shown here resulted from normal behavioral changes in the fall, increased movements by elk associated with opening of hunting seasons would not have declined coincident with normal hunter participation. Human disturbance associated with hunting seasons probably cannot be eliminated because hunting is the primary method for controlling elk populations.

Nonetheless, as demand for outdoor recreation increases, we believe the response of elk to hunters provides a pattern of elk responses to human disturbance during other times of the year. Trends indicate that all-terrain vehicle and snowmobile use has increased dramatically in the past 10 years (Curtis 2000, International Snowmobile Manufacturers Association 2002, Federal Register 2003). In 2003, unrestricted off-highway recreation was recognized as one of four threats to the Nation' national forests (USDA Forest Service 2003). In national forests with high road densities and few restrictions on off-road vehicle recreation, there is little opportunity of elk to seek areas of low disturbance. In areas of low road density, elk select areas to avoid human disturbance (Lyon 1979, Rowland et al. 2000), often moving onto private lands (Vieira et al. 2003). In the Black Hills, elk responded to human disturbance most notably by increasing movements. Models of energy expenditures (Parker et al. 1984, Wickstrom et al. 1984) suggest that elk cannot compensate for the additional energy expended during fall and winter, but this subject needs additional research. Road closures may provide areas of reduced disturbance to elk.

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A Dynamic Test of Spatial Independence Among Bighorn Sheep

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Abstract

The spatial interactions of marked study animals are often of interest in studies of wildlife ecology. All forms of resource selection analysis assume that marked individuals move and select resources independently, and this is often violated when animals are social or territorial. For this paper we deal with relocation data collected from a gregarious species, bighorn sheep (*Ovis canadensis*), and wish to assess the spatial independence of marked animals. Many commonly used methods for quantifying spatial interactions do not include the spatial and temporal details of simultaneous relocation data. In their place, we used a modified nearest-neighbor method and data from three small herds of bighorn sheep in western Montana to test for independence among marked animals. Results suggested that marked ewes within each study area were not selecting habitat independently of one another. Consideration of spatial independence can be important in a *posteriori* analysis and interpretation of data, as well a *priori* consideration of necessary sample sizes.

Key words: bighorn sheep, habitat selection, overlap, *Ovis canadensis*, resource selection, spatial independence

Introduction

The spatial interactions of marked study animals are often of interest in studies of wildlife ecology. In particular, resource selection analyses require that study animals represent independent samples of space use. Animals that attract or avoid each other can violate this assumption, and thus lead to inflated sample sizes and biased results. While *a posteriori* assessment of sampling independence is encouraged, this issue should also be raised during *a priori* study planning. Given the often significant costs of capturing and monitoring many animals in an area, the *a priori* consideration of spatial independence might avoid a frustrating *a posteriori* discovery that 20 sampled animals are in fact acting as one.

Spatial independence is demanded across all forms of resource selection analysis. A variety of analytic methods are available within the broad field of resource selection, including chi-squared goodness-of-fit tests and confidence intervals (eu et al. 1974, Byers et al. 1984), ranking methods (Johnson 1980), compositional analysis (Aebischer et al. 1993), and general linear models (Manly et al. 2002). Each of these methods has its own set of assumptions, but they all require that sampled animals select resources independently. We considered this assumption when dealing with simultaneous radio-telemetry data from a social species, bighorn sheep (*Ovis canadensis*). It was unclear if our study animals were selecting resources as a group or as individuals. Before pooling data, defining the appropriate sample unit for resource selection analyses required an assessment of spatial independence of marked individuals.

Many techniques have been used to quantify spatial independence, and they can broadly be categorized as static (Jorgensen 1968, Millspaugh et al. 2004) or dynamic (Cole 1949, Minta 1992, Millspaugh et al. 1998, Dasgupta and Alldredge 2000).

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Static analyses of spatial independence are generally a measure of shared space use (often home-range overlap) of two animals over a given study period. Dynamic methods require simultaneous relocation data and include the spatial and temporal information of each location in an analysis of independence. Simultaneous relocation data are often possible in telemetry studies with concentrated telemetry sessions, but the biologist must determine the maximum time interval between locations to consider them simultaneous.

While static analysis techniques are growing more sophisticated and studied (Millspaugh et al. 2004), we value the temporal information in simultaneous relocation data and will focus on dynamic methods for the remainder of this paper. Unfortunately, most dynamic tests are fairly simple comparisons of the number of times marked animals are observed together or apart. Cole's (1949) coefficient of association has been used sporadically in the study of bighorn sheep to coarsely assess group cohesion (Brown 1974, Elenowitz 1984, Ebert 1993) and is simply a ratio of how often two animals were observed together over the total number of times they were located. More recent tests are available (Millspaugh et al. 1998, Dasgupta and Alldredge 2000), but they reduce the spatial characteristics of radio-telemetry data into categories of "together" or "apart." This creates arbitrary cut-off values for defining how close the animals must be to be "together" and categorizes animals that are 500 m apart the same as animals 5000 m apart. It also excludes avoidance as a testable form of dependence between study animals.

In this paper, we present an alternative method for quantifying spatial independence with relocation data that has been used to detect avoidance behavior between carnivores (Keenan 1981, Major and Sherburne 1987, Arjo and Pletscher 1999). The modified nearest-neighbor technique tests dependence between two animals as a function of the distance between them, and we use it to detect dependence in radio-telemetry data from bighorn sheep. This method allows researchers to explicitly test relocation data for spatial independence before carrying out further analyses.

Methods

Study Areas

We studied Rocky Mountain bighorn sheep (*O. c. canadensis*) at three sites (Bearmouth, Garrison, and Skalkaho) in the Rocky Mountains of western Montana at elevations of ~ 1100-2000 m. The Bearmouth (N 46° 43', W 113° 27') herd occupied parts of the southern Garnet Range, 50 km east of Missoula, Montana. The Garrison (N 46° 31', W 112° 50') herd was located in the northeastern foothills of the Flint Creek Range, 100 km east of Missoula, and the Skalkaho (N 46° 10', W 113° 59') herd was in the western Sapphire Mountains, 75 km south of Missoula.

Data Collection

In March 2001, we captured and radio-collared 15 adult female Rocky Mountain bighorn sheep at three sites using a net-gun from a helicopter (Krausman et al. 1985). We attempted to capture animals from different subgroups within each herd, and finished with two (Bearmouth), seven (Garrison) and six (Skalkaho) radio-collared animals per site. Between March 2001 and August 2002 we collected 1019 locations for these 15 ewes. We allotted a minimum of 3 days between successive locations for the same animal to ensure suitable temporal independence within an individual set of locations (Swihart and Slade 1985, Swihart et al. 1988, Ebert 1993, McNay et al. 1994). We sorted locations by herd and season, so analyses were done for a given pair of ewes of the same herd during the same season. Biologically meaningful seasons were selected by finding noticeable shifts in habitat use by ewes during the transitional periods. For example, a notable shift towards rocky escape terrain marked the beginning of lambing season each spring. The lambing season lasted from early May through late July, the fall season from early August through late November, and the winter season from early December through late April. Analysis for each season required a minimum of 10 pairs of simultaneous locations (Arjo and Pletscher 1999).

The Modified Nearest-Neighbor Test

The nearest-neighbor test detects whether two animals are randomly located throughout the landscape in relation to one another. Significant results would come from animals that are closer together or further apart than would be expected from random association. It begins with a set of "simultaneous" locations for two animals over time. For our purposes, "simultaneous" meant the two animals were located on the same day, roughly within an eight-hour period. A distribution of distances is created by measuring the distance between the two animals for each pair of simultaneous locations. On a day when the two animals were located together, this distance is essentially zero.

