



Movements and habitat use of bighorn sheep along the upper Yellowstone River Valley, Montana
by Kristin Louise Legg

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management

Montana State University

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Abstract:

The upper Yellowstone River Valley has provided winter range for Rocky Mountain bighorn sheep for thousands of years. Some sheep populations declined during the 1980's, but others may have recolonized new ranges. The Montana Department of Fish, Wildlife, and Parks, the National Park Service and the US Forest Service all share in the responsibility for management of these sheep and their habitat. I conducted a study during 1994 and 1995 to gather more information on bighorn movements and habitat use in the Tom Miner Basin and Point of Rocks winter ranges. The Tom Miner Basin population has been decreasing over the past 20 years and little data were available on the Point of Rocks population. The objectives were to: (1) determine the seasonal range use patterns for sheep that utilize the Tom Miner Basin and Point of Rocks summer ranges; (2) compare the relative intensity of ungulate use, vegetation coverage, and plant species composition in areas occupied by sheep in 1975 with the same sites in 1994-1995; and (3) assess current cattle and elk distribution and use on bighorn winter ranges in the Tom Miner Basin. From March 1995 - September 1996, 10 radio-collared ewes were tracked from the Tom Miner and Point of Rocks winter ranges. The ewes in Tom Miner Basin used traditional migration patterns and summer ranges. The Point of Rocks ewes utilized summer range in Hyalite Basin and the Cinnabar winter range during the rut. I used pellet and grazing transects to assess summer and fall habitat utilization by elk and cattle on sheep winter range. From 1975 to 1995 elk use increased, sheep use decreased, and cattle use remained the same. Univariate chi-squared analysis and classification and regression tree analysis were used to determine bighorn habitat selection based on elevation, slope, aspect, closeness to escape terrain, grass cover, and the number of elk or cattle pellets. These analyses indicated that escape terrain was significant to bighorn habitat selection. Other habitat characteristics important to sheep habitat selection were elevation, slope, and the mean number of elk pellets. Cattle did not affect bighorn habitat selection since most cattle pellets occurred away from escape terrain. Elk may have some indirect influence on bighorns, but the influence was undetectable in this study. Vegetation condition and trend had not changed since 1975 and the vegetation quality did not vary due to the amount of ungulate use on the range. Vegetation utilization was high (30%) in areas with high cattle pellet densities, but utilization was low (<20%) in areas with high densities of bighorn and elk pellets. Vegetation condition and availability do not seem to be affecting bighorn habitat use in the Basin. I assessed other possible factors that may be limiting the Tom Miner Basin bighorn population. These factors were human disturbance (recreational and hunting), mountain goats, predation, weather, disease, inbreeding suppression, and intraspecific competition. Cursory analysis of data showed that human disturbance, mountain goats, disease, inbreeding suppression, and intraspecific competition were not important in limiting the bighorn population. Predation and weather were the two factors that I was unable to assess.

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Kristin Louise Legg

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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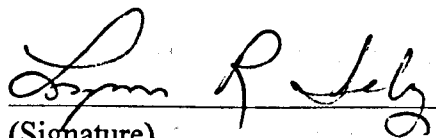
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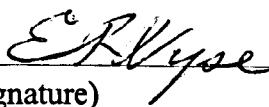
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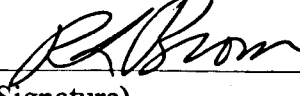
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ABSTRACT

The upper Yellowstone River Valley has provided winter range for Rocky Mountain bighorn sheep for thousands of years. Some sheep populations declined during the 1980's, but others may have recolonized new ranges. The Montana Department of Fish, Wildlife, and Parks, the National Park Service and the US Forest Service all share in the responsibility for management of these sheep and their habitat. I conducted a study during 1994 and 1995 to gather more information on bighorn movements and habitat use in the Tom Miner Basin and Point of Rocks winter ranges. The Tom Miner Basin population has been decreasing over the past 20 years and little data were available on the Point of Rocks population. The objectives were to: (1) determine the seasonal range use patterns for sheep that utilize the Tom Miner Basin and Point of Rocks summer ranges; (2) compare the relative intensity of ungulate use, vegetation coverage, and plant species composition in areas occupied by sheep in 1975 with the same sites in 1994-1995; and (3) assess current cattle and elk distribution and use on bighorn winter ranges in the Tom Miner Basin. From March 1995 - September 1996, 10 radio-collared ewes were tracked from the Tom Miner and Point of Rocks winter ranges. The ewes in Tom Miner Basin used traditional migration patterns and summer ranges. The Point of Rocks ewes utilized summer range in Hyalite Basin and the Cinnabar winter range during the rut. I used pellet and grazing transects to assess summer and fall habitat utilization by elk and cattle on sheep winter range. From 1975 to 1995 elk use increased, sheep use decreased, and cattle use remained the same. Univariate chi-squared analysis and classification and regression tree analysis were used to determine bighorn habitat selection based on elevation, slope, aspect, closeness to escape terrain, grass cover, and the number of elk or cattle pellets. These analyses indicated that escape terrain was significant to bighorn habitat selection. Other habitat characteristics important to sheep habitat selection were elevation, slope, and the mean number of elk pellets. Cattle did not affect bighorn habitat selection since most cattle pellets occurred away from escape terrain. Elk may have some indirect influence on bighorns, but the influence was undetectable in this study. Vegetation condition and trend had not changed since 1975 and the vegetation quality did not vary due to the amount of ungulate use on the range. Vegetation utilization was high (30%) in areas with high cattle pellet densities, but utilization was low (<20%) in areas with high densities of bighorn and elk pellets. Vegetation condition and availability do not seem to be affecting bighorn habitat use in the Basin. I assessed other possible factors that may be limiting the Tom Miner Basin bighorn population. These factors were human disturbance (recreational and hunting), mountain goats, predation, weather, disease, inbreeding suppression, and intraspecific competition. Cursory analysis of data showed that human disturbance, mountain goats, disease, inbreeding suppression, and intraspecific competition were not important in limiting the bighorn population. Predation and weather were the two factors that I was unable to assess.

INTRODUCTION

Rocky Mountain bighorn sheep were once abundant throughout the Rocky Mountains of North America (Couey 1950, Buechner 1960). In the late 1800's, bighorn populations declined due to competition with livestock, introduction of livestock diseases, hunting pressures, and development (Buechner 1960, Keating 1982). Bighorn populations increased once hunting regulations, management areas, and relocation practices were established to protect the sheep, although bighorns did not recolonize all areas occupied prior to European settlement (Buechner 1960, Geist 1971, FWS 1993).

Bighorn sheep populations in the upper Yellowstone River Valley, Montana, were not exempt from these declines. Hunting regulations and changes in land use allowed populations to increase, and sheep colonized historic range through the 1970s (Buechner 1960, Keating 1982). Although some of the populations gained were lost in the 1980s from a *Chlamydia* outbreak (Meagher 1982, Meagher et al. 1992) and possibly other factors (Legg et al., in press), some herds in the area evidently colonized new ranges or shifted seasonal ranges during the same period (L. Irby, Montana State University, pers. comm.).

The Montana Department of Fish, Wildlife, and Parks (MDFWP), National Park Service (NPS), Biological Resources Division (BRD), United States Forest Service (USFS), and the Northern Yellowstone Cooperative Wildlife Working Group (NYCWWG) share responsibility for the conservation and management of bighorn sheep and their habitats in the upper Yellowstone River Valley. These agencies expressed an

interest in gathering more information on bighorn sheep from 2 of 4 winter ranges, Tom Miner Basin and Point of Rocks. The Tom Miner Basin bighorn population has slowly decreased over the past 20 years from unknown causes and few data were available on the Point of Rocks population. The agencies were particularly interested in obtaining data on summer distribution, migration corridors, and factors that regulate population growth for these two subpopulations.

Therefore, I monitored by following habitat use and movements of ewes associated with the Tom Miner Basin and Point of Rocks winter ranges. Also, collected on bighorn sheep from the 1970's to the mid 1980's (Grunnigen 1976, Keating 1982, Irby et al. 1986, Gehman 1985, Irby et al. 1989) were used to assess trends in ungulate populations and vegetation that occurred over the past 2 decades.

The specific study objectives were to:

1. Determine the seasonal range use patterns for sheep that utilize the Tom Miner Basin and Point of Rocks winter ranges with emphasis on changes in distribution that have occurred in the last decade in the Tom Miner Basin and describe the movements of the Point of Rocks herd.
2. Compare the relative intensity of ungulate use, vegetation coverage, and plant species composition in areas occupied by sheep in 1975 with the same sites in 1994-1995.
3. Assess current cattle and elk distribution and use on bighorn winter ranges in the Tom Miner Basin.

During the study, I was able to test the following null hypotheses:

H₁: Bighorn distribution has not changed in the Tom Miner Basin in the past

decade.

H₂: Bighorns at Point of Rocks migrate to the Tom Miner Basin summer ranges.

H₃: Ungulate use has not changed in the Tom Miner Basin since 1975.

H₄: Vegetation and soil condition and trend on sites used by bighorns in the Tom Miner Basin have not changed since 1975.

STUDY AREA

The upper Yellowstone River Valley in Montana includes 4 major bighorn winter ranges adjacent to the northern boundary of YNP; the Everts winter range (EWR), the Cinnabar winter range (CWR), the Tom Miner Basin winter range (TMWR), and the Point of Rocks winter range (PRWR) (Fig. 1). This study focused on the TMWR and the PRWR. The TMWR is located 26 km northwest of Gardiner, Montana in the Gallatin Mountains of southwestern Montana. The TMWR borders the northwest corner of Yellowstone National Park (YNP) and the PRWR is 8 km northeast of the Tom Miner Basin along the Yellowstone River.

Elevations range from 1500 m to over 3000 m in the Tom Miner Basin. The TMWR is composed of several small (1 - 5 km²) bighorn wintering areas scattered over 150 km². Wintering sites are typically on grass-covered southwest-facing slopes between 1800 m and 2500 m and within 100 m of escape terrain. These small wintering areas include whitebark pine (*Pinus albicus*)-subalpine fir (*Abies* spp.), bunchgrass, and subalpine vegetation types (Grunnigen 1976). Dominant land form features in the Tom Miner Basin include Sheep Mountain, Fortress Mountain, Bighorn Peak, Ramshorn Peak, and Tom Miner Creek (Fig. 2). Most ridges are oriented from northwest to southeast. The PRWR and other winter ranges along the Yellowstone River are at lower elevations (1500 - 2000 m), drier, and in grass or sage-steppe communities. Summer ranges for all herds are ridge tops and alpine meadows greater than 2000 m in elevation.

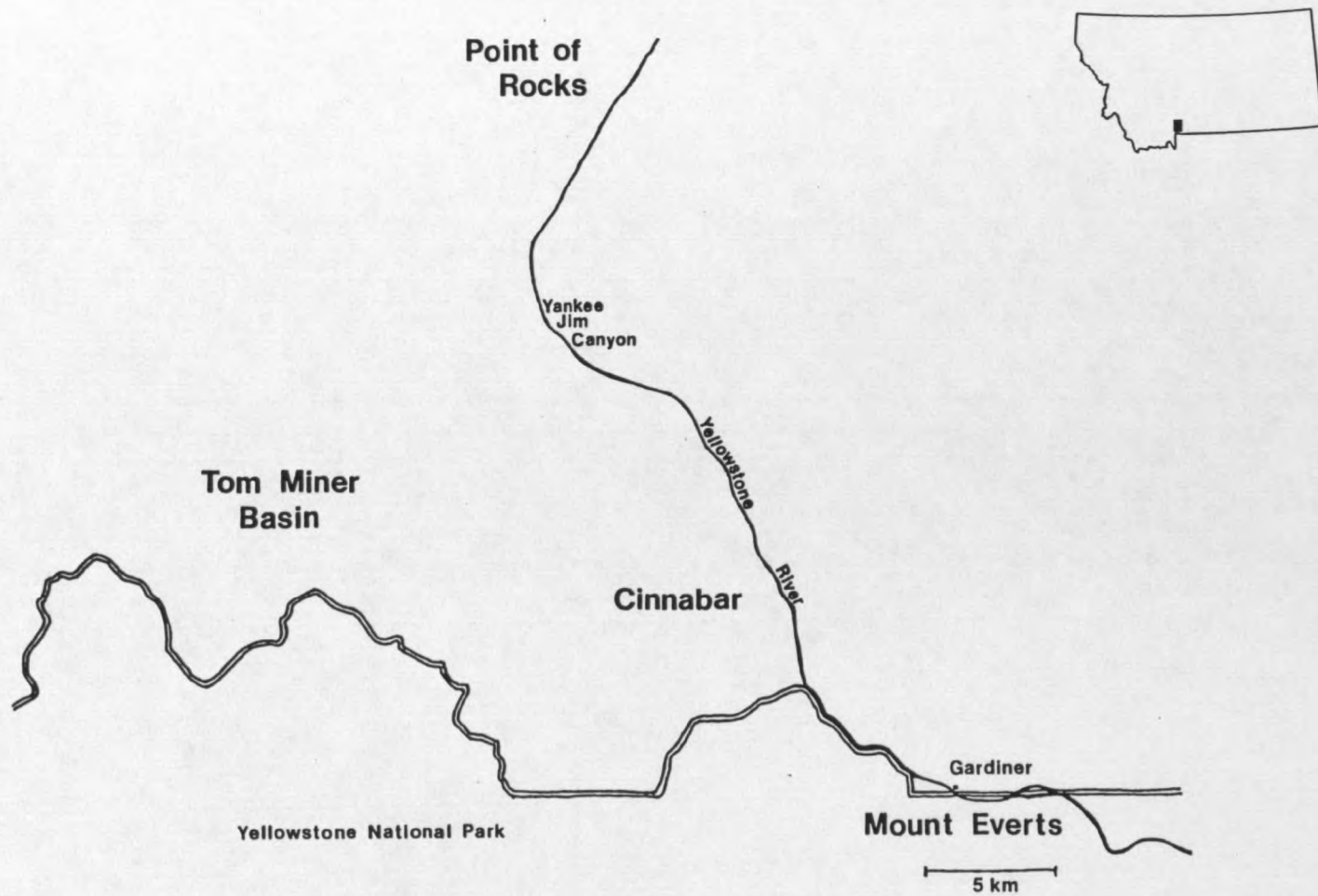


Figure 1. The locations of the Tom Miner Basin, Point of Rocks, Cinnabar and Mount Everts winter ranges in the upper Yellowstone River Valley.

