



Seasonal variation of fecal nitrogen and forage succulence in relation to condition and movements of two southeastern Montana mule deer populations
by Thomas Joseph Olenicki

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:

Seasonal variation in nutrition and habitat use are important in understanding the ecology of mule deer (*Odocoileus hemionus*) in eastern Montana. Consequently, I used fecal nitrogen (FN) to assess nutrition of mule deer during summer and winter in a prairie habitat (Boxelder study area) and a ponderosa pine habitat (Ashland study area). Forage succulence predicted summer FN values ($R^2=0.93$, $P<0.01$) on the Boxelder area but not on the Ashland area. Winter values of FN were lower than summer values for both areas, with those on Boxelder lower than Ashland. There was a curvilinear relationship ($R^2=0.82$, $P<0.001$) between FN and rumen forage nitrogen. Kidney fat index was related linearly ($R^2=0.83$, $P<0.001$) to rumen forage nitrogen and curvilinearly ($R^2=0.59$, $P<0.05$) to FN. Fawn girth measurements were greater ($P<0.01$) at Ashland than Boxelder. Deer use of cover types differed (P

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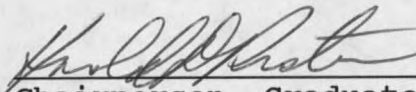
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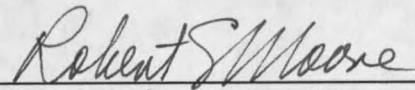
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TABLE OF CONTENTS

	Page
APPROVAL.....	ii
STATEMENT OF PERMISSION TO USE.....	iii
ACKNOWLEDGMENTS.....	iv
TABLE OF CONTENTS.....	v
LIST OF TABLES.....	viii
LIST OF FIGURES.....	xi
ABSTRACT.....	xiii
INTRODUCTION.....	1
DESCRIPTION OF STUDY AREAS.....	3
Boxelder Study Area.....	3
Ashland Study Area.....	8
METHODS.....	13
Forage Succulence.....	13
Fecal Nitrogen.....	14
Physical Attributes of Individual Deer.....	16
Classification of Cover Types.....	17
Capture of Deer.....	18
Visual Observations of Marked and Unmarked Deer....	19
Telemetry Relocations.....	21
Population Estimates.....	21
Mortality.....	22
Weather Conditions.....	23
Analytical Methods.....	23
Forage Succulence and Fecal Nitrogen.....	24
Physical Attributes of Deer.....	24
Population Estimates.....	25
Use of Cover Types.....	26
Home Ranges.....	27
Weather.....	29

TABLE OF CONTENTS-Continued

	Page
RESULTS.....	30
Succulence and Dry Weight of Forage.....	30
Boxelder Study area.....	30
Ashland Study Area.....	33
Fecal Nitrogen Content During Summer.....	36
Boxelder Study Area.....	36
Ashland Study Area.....	37
Fecal Nitrogen Content During Winter.....	39
Boxelder Study Area.....	39
Ashland Study Area.....	39
Gross Energy and Moisture Content of Fecal Samples.	41
Attributes of Collected Deer.....	41
Fecal Nitrogen.....	41
Kidney Fat Index.....	43
Rumen Forage Nitrogen.....	45
Girth Measurements.....	48
Population Characteristics.....	48
Fawn Ratios.....	48
Population Estimates.....	49
Mortality at Boxelder.....	51
Mortality at Ashland.....	52
Classification and Characteristics of Cover Types..	52
Use of Cover Types.....	55
Boxelder Study Area.....	55
Ground Observations.....	55
Flight Observations.....	59
Ashland Study Area.....	60
Ground Observations.....	60
Flight Observations.....	63
Distribution, Movements, and Home Ranges of	
Radio-marked Deer.....	64
Boxelder Study Area.....	64
Ashland Study Area.....	71
Weather.....	71
DISCUSSION.....	74
Fecal Nitrogen.....	74
Attributes of Individual Deer.....	83
Movements and Use of Cover Types.....	85
Boxelder Study Area.....	85
Ashland Study Area.....	88
Home Ranges.....	91
Population Characteristics.....	93