Another distribution of distances was created by randomly pairing the same set of locations without considering time. For example, animal A's location on day 3 might be paired with animal B's location on day 12. These random pairs were selected with replacement; we used a sample size of 500 randomly selected pairs to get a distribution of 500 distances. We used the non-parametric Mann-Whitney *U* to test for differences between these 2 distributions: 1) distances between simultaneous locations of two ewes, and 2) distances between the same set of locations randomly paired with replacement. *P*-values provide a measure of statistical significance, or consistency, when testing independence but do not necessarily relate to the magnitude of the difference (Anderson et al. 2000). To consider biological significance, we also calculated the median separation distances and effect sizes (mean distance between randomly paired locations - mean distance between simultaneous locations) for each herd/season.

We applied this test to ewes from three herds with sample sizes of 2, 7, and 6 radio-collared ewes, resulting in 1, 21, and 15 possible ewe-pairs/herd, respectively. We considered the distribution and range of effect sizes and *P*-values to assess the degree of independence at the herd level.

Results

We found a lack of independence between bighorn ewes within all three herds (Table 1). Median separation distances were small, ranging from 0 to 570 m, and all effect sizes were positive, indicating that ewes were consistently closer together than random expectations. A single ewe-pair was analyzed for the Bearmouth herd; effect sizes were large, and *P*-values were low across seasons (Table 1). This suggests dependence in the movements and resource selection of these two ewes. Twenty-one combinations of ewe-pairs/season from the Garrison herd also showed large effect sizes and low significance values (Table 1); these seven radio-collared ewes evidently lacked independence in their movements. Fifteen possible combinations of ewe-pairs/season in the Skalkaho herd produced a wider range of *P*-values, though effect sizes were consistently positive (Table 1). Each ewe was dependent on at least one other ewe/season, and we found no evidence of segregation between groups of ewes. We concluded that these Skalkaho sheep lacked independence in their movements and should be analyzed as a herd instead of as individuals.

Discussion

We detected dependence among individuals in all three herds of bighorn sheep using nearest-neighbor analyses. It is inappropriate to consider data for each ewe as an independent sample of movement or habitat use. Instead of 15 independent samples of individual use, we have three independent samples of herd use.

Limited solutions are available when a lack of independence has been detected in a set of data. In terms of resource selection, we considered two methods of defining the sample unit. Analyses like the chi-square goodness-of-fit test (Neu et al. 1974) and general liner models (Manly et al. 2002) define the relocation as the sample unit.

Table 1. Median separation distances (m), effect sizes (m) and Mann-Whitney *U* Test probability values for modified nearest-neighbor tests of spatial independence between bighorn sheep ewes of Bearmouth ($n = 2$), Garrison ($n = 7$), and Skalkaho ($n = 6$), Montana, 2000-2001. All possible ewe-pairs within each herd were tested. Separation distance is the median distance between simultaneous locations of ewes. Effect size per ewe-pair = (mean distance between randomly paired locations – mean distance between simultaneous locations).

		Season								
		Lambing			Fall			Winter		
Site	Ewe-pairs	Median separation (m)	Median effect size (m)	*P*	Median separation (m)	Median effect size (m)	*P*	Median separation (m)	Median effect size (m)	*P*
Bearmouth	1	290	1153	<0.001	0[1]	780	0.002	570	373	<0.001
Garrison	21	150	518	<0.001 - 0.012	27	977	<0.001 - 0.003	149	852	<0.001 - 0.096
Skalkaho	15	313	622	<0.001 - 0.617	357	224	<0.001 - 0.460	472	441	<0.001 - 0.907

[1] Distance betwee ewes was recorded as 0 m on days when animals were located together.

In these cases, we suggest data be pooled, switching the sample unit from the locations of individuals to the location of groups. In this way, a group of five radio-collared animals in the same place would be recorded as a single location, and a single radio-collared animal in a different place would be another group location (a group of one). This approach has been used in past studies of gregarious animals like bighorn sheep (Gionfriddo and Krausman 1986, Andrew et al. 1999).

In analyses like Johnson's (1980) ranking method or compositional analysis (Aebischer et al. 1993) where the animal, and not the relocation, is the sample unit, a solution is less evident. If there are multiple social groups of dependent animals, (but the groups remain independent), then the sample unit might become the social group. This could require much data, as in the case of our three herds of bighorn sheep; we have three independent populations, and $N = 3$.

Before pooling these data, we considered the difference between statistical dependence and biological dependence (Millspaugh et al. 1998). For example, in studies of obligatory cooperative hunters, such as African hunting dogs (*Lycaon pictus*), the appropriate sample is the pack, and data from individuals within a pack should be pooled. Radio-collared elk (*Cervus elaphus*) that converge on a patch of scarce winter range may show a lack of statistical independence, when in fact, each elk made an independent choice to be there. Biologically, one might still consider each elk an independent sample (Millspaugh et al. 1998). In the case of bighorn sheep, researchers might argue that ewes congregate on steep, cliffy habitat during lambing season because it is the best habitat, not because of dependence. Each ewe may make an independent choice to be there. However, social groups are a consistent, year-round behavior of bighorn sheep (Geist 1971), and we observed a lack of independence across all seasons; this suggested both statistical and biological dependence. We do not, however, believe that bighorn data from a given site should always be pooled due to lack of independence. Festa-Bianchet (1986) found that three distinct populations of bighorn ewes used a single area during different times of the year. A test of spatial independence with such data would reveal independence between groups, and prevent the loss of information by pooling data across independent study animals.

Dasgupta and Alldredge (2000) adjusted the Neu et al. (1974) method of analysis to incorporate dependency. Unfortunately, their dependency parameter reduces spatially continuous location data into groups of "together" or "apart," and is a less sensitive test than that presented in this paper. However, their goal of accounting for dependency in resource selection analyses is a promising one. They include the degree of independence as an additional parameter in the chi-square goodness-of-fit test for resource selection. We encourage development of such a technique for more recent resource selection analyses like compositional analysis or generalized linear modeling.

Spatial independence is an important assumption in the study of resource selection by animals. When simultaneous data are collected, it is prudent to make full use of all the spatial and temporal information available in such data. We recommend the modified nearest-neighbor test as a dynamic analysis of independence between study animals. Although we have focused on *a posteriori* detection of spatial independence, this is an issue that should be considered *a priori* in future studies. Before expending great effort and resources into marking dependent animals, we encourage researchers to take into account the biology and behavior of the study species. Both *a priori* and *a posteriori* consideration of this issue will improve the reliability of results.

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Feast and Famine on the Lewis and Clark Trail

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Abstract

The Lewis and Clark Journals (1804-1806) provide the first reliable documentation of diversity, relative abundance, distribution, and harvest of large animals in the upper Missouri plains and Columbia River corridor regions between Fort Mandan and the Pacific Ocean. The Upper Missouri plains served as a living dynamic entity with a biological diversity that was nurtured and sustained by the main arterial stem of the Missouri and its extensive network of perennial tributaries. From the Lewis and Clark Journals daily entries, I provide summaries of kills of large wild game by the Expedition by geographic region. I also present these summaries of game kills in context of Merriwether Lewis' 24-hr ration-unit requirement for the Expedition's personnel providing a reasonable picture of animal protein availability along the travel route through a variety of physiographic regions. East of Traveler's Rest, to the Montana-North Dakota border, the accumulation of surplus daily ration units averaged well above the daily requirement. The geographic region between Traveler's Rest and Fort Clatsop provided an average daily ration unit of one-half the needed requirement on the outward and return trip.