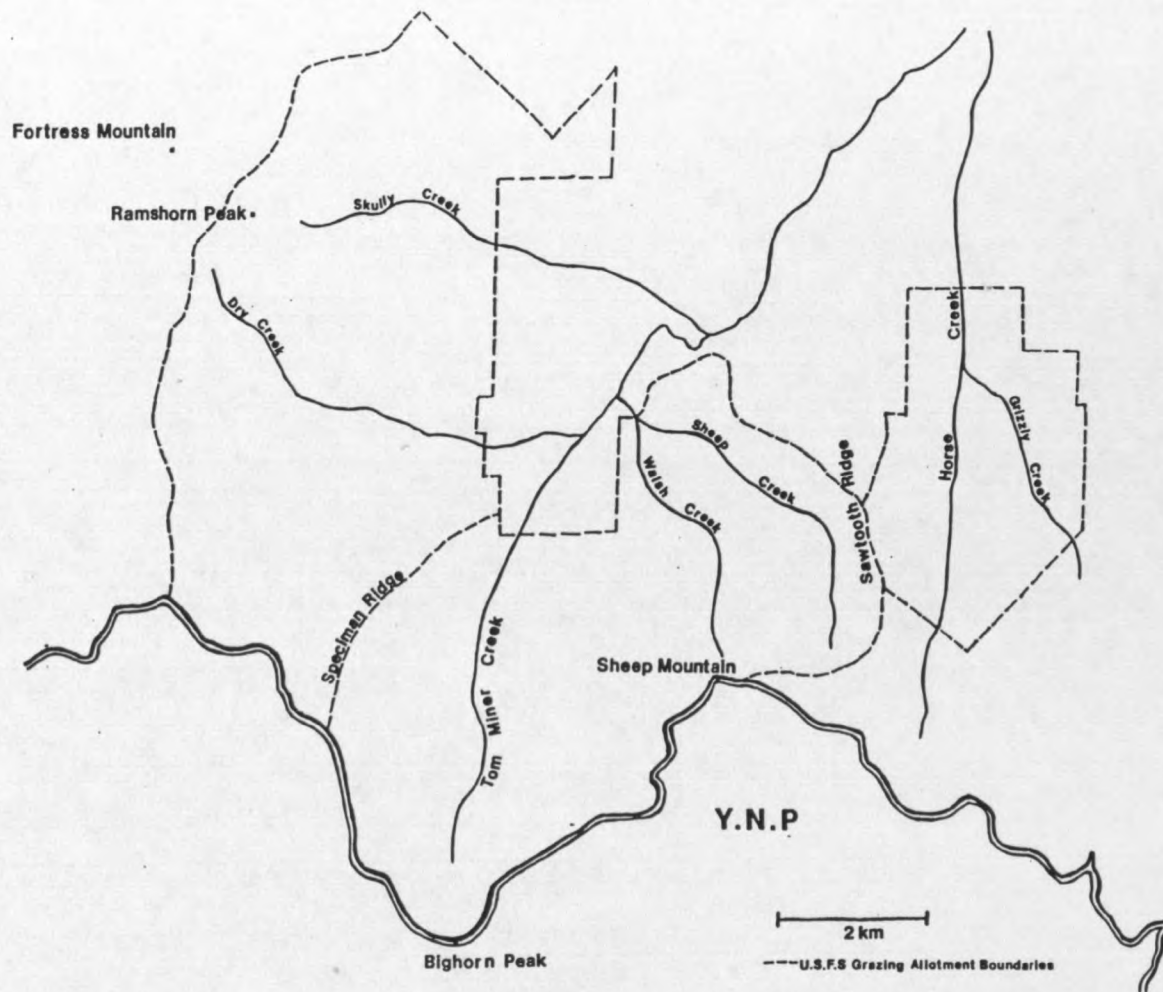


Figure 2. Detailed map of Tom Miner Basin with features mentioned in the text.

The climate of the Gallatin Mountains is cool continental with heavy snowfall beginning in November and snow cover remaining until late May. Summers are short and mild (Chester 1976). Monthly temperature means, minimum and maximum temperatures, and monthly precipitation for January 1994 through April 1996 are listed in Appendix, Table 7. The 2 years of the study had average temperatures and precipitation (NOAA 1995).

Land ownership in the study area is a mix of private, state, and federal (YNP and Gallatin National Forest [GNF]) lands. County roads cross or are adjacent to both winter ranges, but the PRWR is more easily accessible by vehicle in winter than the TMWR. Seventy percent of the wintering areas used by sheep in the TMWR are publicly owned. All of the PRWR is privately owned.

Livestock grazing and hunting are the primary landuses on both winter ranges. The USFS leases Gardiner National Forest land for cattle grazing from late June through October. Grazing leases are mostly in mountain meadows from 1800 - 2500 m and overlap some bighorn winter ranges. The USFS rotates the duration and timing of use for each allotment to vary the distribution of cattle use in Tom Miner Basin each year. Cattle and horses are grazed on the PRWR year round. Hunting pressure directed toward sheep is higher on the TMWR than the PRWR. Recreational use not directly associated with sheep (elk and deer hunting, hiking, horse packing, wildlife viewing) is higher on the TMWR than the PRWR in summer and fall but both areas experience low to moderate use in winter and spring.

Other large mammals in the study area include elk (*Cervus canadensis*), white-

tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), mountain goats (*Oreamnus americanus*), moose (*Alces alces*), grizzly bears (*Ursus arctos*), black bears (*Ursus americana*), coyotes (*Canis latrans*), timber wolves (*C. lupus*), and mountain lions (*Felis concolor*).

METHODS

Seasonal Range Use Patterns

In March 1995, 7 ewes from the PRWR and 3 ewes from the TMWR were fitted with color-coded radio-collars. Sheep were captured by helicopter net-gun (Barrett et al. 1982, Andryk et al. 1983). The ewes were ear-tagged with numbered metal tags, and aged. Blood and throat cultures were taken from each ewe and sent to the MDFWP for analysis.

The ewes were located from the ground or air (Piper Supercub) at weekly intervals during fall and spring migrations and biweekly intervals while sheep were on summer and winter ranges. I made weekly and biweekly flights from May - December 1995 and 4 times from May - September in 1996. Ground observations were made from April - December 1995. The sex, age class, and group size of marked and unmarked bighorns were documented during flights and ground observations. To assess changes in distribution, observations of bighorns during the 1994/95 field study were compared with historic sheep locations over the past decade (Constan 1975, Keating 1982, Gehman 1985, Irby et al. 1986 and 1989).

Population Status

During 1994 and 1995, bighorn counts from observations during the study, the MDFWP survey, and the Annual Cooperative Bighorn Sheep Count were used to

estimate the minimum bighorn sheep population sizes for the upper Yellowstone River Valley winter ranges. The MDFWP survey is a helicopter survey completed annually in the spring since 1991 (Lemke, unpubl. in MDFWP, ann. rep., Helena). The Annual Cooperative Count is a winter ground count conducted since 1979 by the NPS, USFS, and MDFWP (Caslick 1993). Counts in 1994 and 1995 were compared with past surveys (MDFWP; Meagher, unpubl; GNF files; Keating 1982; Irby, unpubl.) in the past decade to obtain trends in sheep populations from winter ranges in the upper Yellowstone River Valley.

Ungulate Use Patterns in the Tom Miner Basin

Use Patterns: 1975 versus 1994-1995

I used pellet group counts in 1994 and 1995 since this method was used in 1975 and comparisons could be made between years. Pellet group counts are an economical method to assess wild ungulate habitat use (Irby 1981). Problems with this method include biases with the size of plots used (the larger the plot the more pellets missed) and observer error (missed groups, differences between observers determining ungulate species and age of pellets) (Neff 1968).

Fecal pellet counts were made in 1994 and 1995 for comparison with counts completed in 1975 by USFS personnel (Grunnigen 1976) to determine if ungulate use had changed on the TMWR over the past 20 years. In 1975, USFS personnel completed 39 fecal pellet group transects from July through August. These transects were randomly placed in areas of potentially high sheep use and ran perpendicular to the contours of

open slopes on the southwest side of the Tom Miner Basin (Grunnigen 1976). Transect locations were marked on aerial photos. I relocated these sites and set up comparable transects in 1994 and 1995. Although I followed sampling techniques employed in 1975 to insure compatibility with 1994 and 1995 ungulate fecal counts, I made some modifications. In 1975, Grunnigen counted only new pellet groups from bighorn sheep, elk, cattle, and other ungulates in each transect. In 1994 and 1995, I counted old and new pellet groups. Pellet group age was distinguished by the color, sheen, and texture of pellets (Grunnigen 1976). To avoid confusion of old from new pellets, I did not measure transects on rainy days. Grunnigen's transects consisted of 10 81-m² circles. The 1994 and 1995 transects included 10 161-m² circles. The potential for missing pellet groups in large plots (Neff 1968) was minimized by breaking the plots into smaller increments within each circle. Each plot was divided into 4 concentric circular belts with radii of 1.83 m, 3.66 m, 5.49 m, and 7.16 m respectively. Counts within the 4 circular belts were totaled for a whole plot count. To compare with Grunnigen's 1975 data, only the new pellet group counts from the 3 inner increments (95 m²) were used. Pellet group counts for each ungulate species were converted to pellet groups per hectare (PGH) by dividing total pellet groups counted in the 10 plots by the total hectares (0.08) covered in the transect.

I assessed the differences in pellet density for the Tom Miner Basin using paired t-tests (Iman 1994) in the MSUSTAT package (Lund 1993). Comparisons included bighorn, elk, and cattle for 1975 versus 1994, 1975 versus 1995, and 1994 versus 1995. Significance levels for a two-tailed test statistic were set at $p < 0.05$ (Type I error level).

Use Patterns in 1994 - 1995

In 1994 and 1995, additional pellet group transects were completed throughout the Tom Miner Basin as an index to ungulate use and distribution on bighorn winter range during the summer and fall. The transects were selected to cover areas with different cattle grazing pressure and areas that appeared adequate for sheep. Total new pellet groups from the 161-m² circles were used for analysis. Slope angle (% slope), distance to escape terrain (< 100 m or > 100 m), grass cover density (ground visible or ground not visible), elevation, and aspect were measured for each transect. This analysis included transects used in comparisons with Grunnigen's (1976) data. Transects were completed every 73 m in elevation from the bottom to top of a sample unit to determine if ungulate use differed with elevation. The number of transects per unit varied from 2 to 4. Some units were measured 3 times in the summer and fall field season, the first prior to cattle grazing, the second following cattle grazing, and the third before snow fall and the number repeated was limited due to time constraints. The results from the 3 transects were averaged to obtain the mean pellet groups per location for the summer and fall seasons.

Chi-square analysis (Neu et al. 1974) was used to measure habitat availability versus bighorn habitat use for individual independent variables and as an aid in interpreting the regression and classification trees used in the multivariate analysis. Habitat characteristics identified as independent variables in univariate and multivariate tests included elevation (categorized in 305-m intervals), aspect (2 categories - cool, wet

slopes [NE, N, E,] and dry warm slopes [S, SE, SW, W, NW]), slope (categorized in 10% intervals), distance to escape terrain (< 100 m, > 100 m), grass cover density (ground visible or ground not visible), elk pellet density and cattle pellet density.

Multivariate analysis was used to identify if bighorns were selecting for a particular habitat characteristic over other habitat characteristics. Classification and regression trees were used in multivariate analysis of the distribution of bighorns with the above habitat characteristics. Classification and regression trees are similar to the approach used to create dichotomous botany keys and have been used extensively in the medical field (Ripley 1996) and in raptor studies (Grubb and King 1991). Tree analysis can be considered a nonparametric alternative to linear or linear logistic and additive or additive logistic models for identifying structure in complex multivariate data (Clark and Pregibon 1992, Steinberg and Colla 1995). Classification trees are used with categorical data, and regression trees are used with continuous data (Steinberg and Colla 1995). The computer program S was used to analyze the ungulate use data I collected on the TMWR. Methods for this analysis are described in Statistical Models in S (Clark and Pregibon 1992). The level of significance for all statistical test was set at $p < 0.05$.

Vegetation Trend, Condition, and Use on the TMWR

Vegetation Trends between 1975 and 1994-1995

Four vegetation condition and trend transects completed in 1975 were repeated in 1994 and 1995 to assess changes in vegetation in the Tom Miner Basin over the past 20 years. Grunnigen (1976) used pace-line transects (USFS 1977). He placed the transects

in areas that "appeared typical of the unit as a whole." The transects were 50 paces in length and paralleled the ridge line. The dominant ground cover type in a 2-cm diameter circle was recorded at each pace. Ground cover types included bare soil, erosion pavement, rock, litter, moss, and individual plant species that were placed in 3 desirability classes (desirable, intermediate, or least desirable) (Grunnigen 1976). Each transect was rated for soil and vegetation condition, and trend was estimated using methods described by the USFS (1977). These same methods were used in the 1994 and 1995 field seasons. I added additional transects in 1994 and 1995 to cover areas not included in Grunnigen's survey.

Vegetation Use in 1994-1995

Grazing transects were completed with each pellet transect to assess range utilization. Transects followed the USFS method of measuring range utilization (USFS 1977). Each grazing transect consisted of 4 100-pace lines with 50 sampling points at 2-pace intervals. A sampling point was considered grazed if 5% or more of the vegetation in a 133-cm² diameter loop was grazed. Percent utilization for each line was obtained by calculating the frequency of grazing (number of sampling points grazed / 50) and comparing this with a graph of percent grazed to percent utilized for mountain grasslands from a USFS range management manual (1977) (Appendix, Fig. 12). The percent utilization of the 4 lines was averaged to obtain the estimated percent utilization of each grazing transect. The USFS manual classified transects with > 30% utilization as high use and potentially overgrazed.

Other Factors Influencing Bighorn Habitat Use on the TMWR

Mountain goats, human use (recreational and hunting), predators, weather, disease, inbreeding, and intraspecific competition have all been identified as potential limiting factors for other sheep populations (Oldemeyer et al. 1971, McCollough et al. 1980, Skiba and Schmidt 1982, Heimer et al 1986, Harrison and Hebert 1988, Haas 1989, Varley 1994). Data on vegetation condition and ungulate fecal distribution directly or indirectly addressed interspecific and intraspecific competition. I evaluated the impact of other factors in the Tom Miner Basin bighorn population based on a variety of available information. All human, elk, cattle, and mountain goats observed in the study area in 1994 and 1995 were recorded to see how bighorn sightings were associated with sightings of other species. Pellet group transects were completed on 2 bighorn summer ranges to determine if any range overlap was evident between elk and sheep use on the summer ranges.

Information on hunting was obtained from MDFWP files. The influence of predation was assessed from studies by Murphy (in prep.) and observations during fieldwork in 1994-1996. Disease prevalence was assessed from blood samples collected during this study, past studies, and disease samples collected in YNP. Weather information was gathered from weather data collected by the MDFWP (Farnes, unpubl.) and the weather station in Gardiner, Montana (NOAA 1995). The potential for inbreeding suppression was indirectly assessed from data collected during this study and past studies (Keating 1982, L. Irby, Montana State University, unpubl.).

RESULTS

Seasonal Range Use Patterns

A total of 281 locations was recorded for 10 radio-collared ewes. Approximately one third of the locations came from the 3 TMWR ewes. Five of the 7 collared ewes captured at Point of Rocks provided > 50% of the locations. One collar on a Point of Rocks ewe failed in August 1995, and another was removed in January 1996 because of interference with radio frequencies used by the Montana State Highway Department. The ewe with the malfunctioning radio was observed 4 times after the failure. Groups of sheep not associated with the marked animals were observed 41 times. Group size for marked and unmarked groups ranged from 1 to 30.

Movements of the radio-collared sheep were recorded from April 1995 through September 1996. In May of both years, the ewes from Point of Rocks moved 16 km north to summer range in the Hyalite Basin south of Bozeman, Montana. The Tom Miner Basin ewes wintered on the south side of the basin and migrated 6 km northwest to Fortress Mountain in the spring (Fig. 3).