TABLE OF CONTENTS-Continued

	Page
CONCLUSIONS AND MANAGEMENT IMPLICATIONS.....	95
REFERENCES CITED.....	98
APPENDIX.....	107

LIST OF TABLES

Table	Page
1 Average dry weight (grams) of grass and forbs for clipping sites on the Boxelder study area.....	32
2 Average dry weight (grams) of grass and forbs for clipping sites on the Ashland study area.....	35
3 Sex, age, eviscerated weight in kg (lbs), fecal and rumen forage nitrogen (%), and kidney fat index (KFI) of deer collected on the Boxelder study area during fall and winter 1990-91.....	42
4 Sex, age, eviscerated weight in kg (lbs), fecal and rumen forage nitrogen (%), and kidney fat index (KFI) of deer collected on the Ashland study area during fall and winter 1990-91.....	43
5 Sex, age, eviscerated weight in kg (lbs), fecal nitrogen (%), and kidney fat index (KFI) of deer collected during January 1991.....	44
6 Monthly fawn ratios from air and ground surveys for the Boxelder and Ashland study areas.....	49
7 Population estimates, standard deviation (SD), and confidence intervals (CI) for the Boxelder and Ashland study areas.....	50
8 Cover types identified on the Boxelder study area.	53
9 Cover types identified on the Ashland study area..	54
10 Mule deer cover type use (% of all visual ground obs.) by activity for each month and summer overall, 1990, on the Boxelder study area.....	56
11 Mule deer cover type use (% of all visual ground obs.) by activity for each month and winter overall, 1991, on the Boxelder study area.....	58
12 Percent of mule deer observed in each of 3 areas on the Boxelder study area during complete coverage aerial surveys.....	59

LIST OF TABLES-Continued

Table	Page
13 Mule deer cover type use (% of all visual ground obs.) by activity for each month and summer overall, 1990, on the Boxelder study area.....	61
14 Percent of mule deer ground observations in each cover type during winter on the Ashland study area.....	62
15 Percent of mule deer flight observations in each cover type on the Ashland study area.....	64
16 Annual, seasonal, and life polygon home range (PHR in km ²) size and average activity radius (AAR in km) for deer on the Boxelder study area...	69
17 Seasonal, annual, life, and partial 1991 polygon home range (PHR in km ²), and average activity radius (AAR in km) for non-migratory deer on the Ashland study area.....	72
18 Identification numbers, ear tag numbers, sex, and age (years) of deer captured on the Ashland area during February, 1990.....	108
19 Identification numbers, ear tag numbers, sex, and age (years) of deer captured on the Boxelder area during February, 1990.....	109
20 Status of previously marked deer located during this study.....	111
21 Moisture content (%) of forage sample plots on the Boxelder and Ashland study areas during summer, 1990.....	112
22 Nitrogen content (%) of fecal samples for the Boxelder and Ashland study areas.....	113
23 Gross energy (kcal/kg) of fecal samples for the Boxelder study area.....	114
24 Weights of left and right kidneys (g) and associated fat (g) for all deer.....	115

LIST OF TABLES-Continued

Table		Page
25	Girth measurements (cm) and estimated bled carcass weights for fawns captured on the Boxelder and Ashland study areas.....	116
26	Monthly geographic activity center of all relocations in 1,000 meter Universal Transverse Mercator units on the Boxelder study area.....	117
27	Mean monthly minimum (MIN) and maximum (MAX) temperatures ($^{\circ}$ C) for the Boxelder study area and nearby NOAA weather stations.....	118
28	Values used for mark-recapture population estimates on the Boxelder and Ashland study areas.....	119

LIST OF FIGURES

Figure	Page
1 Map of the Boxelder study area showing drainages and locations of clipping transects.....	4
2 Mean monthly temperature and precipitation on the Boxelder study area.....	7
3 Map of the Ashland study area showing drainages, location of the Otter Creek trend area, boundary of the population estimate area, and locations of clipping transects.....	9
4 Mean monthly temperature and precipitation on the Ashland study area.....	12
5 Average moisture content (%) of forbs from plots clipped on the Boxelder study area.....	31
6 Average moisture content (%) of grass from plots clipped on the Boxelder study area.....	31
7 Average moisture content (%) of forbs from plots clipped on the Ashland study area.....	34
8 Average moisture content (%) of grass from plots clipped on the Ashland study area.....	34
9 Percent nitrogen of fecal samples collected during summer on the Boxelder study area.....	38
10 Percent nitrogen of fecal samples collected during summer on the Ashland study area.....	38
11 Percent nitrogen of fecal samples collected during winter on the Boxelder study area.....	40
12 Percent nitrogen of fecal samples collected during winter on the Ashland study area.....	40
13 Regression of nitrogen content of rumen forage to FN for all deer collected on the Ashland and Boxelder study areas during fall 1990.....	46

LIST OF FIGURES-Continued

Figure	Page
14 Regression of kidney fat index to rumen nitrogen for all adult deer collected on the Boxelder and Ashland study areas during fall 1990.....	47
15 Regression of kidney fat index to fecal nitrogen for all adult deer collected on the Boxelder and Ashland study areas during fall 1990.....	47
16 Telemetry relocations (n= 373) made between 16 July and 14 November during 1983-86 on the Boxelder study area.....	65
17 Telemetry relocations (n= 1176) made between 15 November and 15 July during 1983-86 on the Boxelder study area.....	66