Key Words: megafauna, physiographic regions, ration units, recorded kills

Introduction

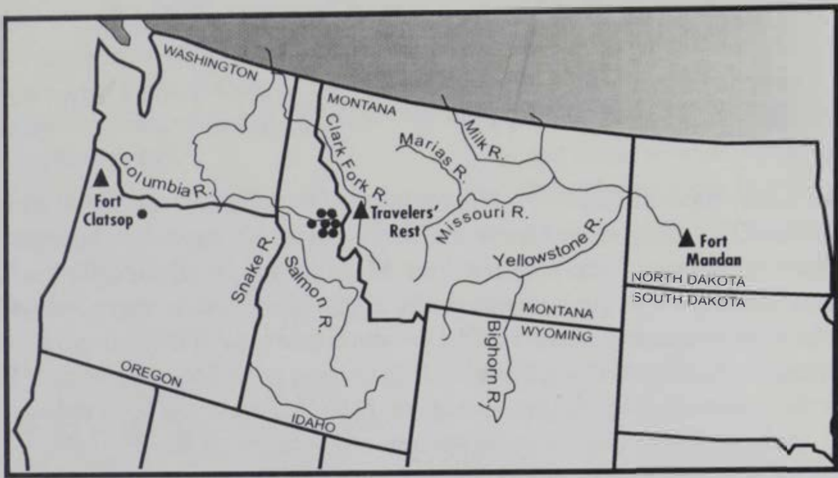
The Lewis and Clark journals (Moulton 1983-2001) provided the first documentation of pre-settlement wildlife habitats, natural history, behavioral characteristics, and game kills during their epic 28-month outward and return journey. The journals also provide an impression of an upper Missouri-Yellowstone drainage basin filled with staggering numbers of wild ungulates.

On departure from Fort Mandan in the late afternoon of 7 April 1805, some concern about the unpredictable aspects of penetrating further into the unknown certainly must have passed through Meriwether Lewis' mind. "We are about to penetrate a country at least 2000 miles in width, on which the foot of civilized man had never trodden; the good or evil it had in store for us was for experiment yet to determine" Lewis wrote in his journal. No Expedition member could guess what the "good" might hold, but an optimistic Lewis was relying on the land to provide substantial amounts of wild game to satisfy and sustain their animal protein needs.

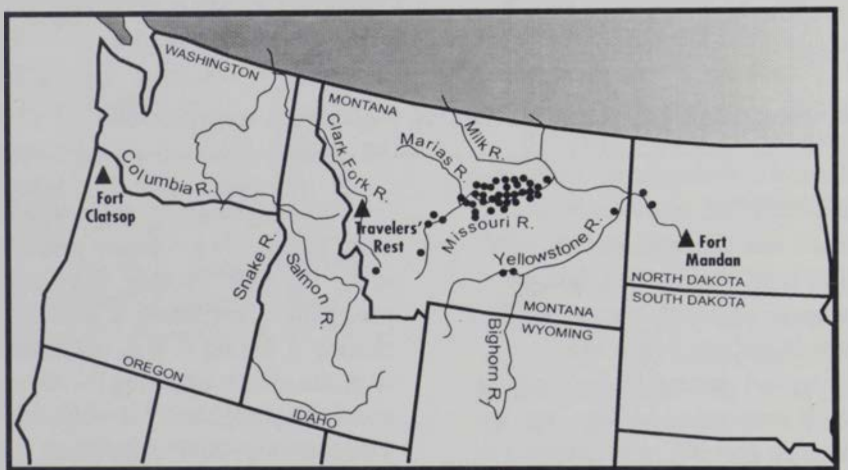
"Food," as Furtwangler (1993) emphasized, "is a constant preoccupation in the Journals. Finding it, capturing or procuring it, preparing it, preserving it, sharing it, eating it, and, not least, coping with the results of eating it—these processes stand out prominently on page after page." The Journals provide elaborate lessons as to how the explorers coped with feast, famine, and adjusting metabolisms as they penetrated and explored different regional environments.

Between 7 April 1805 and 12 August 1806, a total of 494 days of travel from Fort Mandan to the Pacific and their return to the Mandan villages the following year, the expedition killed 567 deer (*Odocoileus* spp.), 280 elk (*Cervus elaphus*), 187 bison (*Bison bison*), 40 bears (*Ursus* spp.) of which 32 were grizzlies (*U. arctos*). In addition they killed 44 mountain sheep (*Ovis canadensis*), 69 pronghorns (*Antilocapra americana*), and an undetermined number of smaller mammals, waterfowl, and fish. Approximate locations for the seven big game species location kills are shown in Figure 1. Although the total number of

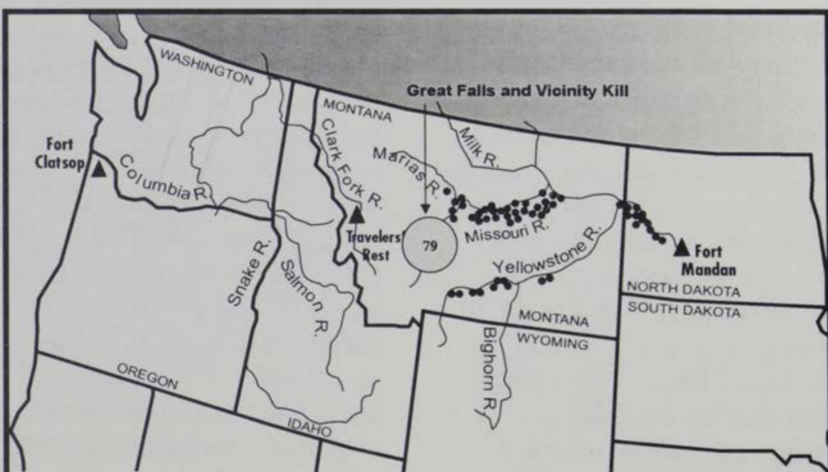
Fig. 1. Lewis and Clark 1805-1806 Expedition approximate big game kill locations from Fort Mandan to Fort Clatsop (1805) and return (1806) trip to Fort Mandan.



Corps of Discovery black bear kills (1806) between Ft. Clatsop and Ft. Mandan. Total black bear kill on return trip (8). Each l represents one bear kill.

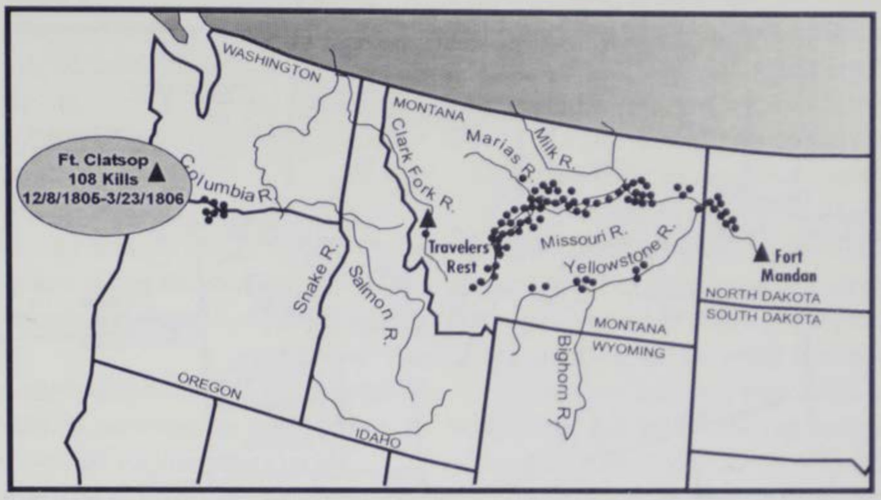


Corps of Discovery bighorn sheep kill (1805-1806) between Ft. Mandan and Ft. Clatsop. Total sheep kill on outward and return trips (44). Each l represents one sheep kill.