In autumn 1995, both groups of ewes returned to the same winter ranges where they were captured. Five ewes from the PRWR went to the CWR, approximately 16 km to the southeast of the PRWR, from mid October to December then moved to the PRWR. The other 2 ewes remained south of Hyalite Basin during this time and returned to the PRWR in December. Flights in early autumn 1996 showed all ewes were following the

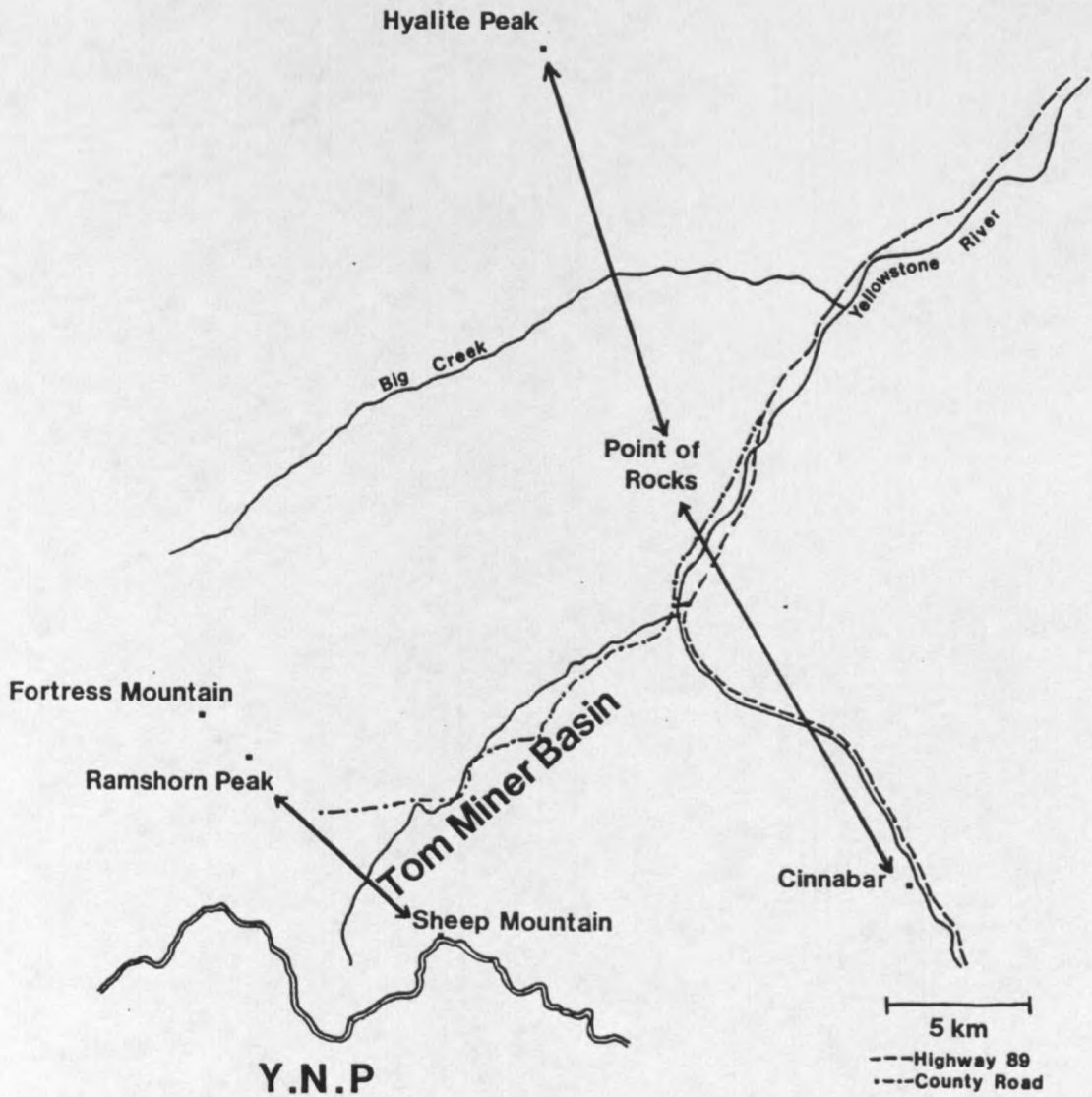


Figure 3. Movements of the 10 radio-collared ewes from Tom Miner Basin and Point of Rocks in 1995 - 1996.

same movement patterns I observed in autumn 1995.

Population Estimates and Trends

The minimum population estimate for bighorns using the Tom Miner Basin summer ranges, Bighorn Peak, and Fortress Mountain, based on unrepeated group sightings in 1994-1995, was 43 sheep. I observed 32 bighorns in the Hyalite Basin during the 1995 summer. The number of individuals, sex classification, and ram:100ewe and lamb:100ewe ratios from each range are presented in Table 1. During the study, 17 sheep were counted on the TMWR and approximately 30 sheep were associated with the PRWR.

Table 1. Bighorn total summer range counts from the Tom Miner Basin and Point of Rocks in 1995 includes classification and lamb:100ewe and ram:100ewe ratios.

RANGE	Ewes	Rams	Lambs	Year.	Total	Lamb:Ewe	Ram:Ewe
Tom Miner Basin							
Ramshorn/Fortress							
1994	12		11		23	92	
1995	15	5	6		26	40	33
1996	13	1	5	2	21	38	8
Bighorn							
1994	11		7		18	64	
1995	9	1	5		15	56	11
Tom Miner Basin							
Combined							
1994	23		18		41	78	
1995	24	6	11	2	43	45	25
Point of Rocks ewes							
at Hyalite Basin							
1995	18	10	4		32	22	56
1996	14	9	6		29	39	64
All Ranges Combined							
1994	23		18		41	78	
1995	42	16	15	2	75	36	38
1996	27	10	11		48	41	37

Ungulate Use on Bighorn Winter Range: 1975, 1994, and 1995

Use Patterns: 1975 versus 1994-1995

Thirty-eight fecal pellet transects measured in 1975 were remeasured at approximately the same time of year (June-August) in 1994 and 1995. Paired t-tests used to compare the pellet groups per hectare (PGH) for each ungulate species (1975 versus 1994, 1975 versus 1995, and 1994 versus 1995) showed significant differences ($p < 0.05$) in all but 3 comparisons (Table 2). Bighorn sheep pellet density decreased by 85% from 1975 to 1994 ($t = 3.35$, $df = 37$, $p = 0.002$, power = 0.80) and by 79% from 1975 to 1995 ($t = 3.10$, $df = 37$, $p = .004$, power = 0.72). Elk pellet density in 1975 was 42% of that recorded in 1994 ($t = 3.93$, $df = 37$, $p = 0.000$, power = 0.90) and 32% of that recorded in 1995 counts ($t = 4.45$, $df = 37$, $p = 0.000$, power = 0.95). Cattle fecal density decreased by 58% from 1975 to 1994 ($t = 3.00$, $df = 37$, $p = 0.005$, power = 0.52) and by 93% from 1975 to 1995 ($t = 4.41$, $df = 37$, $p = .000$, power = 0.99). No significant differences were found between the years 1994 and 1995 for elk ($t = 1.33$, $df = 37$, $p = .193$, power = 0.18), bighorns ($t = 0.57$, $df = 37$, $p = 0.573$, power = 0.07), or cattle ($t = 1.92$, $df = 37$, $p = .063$, power = 0.43). Pellet groups from deer and moose were rare in 1975, 1994, and 1995.

Use Patterns: 1994 - 1995

One hundred and forty-seven fecal pellet transects measured in 1994 and 1995 were used in univariate and multivariate habitat use analysis. Of the 147 transects, 24 (16%) were repeated 3 times in the 1994 and 1995 field seasons. The mean for the 3

Table 2. Paired t-test of bighorn, elk, and cattle pellet densities for 1975 versus 1994, 1975 versus 1995 and 1994 versus 1995.

Species Year	Mean	N	SD	Min	Max	Years Compared in t-test	t	p-value	Confidence Interval
Bighorn									
1975	31.40	38	56.48	0	206	1994 - 1975	3.35	.002	-42.74 -10.51
1994	4.79	38	11.17	0	58	1994 - 1995	0.57	.573	- 7.67 4.31
1995	6.48	38	19.64	0	116	1995 - 1975	3.10	.004	-41.00 - 8.64
Elk									
1975	19.85	38	24.10	0	81	1994 - 1975	3.93	.000	13.39 42.05
1994	47.67	38	46.25	0	162	1994 - 1995	1.33	.193	-35.68 7.45
1995	61.80	38	67.14	0	331	1995 - 1975	4.45	.000	22.96 60.91
Cattle									
1975	32.44	38	42.55	0	170	1994 - 1975	3.00	.005	- 31.85 - 6.15
1994	13.66	38	38.24	0	166	1994 - 1995	1.92	.063	- 0.63 23.48
1995	2.24	38	6.59	0	28	1995 - 1975	4.41	.000	-44.44 -16.25

visits was used in the analysis. Analyses were run on 1994, 1995, and combined 1994-1995 data. Fifty-five transects were completed in the same locations in 1994 and 1995. The averages for 1994 and 1995 transects measured in both years were used in the combined 1994 and 1995 data analysis. Two outliers were excluded from all univariate and multivariate analysis. One transect occurred in a location with high mountain goat use and pellets from the bighorns were difficult to distinguish from goat pellets. The second transect was excluded because of an unexplainable high number of bighorn pellets; confusion with old from new pellets or between species may have occurred.

The univariate chi-square analyses indicated habitat selection by sheep habitat for all features measured (elevation, aspect, slope, escape terrain, grass cover, elk pellet groups, and cattle pellet groups). In 1994, 1995, and combined 1994-1995, escape terrain had the highest chi-square value and aspect had the lowest value. All other habitat characteristics varied in the level of chi-square value (rank) for the three years. Elevation had the second highest chi-square value in 1994 and percent slope had the third highest. In 1995, elk pellet groups and degree slope had the second and third highest chi-square values; respectively. In the combined 1994 - 1995 data cattle pellet groups were second, elevation third, and percent slope had the fourth highest chi-squared value (Table 3). Results from the univariate chi-squared analysis test with confidence intervals for 1994, 1995, and combined 1994 - 1995 are in Appendix, Table 8a, b, c.

The chi-square analyses ranked habitat characteristics in the same patterns as the classification and regression trees. Classification and regression trees identified similar relationships between independent and dependent variables as the chi-square analysis in

Table 3. Chi-squared (X^2) analysis of bighorn habitat use versus habitat availability for pellet group transects in 1994, 1995, and 1994 and 1995 combined for habitat features of elevation, aspect, slope, escape terrain, grass cover, elk pellet groups, and cow pellet groups. Includes X^2 value and rank. The X^2 habitat values were ranked in order of highest to lowest for a specific year.

Habitat Feature(degrees freedom)	Year					
	1994	X^2 (rank) p-value	1995	X^2 (rank) p-value	1994/1995	X^2 (rank) p-value
Elevation(3)		110.05 (2)		48.15 (6)		88.46 (3)
6000	- ¹	<0.0001	-	<0.0000	-	<0.0000
7000	o		+		+	
8000	-		o		-	
9000	+		o		o	
Aspect(1)		13.17 (7)		6.23 (7)		14.55 (7)
N, NE, E, SE	-	0.0003	-	0.0126	-	0.0003
S, SW, W, NW	+		+		+	
% Slope(3)		47.28 (3)		157.28 (3)		79.11 (4)
10	-	<0.0000	-	<0.0000	-	<0.0000
20	o		+		-	
30	o		-		+	
40	o		+		o	
Escape(1)		280.70 (1)		429.30 (1)		401.28 (1)Dyÿÿ
# 100-m	+	<0.0000	+	<0.0000	+	<0.0000
> 100-m	-		-		-	
Grass Cover(1)		25.78 (6)		48.93 (5)		57.01 (6)
low(ground vis.)	+	<0.0000	+	<0.0000	+	<0.0000
high(ground not vis.)	-		-		-	
Elk Pellet Groups(2)		41.30 (5)		270.06 (2)		68.55 (5)
0		<0.0000	+	<0.0000		<0.0000
low ²	+		+		+	
high	-		-		-	
Cow Pellet Groups(2)		43.18 (4)		120.26 (4)		130.88 (2)
0	+	<0.0000	+	<0.0000	+	<0.0000
# 19	-		-		-	
> 19	-		-		-	

¹(-) bighorn sheep use < expected; (+) bighorn sheep use > expected; (o) bighorn sheep use expected habitat availability ($p < 0.05$).

²Low and high break points of elk pellet groups were # 10.4 and >10.4 for 1994, < 23 and > 23 for 1995, and < 14 and > 14 for 1994 and 1995 combined.

1994, 1995, and combined 1994 - 1995 data. Cattle pellet groups were not included in all of the trees because cattle selected areas away from escape terrain.

Classification trees were based on the presence or absence of bighorn pellet groups. For all chosen classification trees (1994, 1995, and combined 1994 - 1995) transects with the highest bighorn pellet frequencies occurred within 100 m of escape terrain. The 1995 classification tree was the only one with a second branching after escape terrain. This branch split on the number of elk pellet groups. Bighorns apparently selected areas with less than a mean of 22.8 elk pellet groups (Fig. 4).

Regression trees were constructed using the continuous variable of mean bighorn pellet groups. The 3 regression trees (1994, 1995, 1994 and 1995 combined) first branched on escape terrain with the highest densities of bighorn pellet groups within 100 m to escape terrain. In 1994 a second branch divided bighorn pellet groups by slope steepness with a mean of 10.02 pellet groups associated with slopes $> 12\%$ near escape terrain (Fig. 5). In 1995, the second splitting variable was the number of elk pellet groups found near escape terrain. Areas with fewer than 22.2 elk pellet groups had a mean of 23.3 bighorn pellet groups versus a mean of 3.6 bighorn pellet groups when mean elk pellet groups were > 22.2 (Fig. 5). The combined 1994 and 1995 regression tree branched 2 additional times after splitting on escape terrain. Elevation was the second splitting variable and slope was the third splitting variable. A mean of 24.45 bighorn pellet groups was found at elevations < 2475 m near escape terrain. If the elevation was > 2475 m, a mean of 10 bighorn pellet groups occurred in areas $> 12.5\%$ slope and a mean of 1.28 bighorn pellet groups occurred on slopes $< 12.5\%$ (Fig. 6).

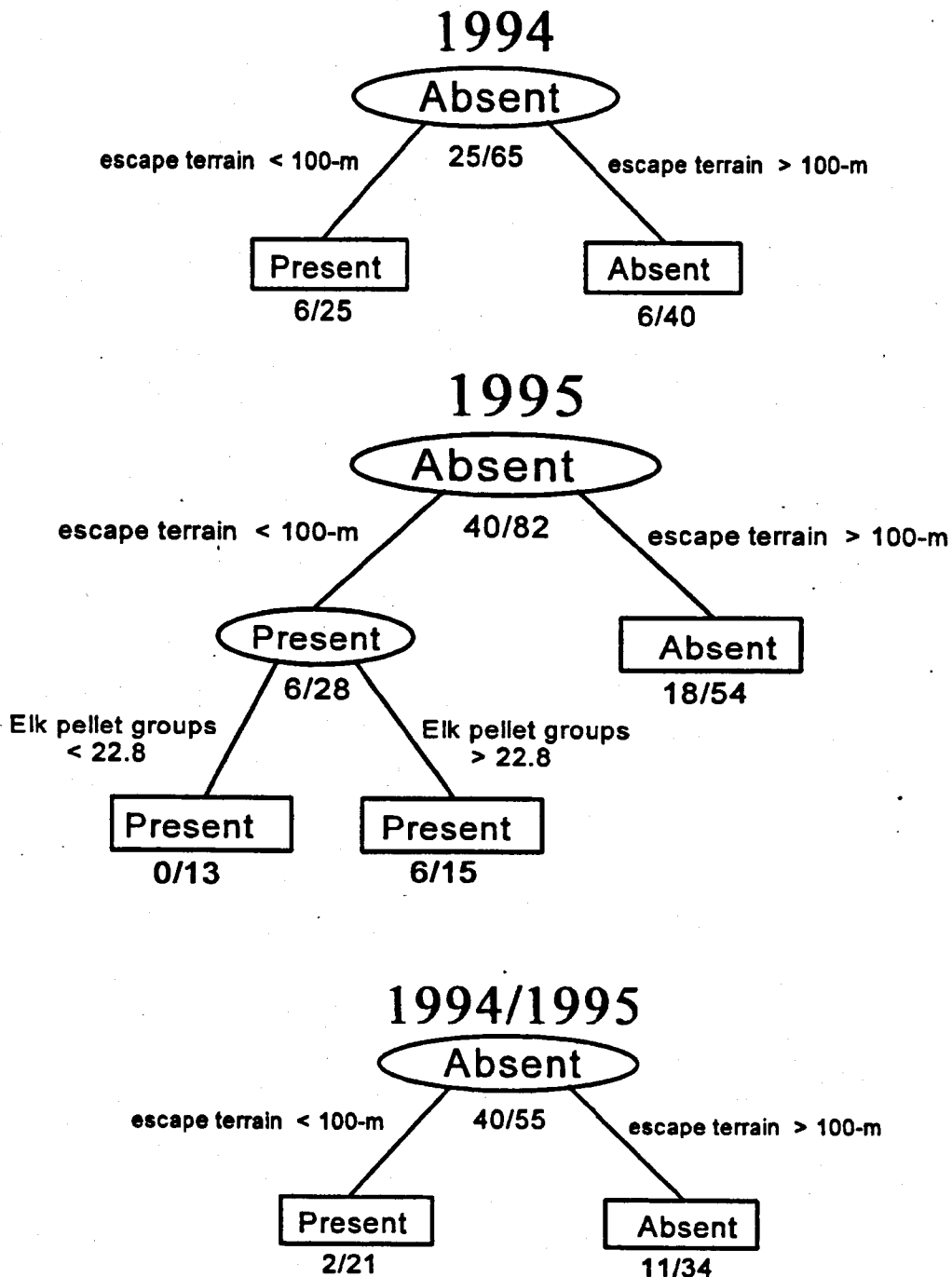


Figure 4. Classification Trees for 1994, 1995, and 1994/1995 bighorn pellet groups. Selection was based on the presence or absence of bighorn pellet groups. The ratio is the misclassification rate. The denominator represents the total number of transects for the node and the numerator is number of transects selected incorrectly for the node. The habitat characteristic that determines when the tree branches is next to the branch.

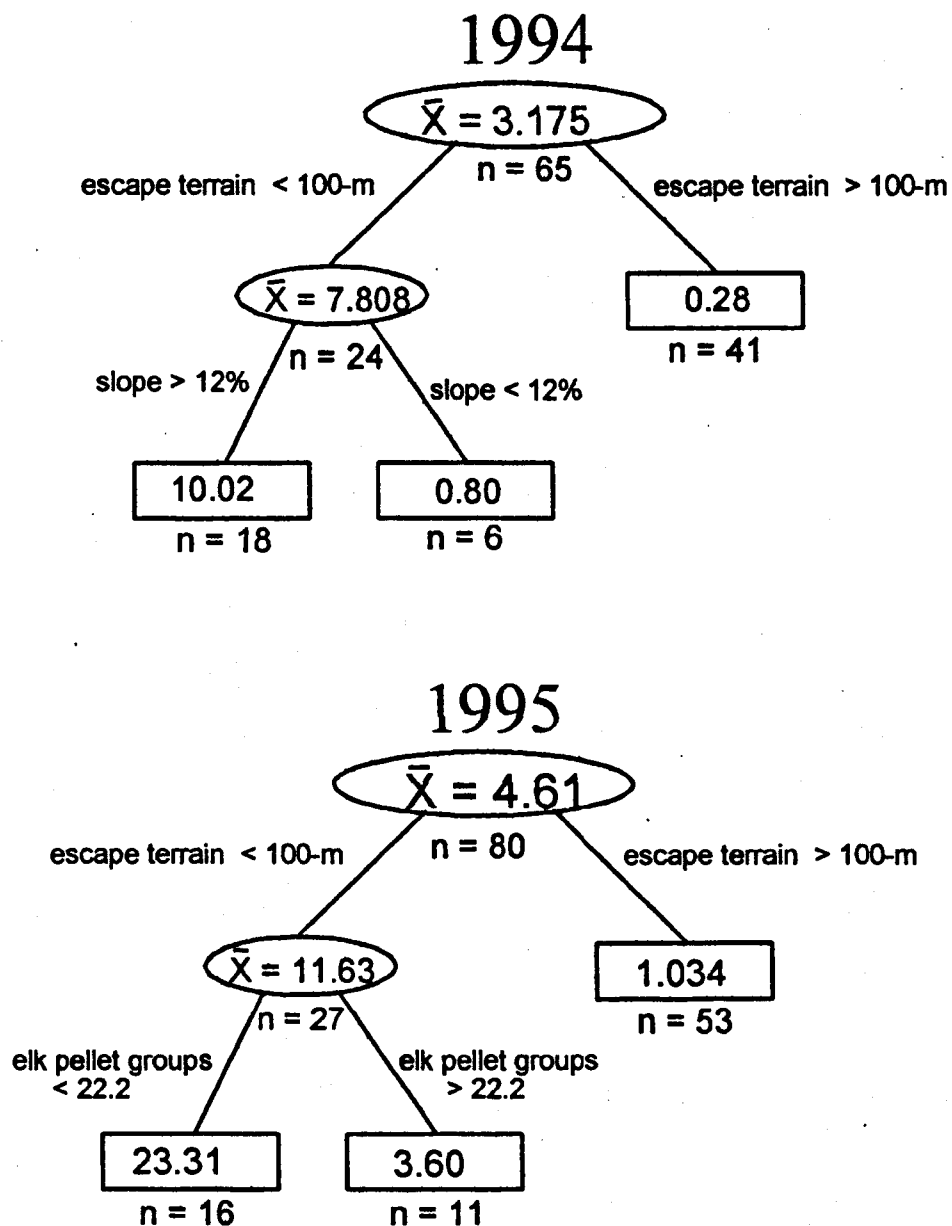


Figure 5. Regression trees for 1994 and 1995 bighorn pellet groups on the TMWR. n = number of transects for each node. Terminal nodes contain the mean bighorn pellet groups for n when the tree branches on the selected habitat characteristic.

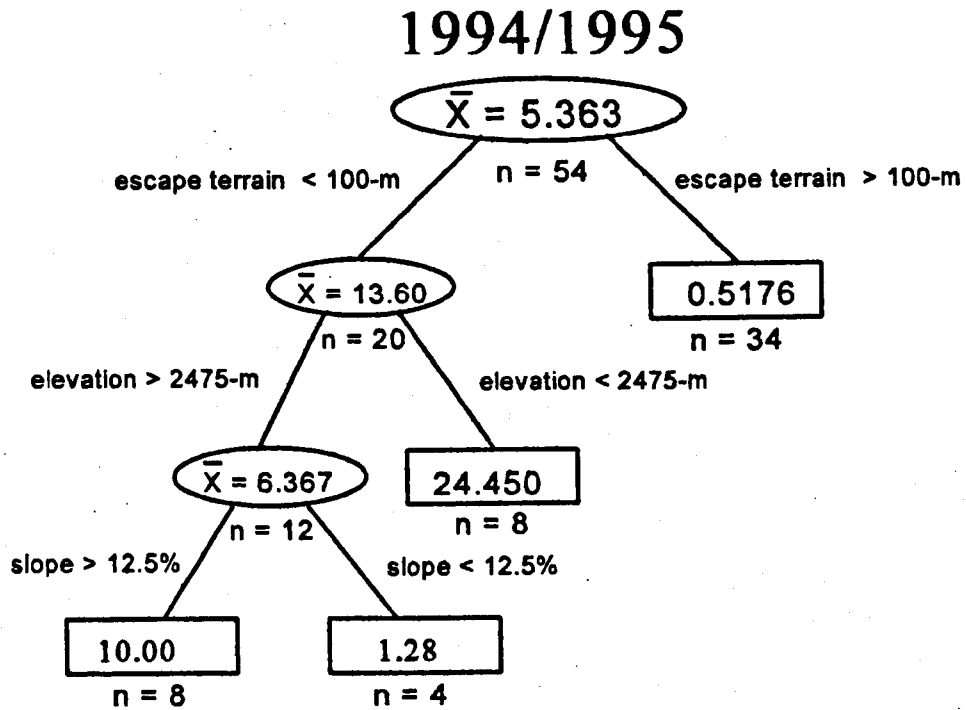


Figure 6. Regression tree for 1994/1995 bighorn pellet groups on the TMWR. See Figure 5 for explanation of symbols and numbers.

Vegetation Trend and Condition

Vegetation Trends between 1975 and 1994-1995

Trend and condition for vegetation and soil at sites in the Tom Miner Basin measured by Grunnigen (1976) indicated vegetation was in good condition in 1975 and had not changed by 1994-95 (Table 4). Vegetation condition at additional sites used heavily by sheep, elk, or both species that I measured in 1994 and 1995 were classified as "fair" to "excellent" (Table 4). When sites heavily used by ungulates were compared to sites lightly used by ungulates, no differences in the frequency of "fair", "good", or "excellent" vegetation classifications were found.

Table 4. Vegetation and soil condition and trend measures in 1975 and 1994 from transects completed in the Tom Miner Basin. Condition was rated on a scale of very poor to excellent (very poor, poor, fair, good, excellent) and trend was either up or down based on USFS description for range analysis. All percent grazing utilization at these sights was less than 20%. Transects 1-5 were transects repeated in 1975 and 1994 and transects 6-11 were additional transects completed in 1995 in areas with various ungulate use.

Transect	Relative Ungulate Use ^a		Vegetation Cond		Soil Condition		Vegetation Trend		Soil Trend	
	1975	1994	1975	1994	1975	1994	1975	1994	1975	1994
1	le, hs	le, ms	fair	fair	fair	fair	down	up	down	up
2	le, hs	me, ms	good	good	excellent	excellent	up	up	up	up
3	le, hs	me, ls	fair	good	excellent	excellent	up	up	up	up
4	le, hs	he, ls	fair	good	good	good	up	up	up	up
5	me, ls	he, ls	fair	good	excellent	excellent	up	up	down	up
6		1995		1995		1995		1995		1995
		me, ls		fair		good		up		down
7		he, ls		excellent		excellent		up		up
8		he, ls		excellent		excellent		up		up
9		me, ms		good		good		up		down
10		le, ls		good		good		up		up
11		le, hs		fair		excellent		up		up

^a Relative ungulate use is based on pellet groups at each transect for elk and bighorns: le = low elk, ls = low sheep, me = moderate elk, ms = moderate sheep, he = high elk, hs = high sheep.

Vegetation Use in 1994-1995

A total of 147 grazing transects was completed in 1994 and 1995. The transects were done in conjunction with the pellet-group transects and indicated how much utilization occurred at each pellet-group transect. Only 14 transects (9% of all transects) had greater than 30% utilization of the range in 1994 and 1995. All other transects had little to no utilization. The transects with greater than 30% utilization all occurred more than 100 m from escape terrain and in areas with high densities of cattle feces. Areas with high densities of elk or bighorn feces had low utilization (91% of the 147 transects had < 25% utilization).

Other Factors Influencing Bighorn Habitat Use on the TMWR

Cattle

In 1994 and 1995, 126 cattle grazed on Forest Service land and 134 cattle grazed on private land on the Tom Miner Creek allotment. In the Grizzly/Horse Creek drainage, 106 cattle grazed forest service land and 14 cattle used private land (Annual Gardiner Forest District Grazing Allotment Operating Plan 1995). New cattle pellets occurred in 47% of the pellet group transects (55 transects total) that were completed on the winter ranges in the Tom Miner Basin July- October of 1994 and 1995. I did not observe cattle on any summer ranges associated with the Tom Miner Basin.

Elk and Deer

During the 1994 and 1995 summer seasons, 1054 hours were spent on summer

(16%) and winter ranges (84%) in the Tom Miner Basin. Eight hundred and twenty elk, 62 mule deer, 59 white-tailed deer, and 9 moose observations were noted on the winter ranges. On the summer range, 50 elk and 5 mule deer sightings were recorded. At Point of Rocks, 600 elk were counted during the MDFWP annual elk survey in 1995, and I observed approximately 100 mule deer per field sampling day on the winter range. Only at the Point of Rocks did bighorn sheep, elk, and deer intermingle. In the Tom Miner Basin, elk were not observed on the winter range during November through May 1994 or 1995. Elk were seen no closer than 1.6 km from bighorns on summer range. The 11 transects completed on the bighorn summer ranges adjacent to the Tom Miner Basin showed low densities of elk pellet-groups on Bighorn Peak but more elk use on Fortress Mountain (Fig. 7).

Mountain Goats

I observed 13 mountain goats in the Tom Miner Basin in 1995. In both 1994 and 1995, 2 herds of goats occupied ranges in the Basin. In 1995, a group of 8 (5 adults, 2 yearlings, 1 kid) summered on Ramshorn Peak and a group of 5 (3 adults, 1 yearling, 1 kid) summered on Sheep Mountain. Goats were also documented along the Gallatin ridge, in Hyalite Basin, and along the north boundary of YNP. The goats were seldom seen within 500 m of sheep in summer and never sighted on sites used heavily by sheep in winter.

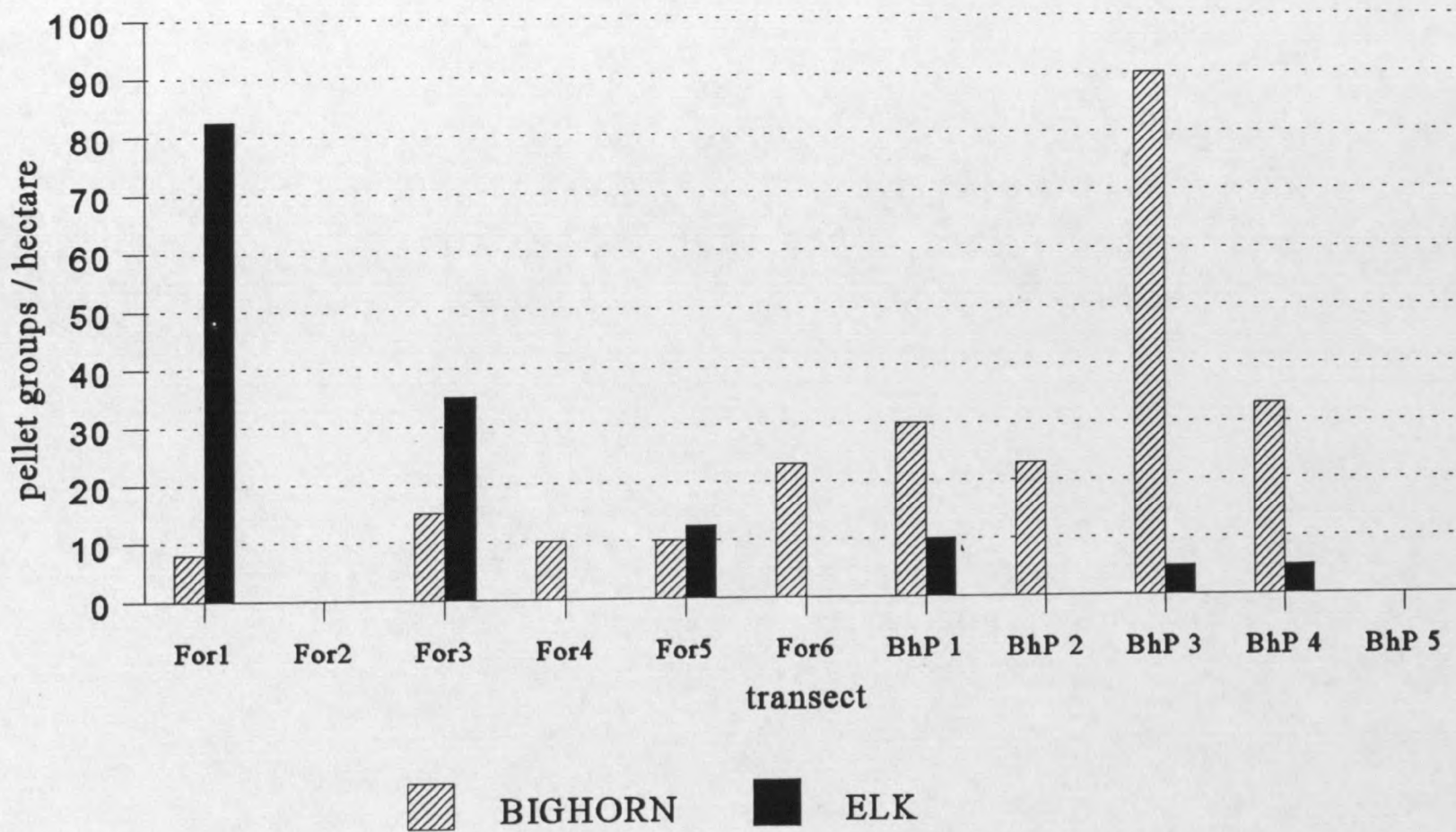


Figure 7. Pellet group transects for bighorn and elk on the Fortress (For) and Bighorn Peak (BhP) summer ranges in the Tom Miner Basin 1995.