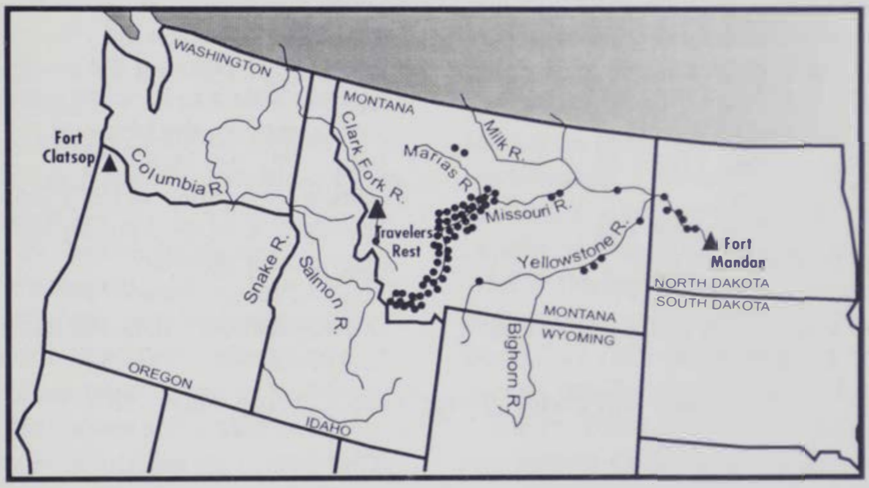


Corps of Discovery bison kill (1805-1806) between Ft. Mandan and Ft. Clatsop. Total bison kill on outward and return trips (187). Each l represents two bison killed.

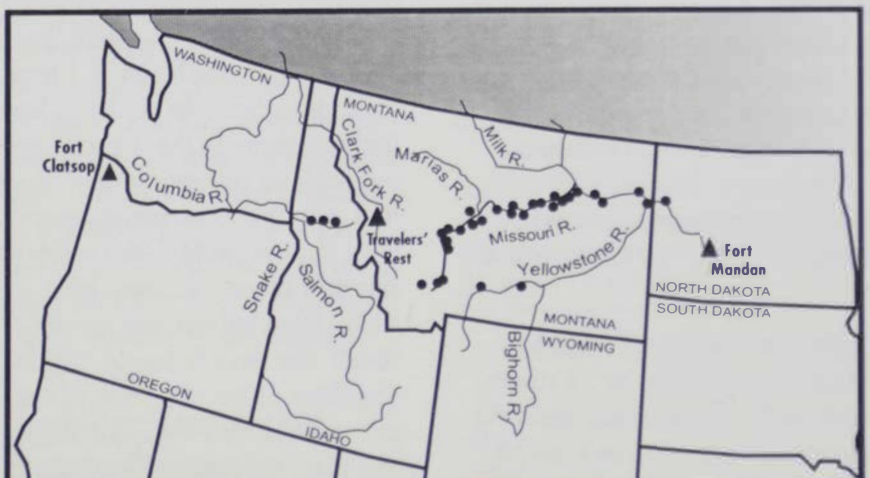
Fig. 1 (continued)



Corps of Discovery elk kill (1805-1806) between Ft. Mandan and Ft. Clatsop.
Total elk kill on outward and return trips (280). Each l represents two elk killed.

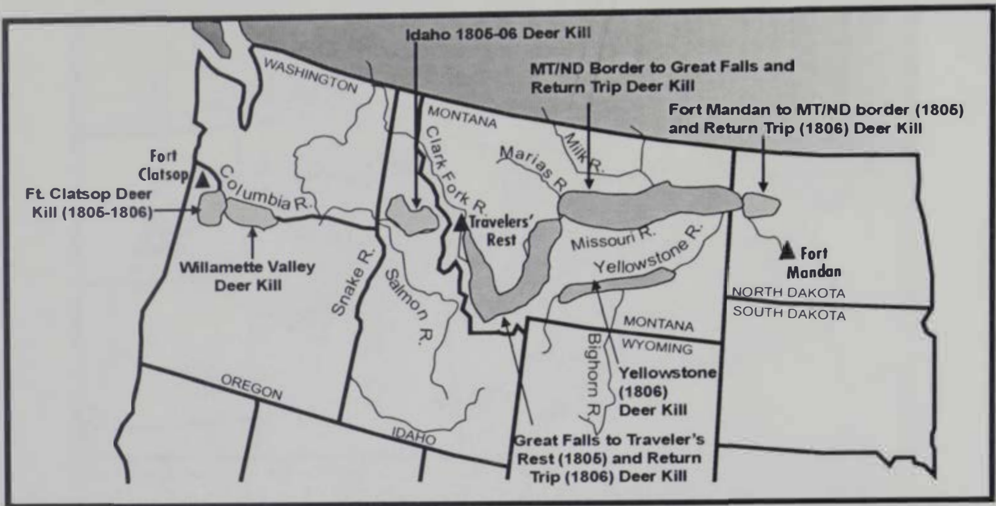


Corps of Discovery pronghorn kill (1805-1806) between Ft. Mandan and Ft. Clatsop.
Total pronghorn kill on outward and return trips (69). Each l represents one pronghorn kill.



Corps of Discovery grizzly kill (1805-1806) between Ft. Mandan and Ft. Clatsop.
Total grizzly kill on outward and return trips (32). Each l represents one grizzly kill.

Fig. 1 (continued)



LEWIS AND CLARK EXPEDITION DEER KILL (1805-1806).
Shaded areas show major deer kill areas.

- Fort Mandan to Traveler's Rest
  7 Apr. 1805 - 11 Sep. 1805 - 235
- Traveler's Rest to Ft. Clatsop
  12 Sep. 1805 - 8 Dec. 1805 - 45
- Winter at Ft. Clatsop
  8 Dec. 1805 - 23 Mar. 1806 - 11
- Ft. Clatsop to Traveler's Rest
  23 Mar. - 30 Jun. 1806 - 89
- Expedition's 3-day stay at Traveler's Rest
  30 Jun.-12 Jul. 1806- 21
- Lewis' exploration of the Marias - Traveler's Rest to Meeting with Clark contingency on the Missouri
  3 Jul. - 12 Aug. 1806 - 78
- Clark's exploration of the Yellowstone - Traveler's Rest to reuniting with Lewis and party on the Missouri
  3 Jul. - 12 Aug. 1806 - 71
- Ordway and Gass detachments
  13 Jul. - 28 Jul. 1806 - 17

Total Deer Kill Count –7 Apr. 1805 - 12 Aug. 1806 - 567

big game kills might sound impressive, it does not portray marked differences in the abundance/scarcity of game for the various physiographic regions that the Expedition passed through each with distinctive climatic, topographic, and vegetative differences. The importance of obtaining sufficient wild game for food and other basic necessities played an important role in determining the success or failure of the expedition.

"We Eat an Emensity of Meat"

To sustain the expedition of 32 adult members with sufficient big game meat, Lewis acknowledged, "we eat an emensity of meat; it requires 4 deer, an Elk an a deer, or one buffaloe to supply us plentifully 24 hours." Each category equates to a single 24-hour ration unit. Following Martin and Szuter's (1999) methodology, each of the following equals one ration unit required for the expedition on a daily basis: four deer; 1.3 elk; one bison; 1.3 bear; and eight pronghorn. In addition, I would add bighorn sheep to the list with four sheep required for one ration unit. Some purport that expedition members ate as much as 9-10 lb of meat/day after a day of excessive physical labor (Ambrose1996). How much of the meat/animal was actually utilized for food? The answer would depend on such variables as the condition of the animal, sex and age of the animal, distance of the kill from the main party of the expedition, spoilage due to warm temperatures, loss of meat to scavengers, killing of animals primarily for hides to make clothing, tow ropes, and other factors. In some areas of game abundance, excess and a waste of meat certainly occurred as only choice cuts, bison tongues and marrowbones were taken. Despite the interpretive limitations, Lewis' 24-hr ration requirement for the expedition's personnel does provide for a fairly realistic picture of animal protein availability to meet that requirement along the expedition's route of travel through a variety of physiographic regions.

The journals also recorded other sources of animal protein provided by small game animals, as well as various other foods including dogs, roots, and fish purchased from Indians. Although this information is important and these foods were necessary for survival and success of the Expedition, I present here only the relative contribution of native game animals to meeting the daily ration requirement.

An examination of the expedition's daily kills of big game provides information on (1) big game species harvested and relative abundance by distinctive physiographic regions, and (2) how well the available wild game provided game ration units in specific localities. For example, as the expedition traveled through a blend of plains river bottom and prairie badlands after leaving Fort Mandan on 7 April 1805 and arrived at the mouth of the Yellowstone River on 26 April 1805, 22 deer (5.5 ration units), eight elk (6 ration units), 20 bison (20 ration units), and three pronghorns (0.38 ration units) were killed.

The above equates to 32 ration units for the 21 days of travel or a daily average of 1.5 ration units. It should be noted that some of the animals killed were in poor condition. The failure to kill any big game until five days after their 7 April departure from the Mandan villages probably can be attributed to excessive local hunting by the Mandan, Hidatsa, and Assiniboin.

Mouth of the Yellowstone to the Great Falls of the Missouri

The expedition's route of travel from the mouth of the Yellowstone to the Missouri's Great Falls consists of a complex and diverse landscape dominated by a plains riverbottom, prairie uplands, badlands and timbered breaks, each with di tinct topographic, climatic, vegetative features, and microsites.

The Missouri plain country at this time was apparently an American Serengeti—a wildlife utopia of staggering proportions with bison dominating the landscape. When first visited by the Corps of Discovery, the area served as a living dynamic entity with a biological diversity nurtured and sustained by the main arterial stem of the Missouri and its interlacing network of perennial tributaries. On 6 May 1805 while traveling through what is now Mc one County, Montana, Lewis wrote " It is now only amusement for Capt. . and myself to kill as much meat as the party can consum; I hope it may continue thus through our whole rout, but this I do not much expect." Two days later he added another note in his journal on game abundance in the plains environment, "We can send out at any time and obtain whatever species of meat the country affords in as large quantity as we wish." During Clark's exploration of the Yellowstone on the return trip, he reported on 27 July 1806 while traveling through present day Treasure County, Montana that " The Buffalow and Elk is estonishingly noumerous on the banks of the river… particularly the Elk…so jintle that we frequently pass within 20 or 30 paces of them without their being the least alarmd." Harvest data obtained from the journals (Table1) verifies that the productive river plains corridors in the plains were a hunters utopia.

Table 1. Harvest data recorded for 78 days travel from the mouth of the Yellowstone River to the Great Falls of the Missouri – 27 Apr - 13 Jul 1805

Species	Recorded kills	Ration units
Deer	11	28 75
Elk	63	48 46
Bison	87	87.00
Bear	14	10.70
Pronghorn	27	3.40
Bighorn sheep	9	2 25
Total ration units		**180.6(2.3/day)**

Because one daily ration unit was sufficient to feed the 32 adult members of the expedition for a 24-hr period, a daily average of 2.3 units (Table 1) assured that the prospects for starving, as Lewis put it, would be " consequently small." However, in retrospect, as Allen (1975) indicated, "…the game-rich abundance of the Plains environment would become greater when, during the next year, the members of the Corps of Discovery with persistent hunger pangs would look back upon the rich buffalo plains from the gameless heights of the Rockies and the sterile plains of the Columbia basin."

Great Falls of the Missouri to Traveler's Rest

Game became scarcer, and leaner times began in the mountain foothill country after the expedition's departure from the Great Falls. Lewis and Clark had been forewarned by the Mandans that the buffalo country would end at the Great Falls. Lewis acknowledged this in his journal on 3 July 1805, " the Indians have informed us that we should shortly leave the buffaloe that we shal sometimes be under the necessity of fasting occasionally." This proved to be correct as the last buffalo on the outward journey was killed on 16 July 1805, two days after leaving the Falls. The meat yielded by Drouillard's kill was the last fresh bison meat they would taste for 12 months, until their return to the high plains in July 1806 (Walcheck 2005). Although deer were fairly consistently harvested during the 62-day passage to Traveler's Rest, located just south of what is now Lolo, Montana, about 2 mi upstream from the Bitterroot River on the south side of Lolo Creek, kills of elk dropped off noticeably (Table 2).

Once the expedition entered the Shoshone country, game became exceedingly difficult to find in the Lemhi valley. "… my party," Clark wrote, " hourly Complaining of their retched Situation and [contemplating ?] doubts of Starving in a Countrey where no game of any kind except a few fish can be found …" This statement was a prelude of deeper and more agonizing pangs of hunger that would soon stare them in the face.

Table 2. Harvest data recorded for 59 days of travel from the Great Falls of the Missouri to Traveler's Rest – 13 Jul - 11 Sep 1805

Species	Recorded kills	Ration units
Deer	98	24.5
Elk	23	17.7
Bison	1	1.0
Bear	6	4.6
Pronghorn	17	2.0
Bighorn sheep	1	0.25
Total ration units		**50.05 (0.84/day)**

During their 10-day stay with the Shoshone, 17 deer were killed allowing for a meager daily average of 0.43 ration units, less than one-half of the required amount.

On 30 August 1805 the expedition departed from the Shoshone village and headed northward following the Lemhi River and the Salmon up to its North Fork along the rugged and heavily timbered slopes of the Bitterroot mountains. They moved over a pass and descended following Camp Creek to its junction with the Bitterroot River and to Ross's Hole in the upper Bitterroot Valley meeting the Flathead, or Salish Indians. After trading for more horses, the party moved down to Lolo Creek and regrouped at Traveler's Rest before going over the Bitterroot Mountains. During the 10-day passage over some difficult mountainous terrain, 12 deer and two elk were killed providing for a daily average of 0.45 ration units.

Lolo Trail to Weippe Prairie—First Encounter with Nez Perce Indians

The harrowing mountain journey over the Lolo Trail, which began on 12 September and ended on 20-22 September 1805 (Clark and Lewis' separate contacts with the Nez Perce) would involve some of the most tortuous terrain in the Rockies and proved to be the most agonizing part of their entire journey. Pushing up steep mountain slopes, winding their way through thickly timbered country choked with underbrush and downed conifers, encountering blinding snowstorms, losing the trail, and killing but one deer during the entire trek, totally erased any lingering thoughts that the land could continuously furnish a sustaining supply of red meat.