Human Disturbance

I saw few other humans in spring, summer, fall, or winter during my field work on the TMWR. Sightings of people on the PRWR were infrequent and usually limited to people in vehicles on the county road that passed through the winter range. In the summers of 1994 and 1995, I observed a total of 65 people on (12) or near (53) the bighorn summer ranges in the Tom Miner Basin. Activities of these people consisted of hiking (43), horseback riding (13), motor biking (6), and mountain biking (2). When I approached the bighorns within 10 m or surprised them on summer range, they fled. On the PRWR I could get within 25 m before the sheep moved to their escape terrain.

Human-induced Mortality

In the study area, 6 rams were legally killed by hunters in 1994, no rams were legally killed in 1995, and 1 ram, at Point of Rocks, was legally killed in 1996.

Ram:ewe ratios were high (98rams:100ewes) in the 1995-1996 winter on the upper Yellowstone River Valley winter ranges combined (Annual Cooperative Bighorn Count 1995). No reports of poaching or other types of human-induced mortality (vehicle collisions, kills by pets, poison, etc.) occurred during the study.

Predation

Potential predators of sheep in the Tom Miner Basin include grizzly bears, black bears, mountain lions, coyotes, wolves and golden eagles (*Aquila chrysaetos*). Presence of all the predators was documented during the study, but verified instances of predation in the Basin were rare. During fieldwork in 1994-1996, 3 sheep mortalities were located:

1 ewe killed by a lion, 1 ram probably killed by a predator, and 1 ewe death due to an unknown cause.

Weather

In 1994, the average temperature was 7.8°C and deviated from the normal by 0.7°C based for the south central region (NOAA 1994). The minimum and maximum temperatures were -24.4°C and 36.1°C respectively. The total annual precipitation was 42.9 cm departing from the normal by +1.1 cm. In 1995, the average temperature was 7.3°C deviating from the normal by 0.1°C. The total annual precipitation 48.2 cm, 6.4 cm above the 30-year average (NOAA 1995).

Disease

No sheep were observed with the symptoms, poor physical condition and coughing, associated with lung worm or pneumonia epizootics in the Tom Miner Basin or in Point of Rocks populations. Blood and throat samples taken from 10 ewes and sent to the MDFWP labs resulted in no obvious signs of disease (Table 5). All ewes marked remained alive throughout the study.

Table 5. Results of blood work^a on the 3 Tom Miner Basin and 7 Point of Rocks ewes that were radio-collared in March 1995.

Ear-tag Number	Age	Brucellosis	Bluetongue	Brucellosis Ovis	Infectious Bovine Rhinotracheitis	Bovine Virus Diarrhea	Para Influenza-3	Leptospirosis 8 Serovars	Bovine Respiratory Syncytial Virus	Ovine Progressive Pnuemonia
34499	3	negative	negative	negative	negative	negative	negative	negative	1:64	negative
30554	6	"	"	"	"	"	1:18	"	1:256	"
30557	3	"	"	"	"	1:128	1:16	"	1:256	"
30560	7	"	"	"	insuffcient serum	1:256	1:18	"	1:256	"
30563	4	"	"	"	"	negative	1:18	1:50	1:256	"
30565	6	"	"	"	"	"	negative	1:50 2x's	1:256	"
30569	5	"	"	"	"	"	1:6	"	1:256	"
30571	5	"	"	"	insuffcient serum	"	negative	"	1:256	"
30575	8	"	"	"	"	"	1:6	1:50	1:256	"
A10786	6	"	"	"	"	1:128	negative	"	1:256	"
no. positive/total		0/10	0/10	0/10	0/8	3/10	6/10	4/10	10/10	0/10

^a Samples were prepared and examined at the Veterinary Diagnostic Lab, Montana State University.

DISCUSSION

Seasonal Range Use Patterns

The ewes from the TMWR used the same set of seasonal ranges identified in earlier studies (Grunnigen 1976, Keating 1982, Gehman 1985) supporting my first hypothesis that seasonal distribution remained stable during 1970-1995. Bighorns observed in this study used 2 summer ranges in the Tom Miner Basin, Bighorn Peak and Fortress Mountain. No marked ewes summered on Bighorn Peak, a summer range identified by Grunnigen (1976), Keating (1982), and Gehman (1985), but unmarked sheep were observed in this area.

Constan (1975) gave a detailed description of bighorn sheep seasonal range north of the YNP boundary and did not mention bighorn occupation of the PRWR. MDFWP surveys in 1975-1983 did not mention sheep at the PRWR. Point of Rocks sheep could have been included with counts in the Tom Miner Basin, although this is unlikely since past surveys I looked at included descriptive locations of sheep observations. The MDFWP survey in 1984 was the first time the PRWR was separated from the TMWR (Irby, unpubl.). Gehman (1985) also documented sheep wintering on the PRWR in 1985. Movements of the PRWR bighorns were unknown prior to 1995. I hypothesized that the bighorns moved to the Tom Miner Basin summer ranges. This hypothesis was rejected since the 7 ewes migrated to Hyalite Basin. The Hyalite summer range was previously known, but the sheep were believed to be a resident population (Irby, pers. comm.). The

movements of ewes associated with the PRWR to Hyalite Basin and the link between the PRWR and the CWR during the breeding season has increased the knowledge of how the northern Yellowstone bighorn subpopulations are connected. All other sheep locations during the study occurred in previously documented ranges, and no new winter or summer ranges were identified along the Gallatin ridge.

Population Estimates and Trends

The numbers occupying the TMWR are lower than those reported during the 1970's and 1980's. MDFWP winter surveys of the TMWR from 1979 - 1996 showed a high of 115 sheep and a low of 15 (Fig. 8). The decline in bighorn numbers should not be an effect of changing survey methods from fixed-wing aircraft (1979-1987) to helicopter (1990-1996). Helicopter wildlife surveys have greater observability than fixed-wings because helicopters can hover, have better maneuverability in a variety of terrain, and can get closer to the animals (Bodie et al. 1995). A major decline evidently occurred between 1983 and 1984 in wintering areas within the Basin (Grizzly Creek, Sawtooth Ridge, Tom Miner Campground, Bighorn Peak, Sheep Mountain). In 1975, Constan counted 52 sheep on Grizzly Creek, but the 1996 MDFWP survey observed only 3 sheep in the same area (Appendix, Table 9). Counts on the summer ranges in 1994 and 1995 were about the same as in past surveys from 1980 - 1986. Extensive ground surveys in 1994 - 1996 in the Tom Miner area did not reveal groups of sheep that were likely to have been missed during annual surveys.

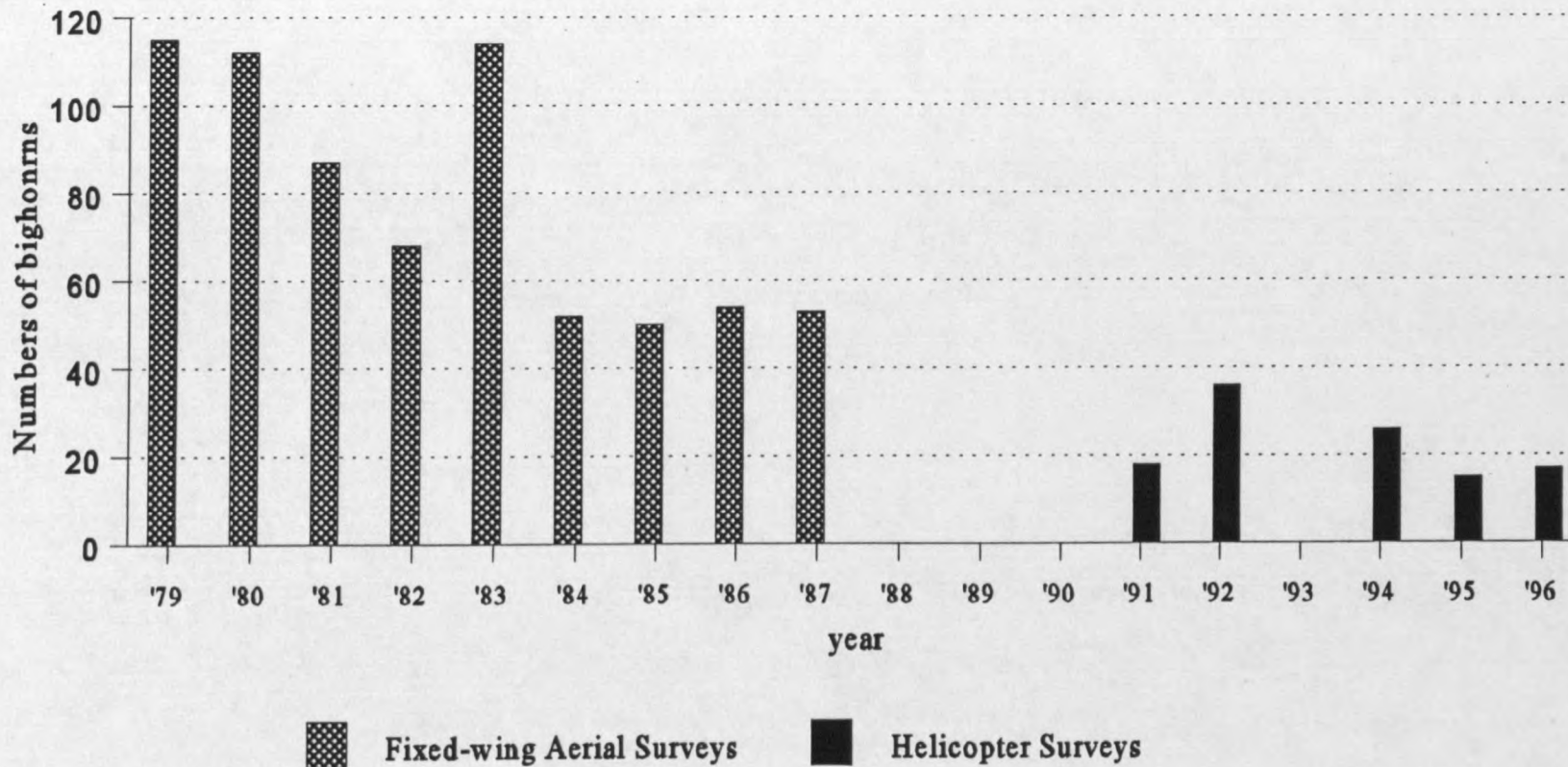


Figure 8. Maximum number of sheep counted in Tom Miner Basin in the years 1979 - 1996, the survey was not completed in 1988, 1989, 1990, and 1993. In 1979 - 1987 counts were from a fixed-wing aircraft (Irby) and in 1991- 1996 surveys were from a helicopter (Lemke).

Overall trends for the upper Yellowstone River Valley obtained from the Annual Cooperative Bighorn Count (ground count) and the MDFWP survey (helicopter count) showed an overall decline in bighorn populations. The highest count for the Annual Cooperative Count was in 1980. Count numbers declined in 1981 and 1982 reflecting a *Chlamydia* epizootic on the EWR (Meagher 1982, Meagher et al. 1992). Counts rose slightly after the outbreak but not to the levels noted in the late 1970's (Fig. 9). The MDFWP helicopter survey showed a decline in population size since 1992 although the survey area was expanded every year. Despite variability in counting conditions due to personnel, weather, and flight conditions survey data indicate an overall decline in numbers during the past decade and fluctuations in distribution.

Ungulate Use on Bighorn Winter Range

Changes since 1975

Ungulate use in the Tom Miner Basin has changed since 1975, and my third null hypothesis, no change in the Tom Miner ungulate population, was rejected. Both bighorn pellet groups and the population decreased since 1975 on the TMWR. Trend counts from MDFWP during 1990 - 1995 show variable elk numbers in the Tom Miner Basin (Fig. 10), but the counts have increased since 1975. This increase coincides with the steady growth of the Northern Yellowstone elk herd since the mid 70's and the expansion of elk into ranges north of YNP (Singer 1991). Elk pellet groups also followed this pattern. For transects repeated in 1975 and 1994-1995, I found elk pellets in all of the 38 transects in

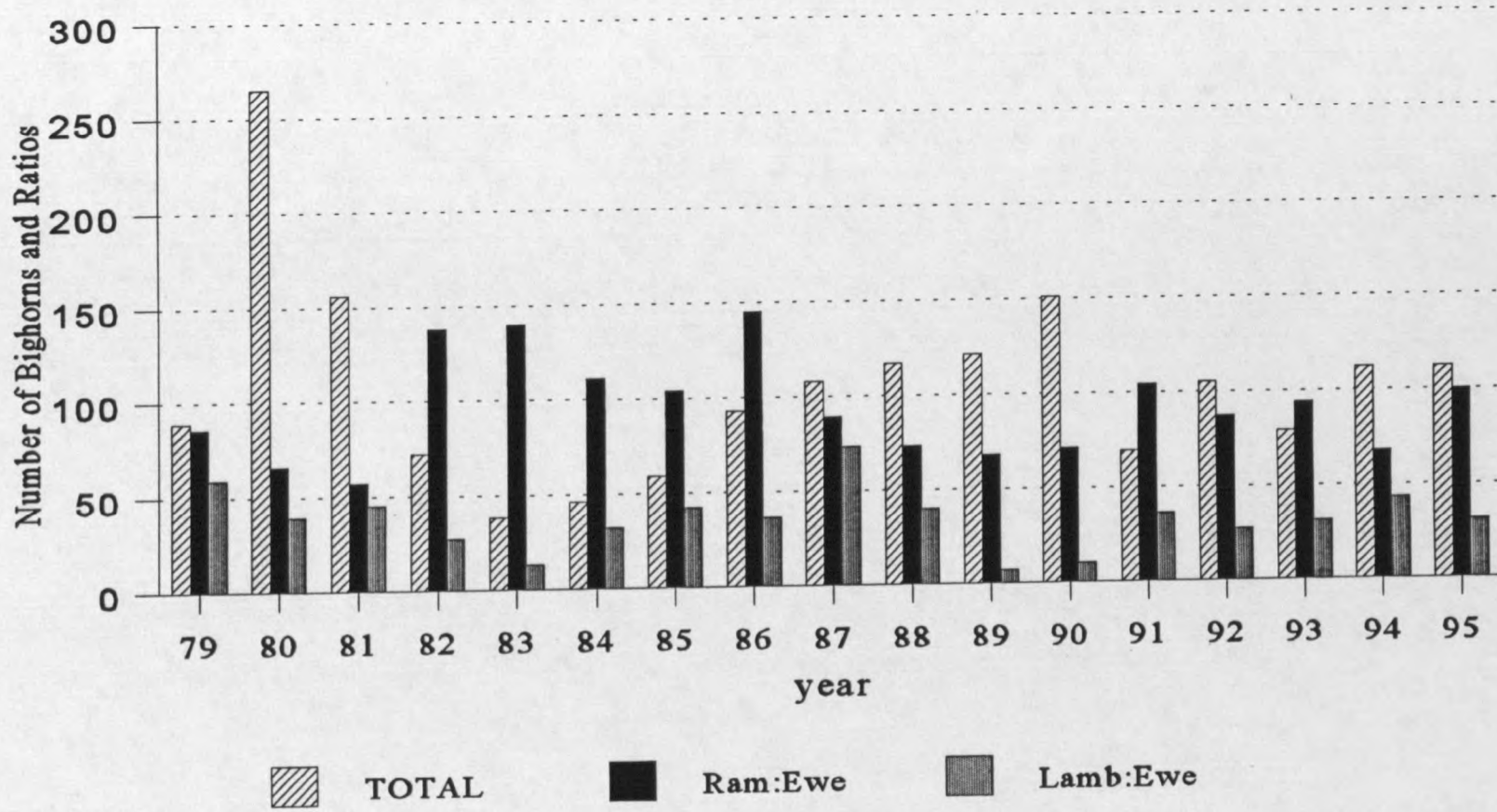


Figure 9. Annual Cooperative Bighorn Sheep Ground Survey conducted in December of years 1979 - 1995 includes total, rams:ewes, and lamb:ewes.