Adding to the nightmarish difficulties were a combination of sagging morale, fatigue, and unrelenting pangs of hunger. Total rations provided by wild ungulates for this 10-day travel period was a mere 0.25 ration unit (0.025/day). Servings of unappetizing portable soup supplemented with horseflesh and a few grouse barely kept the metabolic fires burning. Lewis wrote on 21 September, "I find myself growing weak for the want of food and most of the men complain of a similar deficiency and have fallen off very much."

Weippe Prairie to Canoe Camp on the Clearwater – 22 Sept - 6 Oct 1805

After contacting the openhanded Nez Perce, the party voraciously consumed dried salmon, berries, and dried cakes of camas roots, but many of the men became violently sick with active diarrhea and vomiting. Despite concerted efforts of the expedition's hunting parties, only 14 deer were killed between 22 September and 6 October. Three deer killed on 29 September would be the last taken until 25 October. The total ration count for the 15-day trip was 3.5 ration units or an average 0.23 daily ration unit, a daily deficiency level of 0.77 ration units. Clark's journal entry on 28 September 1805 "Nothing killed today" summed up hunting efforts for this part of their travels.

Canoe Camp to Columbia River – 7 - 16 Oct 1805

After departing from their 26 September–6 October stay at Canoe Camp, the expedition entered the Columbia Plateau country, a striking physiographic transition that differed from other regions. Also clearly apparent to the Corps was a noticeable lack of big game, unlike the Missouri River plains country that teemed with a wide variety and plentiful numbers of easily obtained game.

The Corps passage down the swift-flowing Clearwater and Snake Rivers to the Columbia, a distance of 250 mi, consumed 10 days with no game killed during their passage down the Snake. Hunters, when they could be spared from negotiating the rapids, were sent out to hunt only to return and report that, "they could not See any Signs of game of any kind." On the Snake River alone the canoes had to navigate 39 rapids and near-accidents were too numerous to record. Dogs, purchased from Indians on 10,11, and 16 October supplemented their diet of salmon and roots.

Meriwether Lewis and William Clark may have entertained thoughts that when they entered the Columbia Basin they would enter a pristine aboriginal setting. Such was not the case as pointed out by (Cebula 1999), "...the Indians of the Columbia Plateau whose economy was based on salmon had already experienced the profoundly disruptive effects of indirect white contact. Horses, epidemic disease, Euro-American trade goods, political realignment, and a steady flow of information had entered the region for nearly a century." With the arrival of the horse, the impact on wildlife increased significantly as native hunters traveled longer distances and transported more game.

The Columbia corridor—a game sink—offered a striking contrast to the Missouri plains country; Lewis estimated a permanent population of 80,000 Indians from which hunting pressure significantly depressed megafauna numbers. In addition, expanding trade networks due to the influx of trade goods from European and American ships added more travelers from neighboring tribes placing additional pressures on the wildlife landscape.

Mouth of the Snake River to Columbia River Cascade – 18 Oct - 1 Nov 1805

Hunting continued to be poor, and 40 dogs were purchased on 18 October. After spending two days at the mouth of the Snake during which the expedition investigated the Columbia River for about 10 miles upstream, the explorer's canoes swept downstream on 18 October.

During the 17-day passage to the Cascades, 12 deer were killed during 25-30 October providing 0.18 of the average daily ration, a deficiency level that prompted trading for pounded salmon, roots, and 22 additional dogs.

Cascades to Gray's Bay–2-7 Nov 1805

After leaving the Cascades rapids, the explorers once again penetrated into an abrupt environmental transition consisting of a marine climate and a true rain-forest vegetative association of fir, spruce, cedar, hemlock, ash and alder, which contrasted sharply with the treeless, semi-desert shrub-steppe country of the eastern Columbia Plateau. During the six-day passage poor hunting continued and only one deer was killed on 4 November (0.04 of the daily ration).

Gray's Bay to Fort Clatsop–8 Nov - 7 Dec 1805

In 8 November, the explorers arrived at Gray's Bay, a conspicuous indentation on the north side of the Columbia estuary (Lewis and Clark's " Nitch Bay "). The next seven days brought incessant rain and high winds allowing no opportunities for hunting.

Numerous problems were associated with hunting in the coastal region. These included mist and fog, persistent rain, wind, and dense timber choked with tangled, jungle-like shrubbery that was difficult to penetrate. Transporting meat back to the fort, especially when carcasses were located several miles from the nearest water transportation offered further difficulty.

No elk had been killed since leaving Montana, however on 2 December, one elk was killed, and the following day six more were taken. No more elk would be bagged until 3 January 1806.

A total of 17 deer was killed between 16 November and 5 December. "The deer of the Coast," wrote Clark, "differ materially from our Common deer in as much as they are darker, deeper bodied, Shoerter ledged [legged] horns equally branched from the beem the top of the tail black from the rute [root] to the end. Eyes larger and do not lope but jump." With this basic description, Clark gave to the scientific community the first description of the Columbian black-tailed deer subspecies (*Odocoileus hemionus columbianus*)—a most significant discovery and documentation.

Harvested deer (17) and elk (7) furnished 9.6 rations for the 30-day period and a daily average of 0.32 ration units. Supplementary foods purchased included fish and roots.

Winter at Fort Clatsop – 8 Dec 1805 - 23 Mar 1806

Construction of Fort Clatsop commenced on 8 December and was not completed until 30 December. Persistent daily rains, accompanied by chilly, fog-shrouded weather and gunpowder damaged by dampness, made hunting difficult. Over a 106-day period from 7 December to 23 March, it rained every day but twelve, and only six days proved to be fair. Local Indians had assured Lewis that elk were plentiful on the Columbia's southern shore, and that elk being larger than deer provided better meat and better hides for making clothing.

During their cold, wet, and thoroughly miserable winter at Fort Clatsop, elk, even though many were lean and in "pore" shape, probably made the difference in survival. Between 2 December 1805 and 20 March 1806, 113 elk and 11 deer were killed. George Drouillard was the most productive hunter during the expedition's stay at Ft. Clatsop. On 26 January 1806, Lewis mentioned in his journal that Drouillard had killed seven elk. "I scarcely know how we should subsist were it not for the exertions of this excellent hunter." Despite his exemplary success at hunting, not enough game was harvested to adequately feed the party. The 108 elk and 11 deer furnished 86 ration units for the106-day period for an average of 0.81 of the daily ration, a little better than 80 percent of the total ration required. Berries, roots, dried fish and dogs purchased from the Indians continued to supplement their diet.

Homeward Bound– 23 Mar 1806

Even though a tentative departure date from Fort Clatsop of 1 April was established, difficulty in finding elk called for a re-evaluation of the selected departure date. On 5 March 1806 Lewis wrote, "if we find the Elk have left us, we have determined to ascend the river slowly and indeavour to procure subsistence on the way…" At 1300 hrs on 23 March1806, the expedition, accompanied by windy, rainy, and disagreeable weather, paddled a few miles down the river they knew as the Netul and turned up the Columbia heading home. Later that day two elk were killed.

Hunting continued daily and required the full-time services of the expedition's hunters. After leaving Fort Clatsop, no deer were killed until 28 March 1806 when seven white-tailed deer (*O. virginianus*) were bagged on Deer Island in present Columbia County, Oregon. Of these, only three were salvageable as reported by Clark due to probable scavenging by California Condor (*Gymnogyps californianus*). Later that evening, three additional deer were killed.