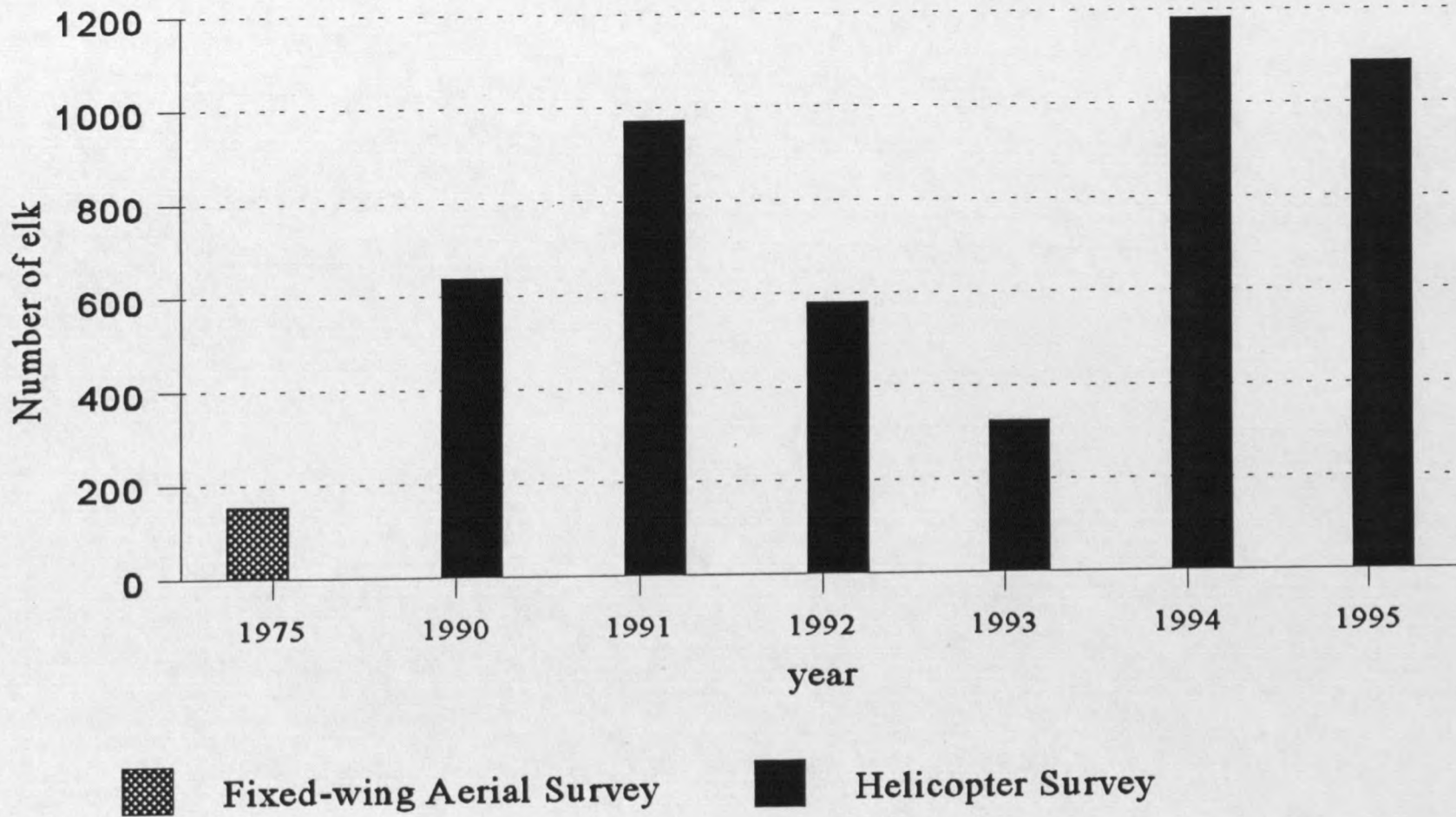


Figure 10. Number elk in Tom Miner Basin from the MDFWP count in 1975 (Constan) and annual winter surveys from 1990 - 1995 (Lemke).

1994 and 1995, but Grunnigen found elk pellets in only 25 of the 38 transects (66%) in 1975.

Cattle fecal groups declined, and the change was due to changes in grazing management instituted by the USFS after 1975. In 1975, cattle grazed throughout the basin with limited regulation. During 1994 and 1995 cattle distribution was regulated through a pasture rotation system and a lower stocking rate on USFS lands than in 1975.

In all years (1975, 1994, and 1995) moose and deer pellet densities were low, suggesting that moose and deer do not affect the utilization of sheep range in the Tom Miner Basin. Although some deer pellets could have been mistakenly identified as sheep pellets, deer were rarely seen near open escape terrain that sheep routinely utilized.

Interspecific Competition

Cattle

Cattle grazing has been a concern in bighorn sheep management (Bodie and Hickey 1980, McCollough et al. 1980). Cattle use was distributed differently than sheep use in the Tom Miner Basin. Most cattle feces were found > 100 m from escape terrain. Most bighorn pellet groups were within 100 m of escape terrain. If cattle were included in the classification and regression tree analyses, a tree may show that bighorns selected areas with few cattle pellet groups but in reality bighorns are choosing areas near escape terrain. Other research showed that limited competition occurred between cattle and bighorns. Gangskopp and Vavra (1987) found that slope steepness affected cattle use. Cattle preferred much gentler slopes than bighorns. Bodie and Hickey (1980) found

bighorns selected areas that were grazed late by cattle during a rest rotation range management system. They hypothesized that the cattle removed old vegetation which increased the growth of new vegetation. Semmens (1996) found that bighorns did not use rested pastures when cattle were not present in a rest rotation system, and indicated that this evidence suggested cattle did not displace bighorns.

The impacts of cattle on bighorns are likely to be negligible under current livestock management systems in the Tom Miner Basin. Cattle are not present during the winter months on the TMWR so if competition occurred it would be due to removal of forage from the winter range during summer. My data and Grunnigen's (1976) data indicate that cattle and sheep selected different habitat configurations and had minimal spatial overlap in areas used. The decrease in stocking rates from 351 head in 1975 to the current rate of 232 head on USFS land and the establishment of the pasture rotation system in 1988 lessens the chance of negative impacts of cattle on bighorn sheep in the Tom Miner Basin.

Elk

Competition for a limited supply of forage may exist between grazers (Jullander 1958), and some studies have suggested that elk impact bighorn habitat use (Schallenberger 1966, Woolf 1968, Oldemeyer et al. 1972). The increase in the elk population and decrease in bighorn population over the past 20 years may indicate that competition is occurring between the two species in the Tom Miner Basin although I found no conclusive evidence that elk were affecting bighorn winter range. Direct

competition was unlikely since elk did not occupy the winter range when the bighorns were present, and elk grazing in the spring through the fall did not remove high quantities of vegetation. Classification and regression tree analysis for 1995 data did suggest that bighorns selected areas near escape cover with low elk use. The reasons for this selection are unknown. Further studies would be required to determine if the negative association between elk and sheep pellets on winter range was an artifact of species-specific habitat selection strategies or driven by vegetation utilization overlap. Elk distribution overlapped that of bighorns on summer range in the Tom Miner Basin, but competition was unlikely given the large areas available and low forage utilization I observed.

Mountain Goats

Mountain goats were first documented in the Tom Miner Basin in 1991 (Lemke, pers. comm.). This population of goats evidently did not influence bighorn summer range, and goats have not been seen on winter ranges with the sheep. Varley (1994) found limited overlap of goats and sheep in the Absorka-Beartooths, Montana. Goats tend to use different habitat features (different aspects, steeper terrain, areas with snow) than mountain sheep. If goat numbers were to increase in the basin, more chance for interspecific competition could develop. The MDFWP has established a goat hunting season in the Tom Miner Basin to help limit the goat population.

Vegetation Trend and Condition

A loss of open grasslands or negative changes in species composition in grass communities are considered detrimental to bighorn sheep (Stelfox 1974). The

vegetation condition and trend did not change in the Tom Miner Basin from 1975 to 1994, and I failed to reject the null hypothesis of no change in vegetation quality. In 1994 and 1995, most transects I measured were rated as "fair" to "excellent", and there was no apparent association in ratings in areas with different grazing intensity (as indexed by fecal density).

Grazing transects revealed low utilization (< 10%) of vegetation during summer in areas with the greatest concentrations of bighorn pellets, a result that might be expected if only bighorns used preferred sites. Transects with the highest utilization (>30%) occurred where mean cattle fecal densities were highest. High elk pellet densities were not associated with areas of high vegetation utilization. Dominant grass species in areas selected by cattle, sheep, and elk were regarded as climax indicators and palatable forage species for the grassland communities sampled. The quality and quantity of grassland vegetation in summer indicate that absolute availability of forage is unlikely to be a major limiting factor for bighorns associated with the TMWR.

Other Factors Influencing Bighorn Habitat Use on the TMWR

Human Disturbance

Recreational use by humans and development did not appear to limit bighorn habitat use in the Tom Miner Basin. During November through April, access to the winter range is difficult because of snow conditions and private lands bordering the winter range. Access to the other winter ranges of the upper Yellowstone River Valley is easier, and humans use these areas more. No development occurred on the winter or

summer ranges or along the migration corridors in the Tom Miner Basin.

Bighorn summer ranges along the Gallatin Ridge (Bighorn Peak, Fortress Mountain, Hyalite Peak) were used heavily by humans for hiking and horseback trips in summer and hunting during autumn. Sheep use of areas with popular trails was relatively common. At least one area that was once occupied by sheep until the 1960's (Stradley, pers. comm.) is no longer used by sheep. This area has much lighter recreational use than current summer ranges which bighorns use. I saw no direct instances where humans besides myself caused sheep to move while on the TMWR during winter or in the Tom Miner Basin during summer. When I startled sheep on their summer or winter range they would run to escape terrain, but if I did not startle them I could approach them within 10 m. I do not think legal human recreation has a negative impact on the bighorns in the Tom Miner Basin.

Human-induced Mortality

The bighorn sheep hunting season in the Tom Miner Basin is one of the few "open" sheep hunts in Montana with 50-125 valid licenses sold per year during the past 20 years. Quotas and hunting season length have been reduced in response to perceived declines in numbers of sheep, but legal mortality is unlikely to limit the growth of the bighorn population. Legal sheep hunting in the Tom Miner Basin is restricted to adult males (3/4 curl or more) and is closely monitored. Annual harvest has varied from 0-9 animals (MDFWP unpubl., Irby et al. 1989) with no reported kills of females. Ram:ewe ratios have remained high in the past 20 years and radiotelemetry studies in the 1980's

suggest that most adult males escape harvest (Irby et al. 1989).

No illegal harvest of females has been reported in the Tom Miner Basin (MDFWP, ann. rep). Females are unlikely to attract much attention from poachers since the large horns of males are the dominant incentives for illegal kills. Although poachers are unlikely to be caught (Pursley 1977, Vilkitis and Butts 1982), the restricted access across private property and the steep, unroaded terrains in the Tom Miner Basin probably limit poaching during most of the year. Poaching during the hunting season would likely be reported by other hunters.

Other human-induced mortality types (vehicle collisions, kills by pets, poison, etc.) are unlikely to be important in the Tom Miner Basin. The limited access to sheep range has decreases the level of human activities harmful to the sheep. Human presence is limited to use by hikers and horseback riders. The other upper Yellowstone winter ranges have more chance for these types of mortalities. On the EWR a lamb and ewe were hit by vehicles during the study (K. Gunther, YNP, pers. comm.). I do not think that the population is being negatively impacted by human-induced mortality since human activities are limited by managers and the physical characteristics of the Basin.

Predation

Populations of mountain lions (Aune 1991, Riley 1993) and coyotes (Giddings pers. comm.), have increased in Montana over the past 20 years. I sighted 10 grizzly bears in the Tom Miner Basin during 1994 -1995 where Grunnigen reported none in 1975. I found 2 sheep killed by predators in 1994 and 1995. Three radio-collared sheep

and 2-3 unmarked sheep were reported as probable predator kills in the Tom Miner Basin in the early 1980's (Irby, unpubl.). Murphy (in prep.) recorded 4 kills of sheep in his study of lions in northwestern YNP during 1990 - 1994. Wehausen (1996) showed that lion predation limited bighorn sheep populations in California. Enk (unpubl.) and Williams (1992) have reported sheep as prey items in lion diets in other areas in Montana. A more detailed study addressing predation on the Tom Miner Basin bighorn sheep population would be necessary to determine the effect of predators on bighorn populations in the upper Yellowstone River Valley.

Weather

The high elevation wintering areas in the Tom Miner Basin insure greater snow depth and longer snow coverage than in wintering areas at lower elevations. The initial drop in the Tom Miner Basin sheep population (1983-1984) occurred in a year with a mild winter. No unusual weather patterns were apparent in years immediately preceding the population drop. Ten years before the decline, winter severity was severe in 6 years, average for 1 year, and mild in 3 years, and after 1984, 3 of 11 winters were classified as severe and 8 winters were classified as mild (Farnes, unpubl.). If severe winters precipitated the decline, the mild winters of the past decade should have promoted population recovery.

Wehausen et al. (1987) suggested a relationship between lamb:ewe ratios and precipitation. Bad weather during lambing could induce hypothermia in the new born lambs. If lamb:ewe ratios are a valid index to impacts of weather on populations (i.e.

assuming lambs are more vulnerable than adults to weather related stress), ratios recorded in the Tom Miner Basin in summer and winter were not consistently lower than other northern Yellowstone herds in the past 20 years (Table 6) (Irby 1994). The potential for catastrophic death due to avalanches is higher in the Tom Miner Basin than in lower winter ranges, but no evidence surfaced of mass death despite extensive searches during the summers of 1994 and 1995 and annual heavy traffic by hunters throughout sheep range in the Tom Miner Basin every September.