On 1 April 1806, the expedition received disturbing news from Indians floating down the Columbia from fishing camps on the Cascades and Dalles concerning an upstream food scarcity; the salmon run was not expected to reach the fishing camps until 2 May. "This information," wrote Lewis, who expected to purchase pounded salmon at the falls, "gave us much uneasiness with rispect to our future means of subsistence. Above falls or through the plains (Columbia) from thence to the Chopunnish there are no deer Antelope nor elk on which we can depend for subsistence …under these circumstances there seems to be but a gloomy prospect for subsistence on any terms." The captains decided to change travel plans and to remain in the Willamette Valley until enough game could be obtained until reaching the Clearwater and the Nez Perce. Lewis was right in his prognosis as no elk or deer would be killed during the passage of the Columbia plains. During their 1 April–6 April 1806 stay before proceeding upriver, hunters killed 16 elk, 10 deer and one black bear with most of the meat being jerked. The 6 April elk kill would be the last elk taken until 10 July. Resuming their journey, Lewis and Clark were optimistic that the jerked meat and purchases of dogs, berries, roots, as well as additional game kills would tide them over until they reached the Clearwater. And, if this was not sufficient, there was also the "fallback" reservoir of horsemeat. Between 10–17 April, 13 deer were killed. No additional deer would be taken until 1 May when the expedition camped in the vicinity of Waitsburg in eastern Walla Walla County, Washington. On 1 May 1806, one deer was killed.

During the passage of the Dalles on 15-18 April and Celilo Falls on the 21st, 10 horses were purchased to serve as pack animals to transport baggage not carried by canoes. Six additional days of travel would place them in contact with a party of Walla Wallas, including Chief Yellert, who graciously supplied the men with firewood and food, and sold them numerous dogs during their three-day visit. Yellert also supplied valuable information on a shortcut route to the Clearwater. As reported by Lewis on 26 April, "there was a good road which passed from the Columbia opposite to this village to the Kooskooske [Clearwater] … they also informed us, that there a plenty of deer and Antelopes on the road …a road in that direction…would shorten our rout at least 80 miles." As a precautionary measure, 10 additional dogs were purchased – a precaution well taken as the six-day trek from the Columbia to the Clearwater would take six days and net only one deer to supplement a continuous menu of skimpy meals.

Lewis' 1 May comment on the lack of game in the plains region is of interest, "I see very little difference between the apparent face of the country here and that of the plains of the Missouri only that these are not enlivened by the vast herds of buffaloe Elk…" On 7 May, he further mentions the landscape's pasture of thick purchased from the Indians continued to supplement their diet.

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Lewis' 1 May comment on the lack of game in the plains region is of interest, "I see very little difference between the apparent face of the country here and that of the plains of the Missouri only that these are not enlivened by the vast herd of buffaloe Elk…" On 7 May, he further mentions the landscape's pasture of thick grasses, herbaceous plants, and a dark rich soil "which afford a delightfull pasture for horses." Total recorded kills and ration units for this trip segment are shown in Table 3.

Table 3. Harvest data recorded for 39 days travel from Fort Clatsop to the Touchet River camp (Vicinity of Waitsburg, WA) – 23 Mar – 1 May 1806.

Species	Recorded kills	Ration units
Deer	31	7.75
Elk	18	13.46
Bear	1	0.77
Total ration units		**21.98 (0.56/day)**

Touchet Camp–Camp Chopunnish–Weippe Prairie–Traveler's Rest – May - 30 Jun 1806

During the Corps' 14-day transit from their 1 May campsite on the Touchet to Camp Chopunnish on the Clearwater, only six deer were killed. The expedition selected the Chopunnish site on the recommendation of the Nez Perce because it offered the best hunting in the region. Also, the salmon run was expected in a few days. From their 14 May to 10 June1806 stay at Chopunnish, daily efforts to harvest game became a primary objective not only for their daily requirement but also to stock up on their supply of jerked meat for the trek over the Lolo Trail where little or no game would be available. Despite concerted hunting efforts, they killed only 20 deer, i.e., < 1 deer/day or a meager average of 0.18 daily ration units, < 80 percent of the required amount.

Due to the acute shortage of game and a failure of the salmon to arrive as anticipated, a decision was made to move their camp to the Weippe Prairie, which would afford better hunting. On 10 June1806, the Corps abandoned Camp Chopunnish and ascended the north side of the Clearwater canyon and traveled northeastward about 8 mi to the Weippe Prairie. Here, they stocked up on game meat until the morning of the 24 June 1806 when they embarked on their passage over the Bitterroots. The seven-day passage over Lolo Pass would provide only one deer killed on 29 June.

During their stay at the Weippe Prairie site, 29 deer were harvested in addition to eight bears (of which two were grizzlies) furnishing 13.5 ration units for the 20 day period between 10 June and 30 June and an average daily ration unit of 0.68. During the trip from Fort Clatsop to Traveler's Rest, large wild game supplied only 0.42 of the average daily ration unit requirement (Table 4).

Table 4. Ration unit summary for the departure from Fort Clatsop – 23 Mar to Traveler's Rest 30 Jun 1806

Species	Recorded kills	Ration units
Deer	86	21.5
Elk	18	14
Bear	9	7
Total ration units		**42.5 (0.42/day)**

Traveler's Rest to the Reuniting of the Two Separated Lewis and Clark Contingents – 3 Jul - 12 Aug 1806

The two-day stay at Travelers' Rest allowed Lewis and Clark to further firm-up travel details previously formulated at Fort Clatsop for the forthcoming exploration of present-day Montana, which would differ considerably from the 1805 westbound route. Lewis and a party of nine would take an 8-day shortcut route following the Blackfoot River, cross the Continental Divide over Lewis and Clark Pass, and then down the Sun River to Great Falls. Lewis and a party of three would then explore the Upper Marias, leaving behind six men who would be joined by Sergeant Ordway and party of nine. After exploring the Marias country, Lewis would then rendezvous with the Gass – Ordway detachments and descend the Missouri to reunite with Clark on the Missouri 12 August 1806.

Clark and the remainder of the detachment left Travelers' Rest and headed south up the Bitterroot Valley, crossed the Continental Divide at Gibbon's Pass, then into the Big Hole country, reaching Camp Fortunate, at the forks of the Beaverhead (Horse Prairie Creek and Red Rock River) on 8 July. From here the party set out for Three Forks where Sergeant Ordway took nine men and joined Sergeant Gass at Great Falls. Clark and the remainder of the party and crossed over Bozeman Pass to the Yellowstone and followed the river down to the Missouri, eventually rejoining Lewis on 12 August 1806 in present Mountrail County, North Dakota, some 30 mi upstream from the mouth of the Little Missouri River. The following is a listing of the expedition's big game kills:

a) Expedition's 3-day stay at Traveler's Rest (30 June-2 July 1806). Deer harvested (21); total ration units (5.3) with an average of 1.8 the daily ration,

b) The 8-day trip (Lewis unit) from Traveler's Rest to the Great Falls of the Missouri (3-10 July 1806): Deer kill (18); bison (1); elk (3); grizzly (1). Total ration units (8.6) for an average of 3.44 times the daily ration for ten men. The bison killed on 9 July was the first killed since July 16 of the previous year.

c) Lewis' 7-day stay at the Great Falls area (11-17 July 1806). Bison kill (13); total ration units (13) for an average of 5.44 times the ration for ten men. Bison hides were utilized for canoe and "bullboat" coverings and for shelter and gear coverings.

d) Lewis' exploration of the Marias (18-28 July 1806). Deer kill (2); bison (2); elk (2); pronghorn (2). Total ration units of 4.3 for an average of 3.13 times the daily ration for four men. Lewis' 22 July comment, "We have seen but few buffaloe today no deer and very few Antelopes; gam(e) of every discription is extremely wild which induces me to believe that the indians are now, or have been lately in this neighbourhood" suggested that hunting pressure may have been a factor for the lack of game.

e) Lewis moves down the Missouri (29 July) with the Gass and Ordway detachments to meet with the Clark contingent on 12 August 1806). Total harvest for this trip segment: Deer kill (58); elk (23); grizzlies (6); bison (10); bighorn sheep (20); total ration units (51.8) for an average of 5.53 times the ration for 20 men.