Drought could also influence population dynamics. Drought may have triggered the epizootic in the Highland/Pioneers in 1995 (Semmens 1996). Twelve of the last 20 years have had snow levels below normal, but below normal snow levels should favor sheep at high elevation by reducing snow cover on winter range. During the population decline in 1983 to 1984, the annual precipitation was below normal in both years (NOAA 1983 and 1984) suggesting that drought could have affected forage on summer ranges. Sheep entering autumn in a year with poor summer forage may not have enough reserves to carrying them through the winter. My study yielded no conclusive evidence on the effects of weather. This would be another area where additional research could be useful.

Table 6. Lamb: Ewe ratios for the Mount Everts, Cinnabar Mountain, Tom Miner Basin, and Point of Rocks winter ranges from 1984 to 1995 based on highest counts per class recorded during ground and helicopter surveys in November - April (Irby 1994).

Year	Mount Everts			Cinnabar			Tom Miner Basin			Point of Rocks		
	ewe	lamb	ratio	ewe	lamb	ratio	ewe	lamb	ratio	ewe	lamb	ratio
1984	40	8	20	21	5	24	10	8	80			
1985	15	5	33	44	18	41	26	7	27	15	5	33
1986	20	8	40	46	15	33	28	6	21	14	6	43
1987	10	5	50	47	9	19	37	18	49	3	2	67
1988	9	3	33	44	17	39	9	2	22	4	3	75
1989	14	1	7	30	4	13	18	0	0			
1990	18	4	22	34	2	6	14	2	14	11	3	27
1991	34	7	21	40	9	23	18	5	28	12	3	25
1992	17	2	12	16	3	11						
1993	32	9	28	31	5	16	16	4	25	4	0	0
1994	21	12	57	23	7	30	15	2	13	18	3	17
1995	35	7	20	20	6	30	13	1	8	12	3	25

Disease

Disease is commonly regarded as a major factor limiting bighorn populations (Dunbar 1992). However, I did not gather any data that indicated that disease was a factor influencing bighorns in the Tom Miner Basin during 1994-1996. All blood samples from the 10 radio-collared ewes had low positive reactions for common disease organisms and normal blood chemistry. None of the ewes died during the study. Poor physical condition and coughing, symptoms associated with pneumonia-complex dieoffs, were not observed in the Tom Miner Basin in 1994 and 1995.

Mortalities reported on other winter ranges in the upper Yellowstone River Valley also indicated that disease was not an important factor in 1994-1996. The ewe hit by the car on the EWR had renal medullary amyloidosis which is uncommon in most species but

has been described in cats (*Felis* spp.), cattle, and Dorcas gazelles (*Gazella dorcas*). Two rams also died on the EWR from unknown causes. Their bodies were too far decomposed for any disease analysis.

The *Chlamydia* outbreak on the EWR in 1981-1982 (Meagher 1982) is the largest recent epizootic associated with any of the northern Yellowstone winter ranges. Scabies and eczema (probably mechanically induced soremouth that appeared during a winter when snow depth forced sheep to feed extensively on sagebrush) have occasionally been observed in individuals from the Cinnabar herd, but no major dieoffs have occurred since colonization of the area in the late 1960's (Irby et al. 1989). Contact with domestic sheep occurred historically in the Tom Miner Basin (Keating 1982), but the only recent commercial herd maintained in the area was in a range occupied by sheep in the Cinnabar herd from 1983-93. No acute dieoffs occurred during this period. All upper Yellowstone herds had low lamb: ewe ratios in many years that could indicate disease in lambs. I did not sample tissue from lambs on summer range to verify this possibility. The possibility of disease in the bighorns needs to be further explored before eliminating disease as a controlling factor in the population.

Inbreeding Suppression

No tissue samples were analyzed to determine relative heterozygosity in sheep from the Tom Miner Basin, but I was able to look at several indirect indications of inbreeding depression such as overall health, physical appearance, susceptibility to disease. Severe inbreeding frequently reduces viability of young individuals (Skiba and

Schmidt 1982). During 1994-1996, lambs that I observed were present in typical numbers for the area, showed no obvious physical defects, grew at normal rates, and maintained normal activity levels.

More subtle defects due to inbreeding result in increased mortality in young (Haas 1989). I counted the same number of lambs in the summer and fall, so if lamb deaths occurred they most likely happened during the first few weeks of life when I was unable to access the study area. Inbreeding may also result in reduced size, and compared to other populations in Montana, harvest data indicate that ram horns are relatively small (Stewart and Butts 1982, Fitzsimmons et al. 1995).

The present population in the Basin is below the theoretical number required to minimize loss of genetic variability (Fitzsimmon et al 1995), but past radiotelemetry studies (Keating 1982, Irby et al. 1986) and observations from this study showed genetic linkages are likely to occur between subpopulations of the upper Yellowstone River Valley. Males from Cinnabar have been located in the EWR and TMWR. Ewes from PRWR were observed on the CWR during the breeding season, and ewes from Cinnabar have visited the EWR (Fig. 11). Although the Tom Miner Basin subpopulation is small, inbreeding depression is unlikely due to the interconnectedness with the other winter range populations. Picton (1994) found low fluctuating asymmetry in the ram horns in the general area which also indicates no problems with inbreeding depression.

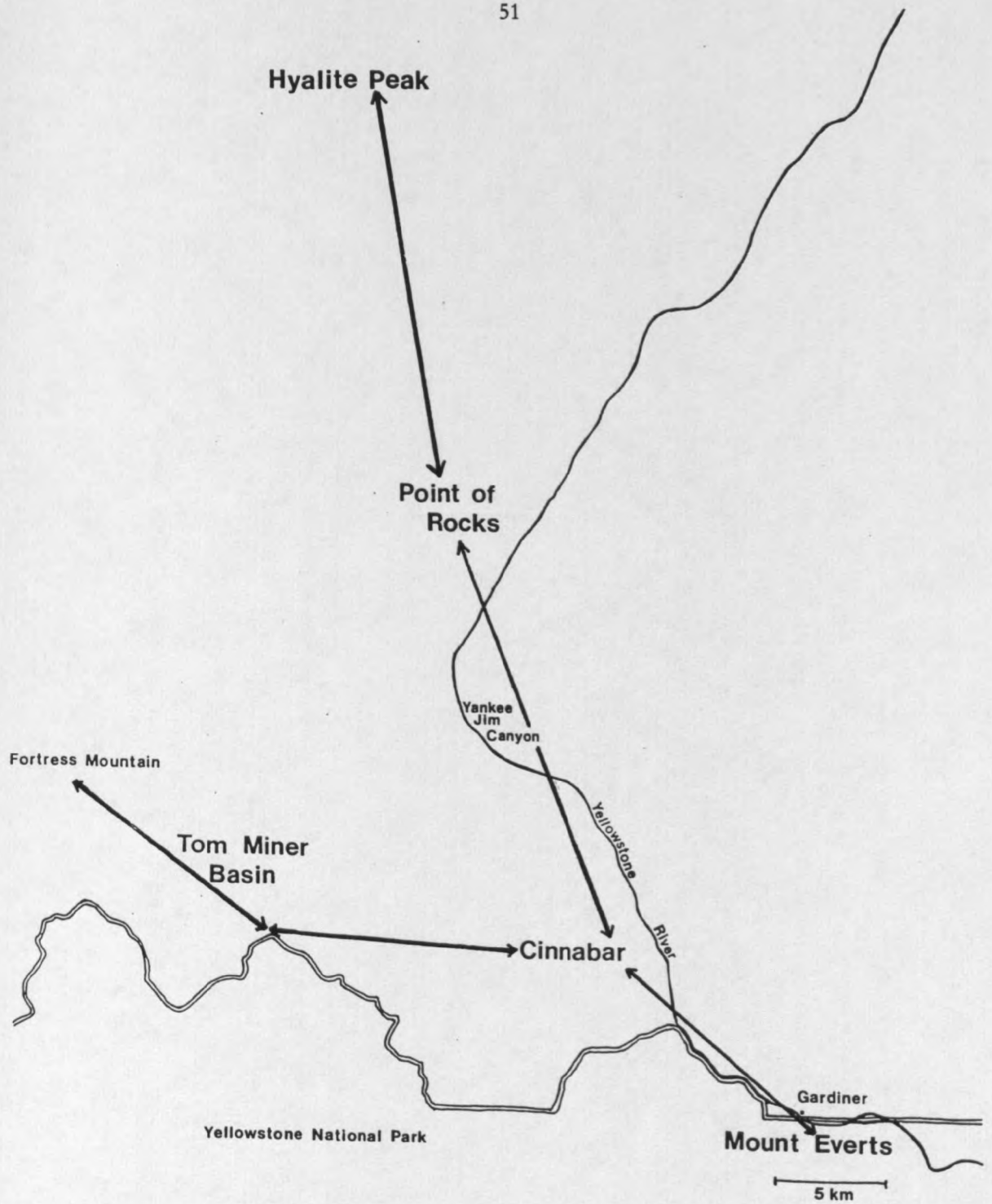


Figure 11. Known bighorn movements between subpopulations of the upper Yellowstone River Valley.

Intraspecific Competition

If sheep in the Tom Miner Basin are restricted to small, winter range sites with favorable snow and vegetation conditions, excessive use of these sites could reduce quality or quantity of vegetation actually available to sheep in winter though abundant nutritious forage is nearby but rendered unusable by snow. Under these conditions, over use of accessible forage on the limited winter range could lead to population declines that are due to direct or indirect effects of intraspecific competition when vegetative transects indicate abundant vegetation is present. This possibility implies that vegetation composition on heavily used sites should change over time and productivity of the herd should decline. Data from 1975 and 1994-95 indicate no change or a slight improvement in range condition on sites heavily used by sheep in 1975. However, sheep could deplete the vegetation above snow in favorable micro sites without affecting the quality and/or species composition of vegetation for the wintering site as a whole. If bighorns used the limited forage available above the snow, intraspecific competition could occur in an area in which abundant vegetation existed. Recovery of favorable sites would presumably be slow in the severe climate of the TMWR so high intensity use in and before the 1970's could effectively influence population dynamics in the 1990's. Unfortunately, data on the population size prior to 1979 are nonexistent. Current lamb:ewe ratios suggest forage is ample for the small numbers of sheep present today at least in some winters. Long-term intensive studies would be needed to verify or eliminate intraspecific competition as a major factor in the Tom Miner Basin.

CONCLUSION

The seasonal range use patterns of the TMWR ewes followed traditional movements and no new use areas had been established in the Basin over the past 2 decades. However, ewes from the PRWR migrated to summer range in Hyalite Basin and to the CWR in the fall. These movements had not been previously noted.

During the 1975-1995 period, elk numbers increased and sheep numbers decreased significantly in the Tom Miner Basin. Cattle use of bighorn ranges decreased due to changes in grazing management. Mountain goats invaded the Basin, and large predator mammals likely increased. Deer and moose populations were stable.

The results of my study suggested that cattle have little to no effect and elk may have some indirect effect on bighorn habitat use on the TMWR. Direct impacts from cattle and elk did not occur because neither species used winter range sites selected by bighorns extensively in winter or spring. Indirect effects due to use of vegetation on bighorn winter ranges during the summer were negligible for cattle and low for elk. The vegetation quality and availability on bighorn wintering sites has not changed since 1975. Summer ranges used by bighorns did not overlap cattle grazing allotments. Elk used bighorn summer ranges, but use intensities for sheep and elk were low.

Inbreeding suppression is an unlikely explanation for the population decline in the upper Yellowstone River Valley since extensive movements among subpopulations occur. Intraspecific competition was not eliminated as the cause in the initial drop in the Tom Miner Basin herd in 1983 but presently should not be a concern with such low

numbers of sheep. Activities by humans and human-induced mortality are unlikely to be factors in sheep population dynamics on the TMWR or the PRWR due to the strict hunting regulations and limited access to the winter and summer ranges. Competition with mountain goats on summer range is not currently a problem, but if the goat population increases, interspecific competition could occur. Disease was not thoroughly investigated, but no sheep showed symptoms of any disease, and all the collared ewes were healthy. Predation and weather are factors that could play a role in sheep population dynamics, but I was unable to conclusively determine the importance of either factor.

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APPENDIX

Table 7. Mean monthly temperatures (°C), minimum and maximum monthly temperature (°C), total monthly precipitation (cm), and deviations from the 30 year average for the Gardiner weather station and the south central region from January 1994 through April 1996.

Year Month	Monthly Mean Temp.		Monthly Temp.			Precipitation	
	Region	Gardiner	Gardiner		deviation from average	Region	Gardiner
			Min.	Max			
1994							
January	-2.2	-1.3	-16.7	8.3	3.5	1.8	0.0
February	-5.8	-4.3	-24.4	11.1	-2.3	1.7	5.1
March	3.8	4.3	-11.7	19.4	2.8	2.0	0.5
April	7.1	28.1	-8.3	26.7	1.2	5.5	0.5
May	13.6	40.0	1.1	28.3	2.8	4.4	5.2
June	16.9	17.0	1.1	35.0	0.7	5.5	4.3
July	19.6	3.0	4.4	36.1	-0.9	6.2	3.3
August	20.3	21.0	6.1	33.3	1.3	1.2	1.9
September	15.7	17.0	0	32.2	2.8	2.8	0.4
October	7.4	7.6	-6.7	23.3	1.1	8.1	4.0
November	-0.9	-2.1	-17.2	12.8	2.9	2.3	1.0
December	-2.1	-1.9	-16.7	8.3	2.4	1.4	
Annual	7.8	29.1			0.9	42.9	26.2
							deviation from average = 1.2
1995							
January	-2.2	-2.7	-21.1	7.8	2.2	1.8	0.4
February	.17	0.3	-22.8	16.7	2.2	1.3	0.8
March	.22	1.1	-20.0	15.0	0.4	4.5	5.9
April	4.9	5.2	-6.1	20.0	1.3	6.0	1.5
May	9.4	10.7	-2.8	26.1	0.8	7.8	1.0
June	15.2	15.3	1.1	31.7	1.1	7.3	3.5
July	19.1		2.2	33.3		5.5	0.9
August	19.8	20.5	6.1	34.4	0.8	2.9	2.0
September	13.8	14.7	-5.6	33.3	0.2	3.2	1.0
October	6.9	6.3	-8.3	24.4	2.2	4.1	
November	2.4	3.4	-15.6	15.0	2.5	2.7	3.0
December	-2.7	-2.2	-21.1	12.8	2.1	1.2	1.3
Annual	7.3	6.6			0.4	48.2	21.2
							deviation from average = 6.4
1996							
January			-26.7	7.8		1.5	
February			-30.6	12.2		3.4	
March			-20.0	13.9		4.7	
April			-9.6	24.4		2.3	

Table 8a. Chi-squared (X^2) analysis test for bighorn habitat use versus habitat availability in 1994. A total of 65 transects with 206 observations were used in analysis. Confidence intervals determined if use was $>$, $<$, or $=$ to expected (Neu et al. 1974).

Habitat Feature	X^2 -value	p-value	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	$>$, $<$, or $=$ to Expected
ELEVATION (m)	110.049	.0000						
1829			0	24.768	0.000	0.000 - 0.002	0.120	$<$
2134			100	101.136	0.486	0.400 - 0.573	0.490	$=$
2439			44	59.856	0.215	0.144 - 0.287	0.290	$<$
2744			62	20.640	0.298	0.219 - 0.378	0.100	$>$
ASPECT	13.174	.0003						
N, NE, E			0	12.384	0.000	0.000 - 0.002	0.060	$<$
S, SE, SW, W, NW			206	194.016	1.000	1.000 - 1.000	0.940	$>$
SLOPE	47.271	.0000						
10%			5	45.408	0.023	0.000 - 0.049	0.220	$<$
20%			86	72.24	0.417	0.331 - 0.502	0.350	$=$
30%			64	47.472	0.310	0.230 - 0.350	0.230	$=$
40%			52	41.280	0.250	0.175 - 0.325	0.200	$=$
ESCAPE	280.704	.0000						
$<$ 100 m			195	78.28	0.947	0.911 - 0.982	0.380	$>$
$>$ 100 m			11	127.72	0.053	0.018 - 0.089	0.620	$<$
GRASS COVER	25.779	.0000						
ground visible			181	148.464	0.879	0.828 - 0.930	0.720	$>$
ground not visible			25	57.736	0.121	0.070 - 0.172	0.280	$<$
ELK	41.302	.0000						
\leq 10.4 pellet groups			145	99.072	0.703	0.632 - 0.775	0.480	$>$
$>$ 10.4 pellet groups			61	107.328	0.297	0.225 - 0.368	0.520	$<$
CATTLE	43.178	.0000						
0 pellet groups			178	136.224	0.862	0.805 - 0.920	0.660	$>$
1-19 pellet groups			0	22.704	0.000	0.000 - 0.002	0.110	$<$
$>$ 19 pellet groups			28	47.472	0.138	0.080 - 0.195	0.230	$<$

Table 8b. Chi-squared (X^2) analysis test for habitat used by bighorns versus availability in 1995. A total of 80 transects with 369 observations were used in analysis. Confidence intervals determined if use was $>$, $<$, or $=$ to expected (Neu et al. 1974).

Habitat Feature	X^2 -value	p-value	Number Observed	Number Expected	Percent Observed	Interval	Percent Expected	$>$, $<$, or $=$ to Expected
ELEVATION	48.148	.0000						
1829			1	40.59	0.003	0.000 - 0.009	0.110	$<$
2134			241	202.95	0.653	0.591 - 0.715	0.550	$>$
2439			98	103.32	0.266	0.208 - 0.323	0.280	$=$
2744			29	22.14	0.079	0.044 - 0.114	0.070	$=$
ASPECT	6.230	.0126						
N, NE, E			8	18.450	0.022	0.005 - 0.039	0.050	$<$
S, SW, SE, W, NW			361	350.550	0.978	0.961 - 0.995	0.950	$>$
SLOPE	157.28	.0000						
10%			22	110.700	0.060	0.029 - 0.090	0.300	$<$
20%			169	114.390	0.458	0.393 - 0.523	0.310	$>$
30%			39	66.420	0.106	0.066 - 0.146	0.180	$<$
40%			139	77.490	0.377	0.314 - 0.440	0.210	$>$
ESCAPE	429.297	.0000						
< 100 m			314	125.460	0.851	0.805 - 0.893	0.340	$>$
> 100 m			55	243.540	0.149	0.107 - 0.191	0.660	$<$
GRASS COVER	48.928	.0000						
ground visible			294	228.780	0.797	0.750 - 0.844	0.620	$>$
ground not visible			75	140.220	0.203	0.156 - 0.250	0.380	$<$
ELK	270.063	.0000						
< 23 pellet groups			275	125.460	0.745	0.694 - 0.796	0.340	$>$
\geq 23 pellet groups			94	243.540	0.255	0.204 - 0.306	0.660	$<$
CATTLE	120.205	.0000						
0 pellet groups			352	254.610	0.954	0.928 - 0.980	0.690	$>$
1-19 pellet groups			7	40.590	0.019	0.002 - 0.036	0.110	$<$
>19 pellet groups			10	73.800	0.027	0.007 - 0.047	0.200	$<$

Table 8c. Chi-squared (X^2) analysis test for habitat used by bighorns versus availability in 1994 and 1995 combined. A total of 54 transects with 290 observations were used in analysis. Confidence intervals determined if use was $>$, $<$, or $=$ to expected (Neu et al. 1974).

Habitat Feature	X^2 -value	p-value	Number Observed	Number Expected	Percent Observed	Interval	Percent Expected	$>$, $<$, or $=$ to Expected
ELEVATION	88.463	.0000						
1829			0	26.100	0.000	0.000 - 0.002	0.090	$<$
2134			208	136.300	0.717	0.651 - 0.783	0.470	$>$
2439			48	95.700	0.166	0.111 - 0.220	0.330	$<$
2744			34	31.900	0.117	0.070 - 0.164	0.110	$=$
ASPECT	13.174	.0003						
N, NE, E			2	17.400	0.007	0.000 - 0.018	0.060	$<$
S, SE, SW, W, NW			288	272.600	0.993	0.982 - 1.004	0.940	$>$
SLOPE	79.113	.0000						
10%			37	75.400	0.128	0.079 - 0.177	0.260	$<$
20%			56	87.000	0.193	0.135 - 0.251	0.300	$=$
30%			108	58.000	0.372	0.302 - 0.443	0.200	$=$
40%			89	69.000	0.307	0.239 - 0.375	0.240	$=$
ESCAPE	401.279	.0000						
< 100 m			272	107.300	0.938	0.906 - 0.970	0.370	$>$
> 100 m			18	182.700	0.062	0.030 - 0.094	0.630	$<$
GRASS COVER	57.010	.0000						
ground visible			271	214.600	0.934	0.902 - 0.967	0.740	$>$
ground not visible			19	74.400	0.066	0.033 - 0.098	0.260	$<$
ELK	68.555	.0000						
<14 pellet groups			162	95.700	0.559	0.493 - 0.624	0.330	$>$
\geq 14 pellet groups			126	194.300	0.441	0.376 - 0.507	0.670	$<$
CATTLE	130.876	.0000						
0 pellet groups			259	165.300	0.893	0.850 - 0.937	0.570	$>$
1-19 pellet groups			31	63.800	0.107	0.063 - 0.150	0.220	$<$
>19 pellet groups			26	60.900	0.000	0.000 - 0.002	0.210	$<$

Table 9. Number of bighorns observed from the ground and air at specific locations in the Tom Miner Basin in the years 1974, 1975, 1980-1986, 1994-1996. Observers include K. Constan, K. Keating, L. Irby, S. Gehman, K. Legg, and T. Lemke. Dashed line (---) indicates no survey or observations for that year.

Location	Year, Month	Observer	No. Bighorns
Bighorn Peak	1974	---	---
	1975	---	---
	1980		
	Summer	Keating	10
	Fall	"	11
	1981		
	Summer	"	11
	1982		
	Summer	Irby	17
	Fall	"	5
	1983	---	---
	1984		
	Summer	Irby	10
	Fall	"	3
	1985		
	July	Irby	26
	1986	---	---
1994			
Summer	Legg	18	
1995			
Summer	Legg/Chapman	21	
Dry Creek	1974	---	---
	1975		
	Spring	Constan	2
	1980		
	Summer	Keating	6
	1981	---	---
	1982	---	---
	1983	---	---
	1984	---	---
	1985	---	---
	1986	---	---
	1994		
	Fall	Legg	6
	1995		
Summer	Legg	6	
Fortress Mountain	1974	---	---
	1975	---	---
	1980		
	Spring	Keating	7
	Summer	"	22

Table 9. (Continued)

Location	Year, Month	Observer	No. Bighorns
Fortress (Con't)	Fall	"	5
	1981		
	Summer	"	2
	Fall	"	3
	1982	---	---
	1983	---	---
	1984		
	Summer	Irby	8
	1985		
	Summer	Irby	3
	1986	---	---
	1994		
	Summer	Legg	23
	1995		
	Summer	"	17
September	"	20	
1996			
Summer	"	19	
Grizzly Creek	1974		
	Winter	Constan	52
	1975		
	Winter	Constan	26
	Spring	"	13
	Summer	"	9
	1980		
	Winter	Keating	9
	Spring	"	13
	1981		
	Winter	Keating	7
	1982		
	Spring	Irby	14
	Summer	"	18
	1983		
	Winter	Irby	18
	Winter-Dec.	"	23
	1984		
	Winter	Irby	13
	Spring	"	21
Summer	"	19	
Fall	"	13	
1985			
Winter	Irby	17	
1986			
Winter	Irby	25	

Table 9. (Continued)

Location	Year, Month	Observer	No. Bighorns
Grizzly (con't)	1994		
	Spring	Lemke	12
	1995		
	Spring	Lemke	4
	1996		
	Spring	Lemke	3
Horse Creek	1974		
	Summer	Constan	17
	1975		
	Spring	Constan	3
	1980		
	Spring	Keating	5
	1981		
	Spring	Keating	1
	Fall	"	6
	1982		
	Spring	Irby	11
	Summer	"	2
	Fall	"	1
	1983		---
	1984		---
	1985		---
	1986		---
	1994		
	Spring	Lemke	2
	1995		
Spring	Lemke	2	
1996		---	
Ramshorn Peak	1974		---
	1975		---
	1980		
	Summer	Keating	12
	Fall	"	7
	1981		
	Spring	Keating	10
	Summer	"	8
	1982		---
	1983		---
	1984		
	Summer	Irby	5
	1985		
	Summer	Irby	32
1986		---	

Table 9. (Continued)

Location	Year, Month	Observer	No. Bighorns
Ramshorn(con't)	1994	---	---
	1995		
	Summer	Legg	3
	Fall	"	18
	1996		
	Summer	Legg	3
Sawtooth Ridge	1974	---	---
	1975	---	---
	1980		
	Winter	Keating	1
	1981		
	Summer	Keating	4
	1982		
	Summer	Irby	2
	1983	---	---
	1984		
	Spring	Irby	4
	1985	---	---
	1986	---	---
	1994	---	---
	1995		
	Summer	Legg	6
1996	---	---	
Sheep Creek	1974	---	---
	1975		
	Spring	Constan	17
	Summer	"	14
	1980		
	Spring	Keating	10
	1981		
	Winter	Keating	41
	1982		
	Spring	Irby	3
	1983		
	Spring	Irby	21
	1984		
	Spring	Irby	14
	Summer	"	13
1985	---	---	
1994	---	---	
1995			

Table 9. (Continued)

Location	Year, Month	Observer	No. Bighorns
Sheep Ck (con't)	Spring	Legg	7
	May	"	7
	1996 Summer	Legg	1
Sheep Mountain	1974	---	---
	1975	---	---
	1980	---	---
	1981		
	Winter	Keating	3
	Summer	"	9
	1982		
	Summer	Irby	6
	1983		
	Winter	Irby	21
	Spring	"	12
	1984		
	1985		
	Spring	Irby	13
	1986		
	Winter	Irby	3
	1994		
1995			
Fall	Legg	7	
Winter	"	11	
1996			
Spring	Legg	12	
Stateland	1974	---	---
	1975	---	---
	1980	---	---
	1981		
	Spring	Keating	40
	1982		
	Spring	Irby	4
	1983		
	Winter	Irby	4
	Spring	"	6
	Summer	"	1
	1984		
	Spring	Irby	2
	1985		
	1986		
	1994		
	1995		
Spring	Legg	4	

Table 9. (Continued)

Location	Year, Month	Observer	No. Bighorns
Tom Miner Campground (cliffs to north)	1974	---	---
	1975	---	---
	1980		
	Winter	Keating	1
	Spring	"	17
	Summer	"	21
	Fall	"	12
	1981		
	Winter	Keating	3
	Spring	"	17
	1982	---	---
	1983	---	---
	1984		
	Summer	Irby	13
	1985	---	---
	1986	---	---
	1994		
	Spring	Legg	3
	1995		
	Spring	Legg	11
Summer	"	22	
1996			
Summer	Legg	5	
Tom Miner Creek	1974		
	Summer	Constan	51
	Fall	"	10
	Winter	"	6
	1975		
	Winter	Constan	6
	Spring	"	10
	1980	---	---
	1981		
	Summer	Keating	7
	1982		
	Spring	Irby	10
	1983	---	---
	1984		
	Spring	Irby	2
	1985		
Spring	Irby	4	
1986			
Winter	Irby	8	
1994	---	---	
1995	---	---	
1996	---	---	

Table 9. (Continued)

Location	Year, Month	Observer	No. Bighorns	
Twin Peaks	1974	---	---	
	1975	---	---	
	1980	---	---	
	1981	---	---	
	1982	---	---	
	1983	---	---	
	1984			
	Summer	Irby	1	
	1985	---	---	
	1986	---	---	
	1994	---	---	
	1995			
	Fall	Legg	2	
	Walsh Creek	1974		
Winter		Constan	1	
1975				
Summer		Constan	10	
1980		---	---	
1981				
Summer		Keating	13	
1982		---	---	
1983				
Winter		Irby	7	
Spring		"	16	
1984				
Spring		Irby	10	
1985		---	---	
1986				
Spring		Irby	18	
1994		---	---	
1995		---	---	
1996				
Spring	Legg	2		
Summer	"	4		

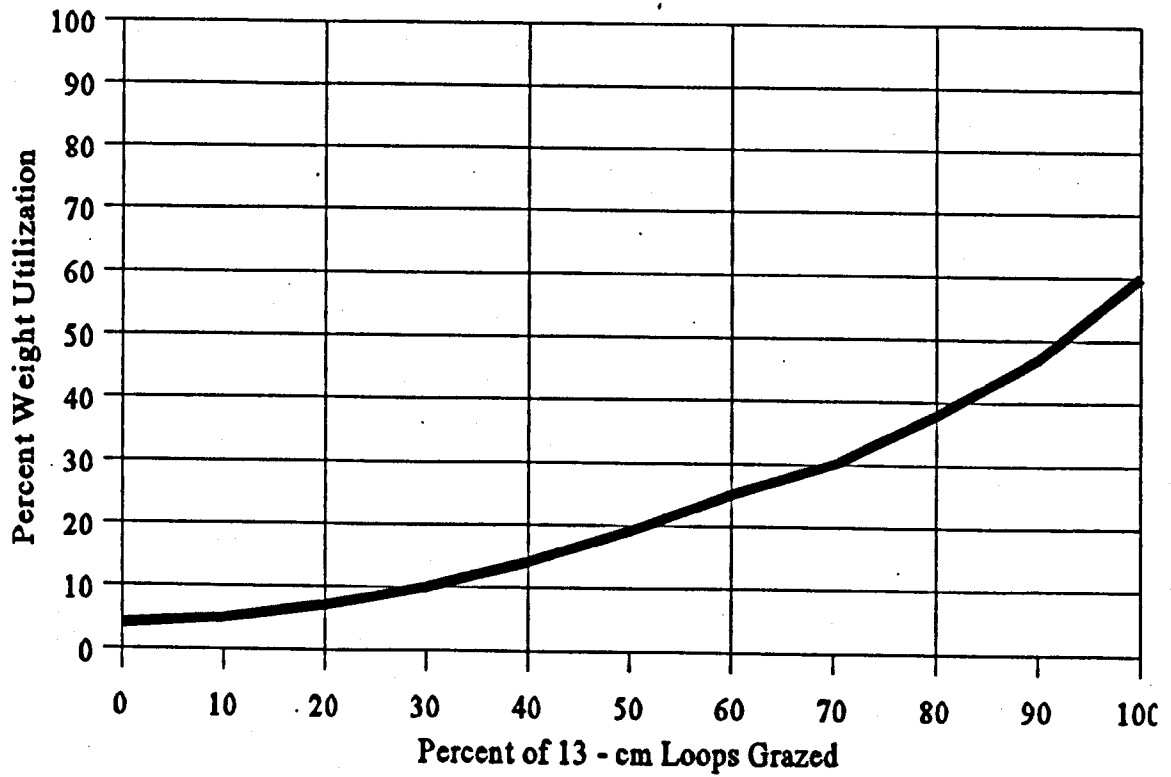


Figure 12. USFS graph to correlate the percent grazed to the percent utilized in mountain meadows. Data from Beaverhead, Clearwater, Deerlodge, Kaniksu, Lolo, Nezperce National Forests 1968.

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