Clarks's Exploration of the Yellowstone

a) Traveler's Rest to Camp Fortunate (3-10 July 1806). Deer kill (9); bighorn sheep (1); pronghorn (2); total ration units (2.75) for an average of 0.50 of the daily ration for 22 men.

b) Camp Fortunate to Three Forks (11-13 July 1806). Deer kill (13); grizzly (1); pronghorn (1); total ration units (4.3) with an average of 2.08 times the daily ration for 22 men.

c) Three Forks to Pompey's Pillar (14-25 July 1806); deer kill (17); elk (10); bison (8); bighorn sheep (2); pronghorn (2); total ration units (20.7) with an average of 4.60 times the daily ration for 22 men.

d) Pompeys Pillar to reuniting with Lewis and party on the Missouri (26 July–12 August 1806); deer kill (32); elk (11); bison (12); grizzlies (2); bighorn sheep (2); pronghorn (13); total ration units (32.1) with an average of 4.76 times the ration for 22 men.

Ordway and Gass Detachments Three Forks to Great Falls of the Missouri – 13-28 Jul 1806

On 13 July 1806 Sergeant Ordway and nine men separated from the Clark party and pushed down the Missouri from the Three Forks to rendezvous with the Gass detachment of the Lewis party at the Great Falls on July 20. During the eight-day trip 13 deer, five elk, four bison, four sheep, and one pronghorn were killed for a total ration unit count of (12.2) and an average of 4.88 times the ration for ten men.

The united Ordway-Gass units (20-28 July) killed four deer, 14 bison, and one pronghorn for a total ration unit count of 15.1 and an average of 3.36 times the ration for 10 men. eedless to mention, both groups feasted "high on the hog" while making up for lost calories. Both groups reunited with Lewis and his three-member party on 28 July.

Discussion

The journals provide a wealth of information about the game-rich upper

Missouri plains with its numerous feasts of buffalo hump, elk steaks, and Charbonneau's white puddings contrasted with that of a semi-desert Columbia Plateau region of game scarcity, malnutrition, adjusting metabolisms, and a shared, dedicated personnel effort in coping with the needs of subsistence and of survival. It was a determined band of men who endured hardships, uncertainties, hunger pangs, dwindling supplies, and constant dangers; a Corps of Discovery who through cooperation, teamwork, and a dogged, unrelenting determination made the most of every day. A frequent, three-worded journal entry that a reader frequently encounters, "We proceeded on" adequately summed up their efforts to courageously reach out each day for that distant horizon.

A comparison of the total game kills and average daily ration units accumulated on the east-west sides of the Continental Divide show a marked difference between the Columbia River Corridor and the Upper Missouri region (Fig. 2). The 1805 westward trek west of Travelers' Rest to the Pacific and winter stay at Fort Clatsop provided an average 0.5 of a daily ration unit, one-half the needed requirement. Foods such as salmon, berries, roots, and dogs purchased from the Indians were necessary for survival. If it were not for the 108 elk harvested at Fort Clatsop, the average daily ration unit would have dropped to starvation levels. The 1806 return trip from Fort Clatsop to Travelers' Rest provided a meager average 0.42 of a daily ration unit.

East of Travelers Rest, we have a completely different picture, with an abundance of wild game including bison, pronghorn, and bighorn sheep which were not harvested west of Travelers' Rest. The accumulation of surplus ration units averaged well above the Expedition's daily needed requirement. Although the role of Indian hunting and game differences between the regions might be speculative (Martin and Szuter 1999, Cebula 1999, Kay1994, Schneiders 2003), little or no attention has been directed toward

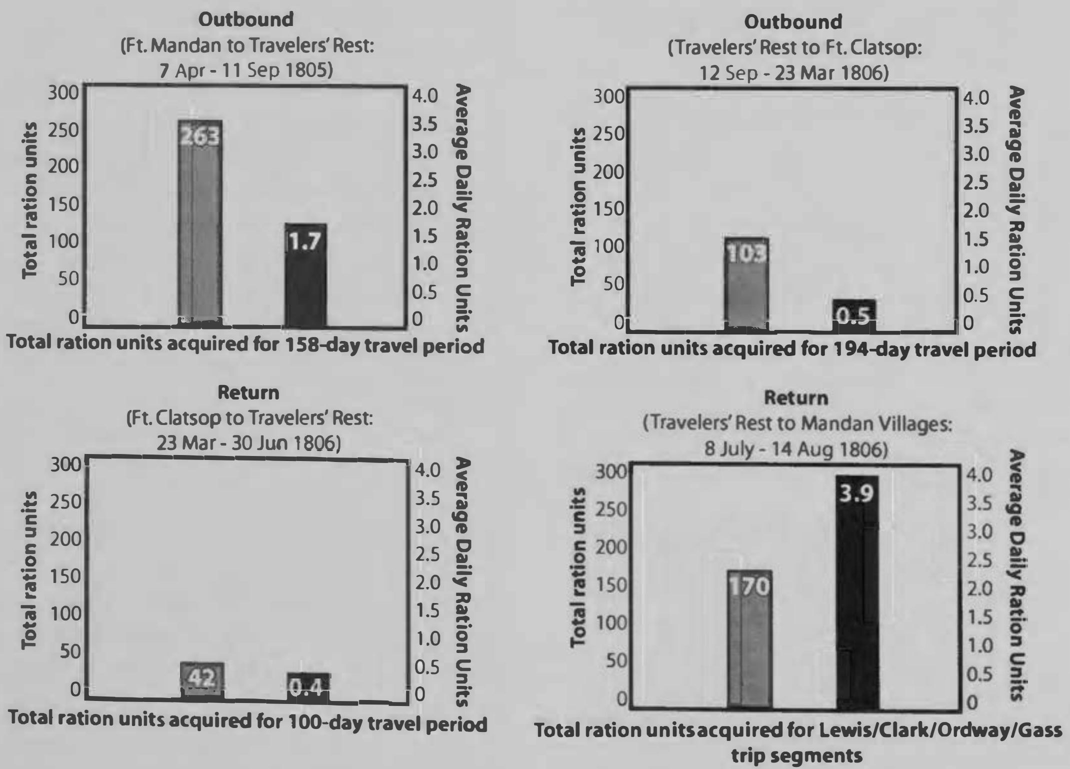

Figure 2. Comparison of total and average daily ration units accumulated for the Expedition's travel segmens east and west of Traveler's Rest (1805-1806)

a comparative analysis of physical and biotic habitat and productivity differences between the two regions. An important question, then, remains as to how much of the difference in game abundance can one attribute to human intervention, regional habitat productivity and carrying capacities, or other factors. Even though a study of historic habitats for the Missouri plains region and the Columbia River Basin east of the Cascades poses its share of problems due to a complexity of variables involving climatic shifts, land fertility differences, geological changes, and other environmental influences, we should not rule out the importance of doing so. No realistic assessment of wildlife can be made without first assessing the habitat.

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