ABSTRACT

Seasonal variation in nutrition and habitat use are important in understanding the ecology of mule deer (Odocoileus hemionus) in eastern Montana. Consequently, I used fecal nitrogen (FN) to assess nutrition of mule deer during summer and winter in a prairie habitat (Boxelder study area) and a ponderosa pine habitat (Ashland study area). Forage succulence predicted summer FN values ($R^2=0.93$, $P<0.01$) on the Boxelder area but not on the Ashland area. Winter values of FN were lower than summer values for both areas, with those on Boxelder lower than Ashland. There was a curvilinear relationship ($R^2=0.82$, $P<0.001$) between FN and rumen forage nitrogen. Kidney fat index was related linearly ($R^2=0.83$, $P<0.001$) to rumen forage nitrogen and curvilinearly ($R^2=0.59$, $P<0.05$) to FN. Fawn girth measurements were greater ($P<0.01$) at Ashland than Boxelder. Deer use of cover types differed ($P<0.001$) between winter and summer on both areas. Aerial observations indicated greater use by deer of pine dominated cover types than was indicated by ground observations for the Ashland area. Mesic sites appeared to be important on both areas. Telemetry relocations at Boxelder indicated movement of deer onto the main drainage for a short period during late summer and fall. Most deer at Ashland were yearlong residents of the same areas, with 7 of 58 marked deer using distinct summer and winter ranges. Population estimates indicated higher population growth rates and densities at Boxelder than Ashland since the mid-1980s. Weather data from the Broadus NOAA station provided a better prediction of winter conditions on the Boxelder area than NOAA stations at Albion and Ridgeway. Seasonal and yearly differences in FN may be useful in estimating physical condition of deer; thereby helpful in predicting population trends based on relative periods of energy gain and loss.

INTRODUCTION

Weather and climate may be the ultimate variables controlling year round energetics of rocky mountain mule deer (Odocoileus hemionus hemionus) by influencing forage quantity and quality in summer and rate and extent of energy loss during winter. This may be especially true in prairie habitats of eastern Montana where climatic conditions and deer population numbers both vary widely. The ability to predict changes in deer numbers based on climatic factors would be beneficial from a management standpoint to balance hunter opportunity with landowner tolerance to high population levels.

The New Mexico deer model (Green-Hammond 1986) and the Hobbs model (Hobbs 1989) are potential management tools that include weather as an input for predicting trends in deer population levels. The relationship between vegetation, rumen nitrogen, and fecal nitrogen are important in the New Mexico model. Griffiths (1990) found this model to offer potential application in southeastern Montana, although it needed to be modified to reflect specific deer-habitat relationships. Likewise, the Hobbs model predicts overwinter mortality based on winter weather limiting the availability and digestibility of forage.

Work by Griffiths (1990) was the start of an effort to develop predictive capability of mule deer populations in southeastern Montana. My study was a continuation of this effort, undertaken as an exploratory study to better define fecal nitrogen (FN) patterns and its usefulness as an indicator of nutrition. Specific objectives were to:

- 1) examine the accuracy of FN as a measure of consumed protein
- 2) determine the relationship of forage succulence (as a general indicator of forage quality) to FN
- 3) evaluate seasonal variation in nutrition of deer and relate their movements and use of cover types in response to declining forage quality during the year.

I conducted field work full time during the summer of 1990 and winter of 1990-91. Additional field work was done part time between these periods and after the winter season.

DESCRIPTION OF STUDY AREAS

Two separate study areas approximately 140 km apart in southeastern Montana were used for this study. Topography and habitat types were distinct for each area. Boundaries were identical to those used by Griffiths (1990).

Boxelder Study Area

The 142 km² Boxelder study area was located approximately 10 km northeast of Hammond, Montana in Carter county. Bounded areas were the Boxelder Creek road to the northwest, Alzada Ridge to the southeast, the divide between T.L. Creek and Cow Creek to the northeast, and the divide between Steep Creek and Goat Creek to the southwest (Fig. 1). Population trends on this area have been monitored by MDFWP since 1979.

Elevations range from 1,045 m along Boxelder Creek to 1,235 m on Alzada Ridge. Buttes are present throughout the rolling terrain.

The study area is characterized by highly eroded ephemeral streams. In some areas, stream width is only 1 m, with vertical sides reaching a depth greater than 2 m. In other areas, undercutting and slumping have increased stream width to >15 m with terraced sides. Branching and sinuosity have greatly increased stream length throughout

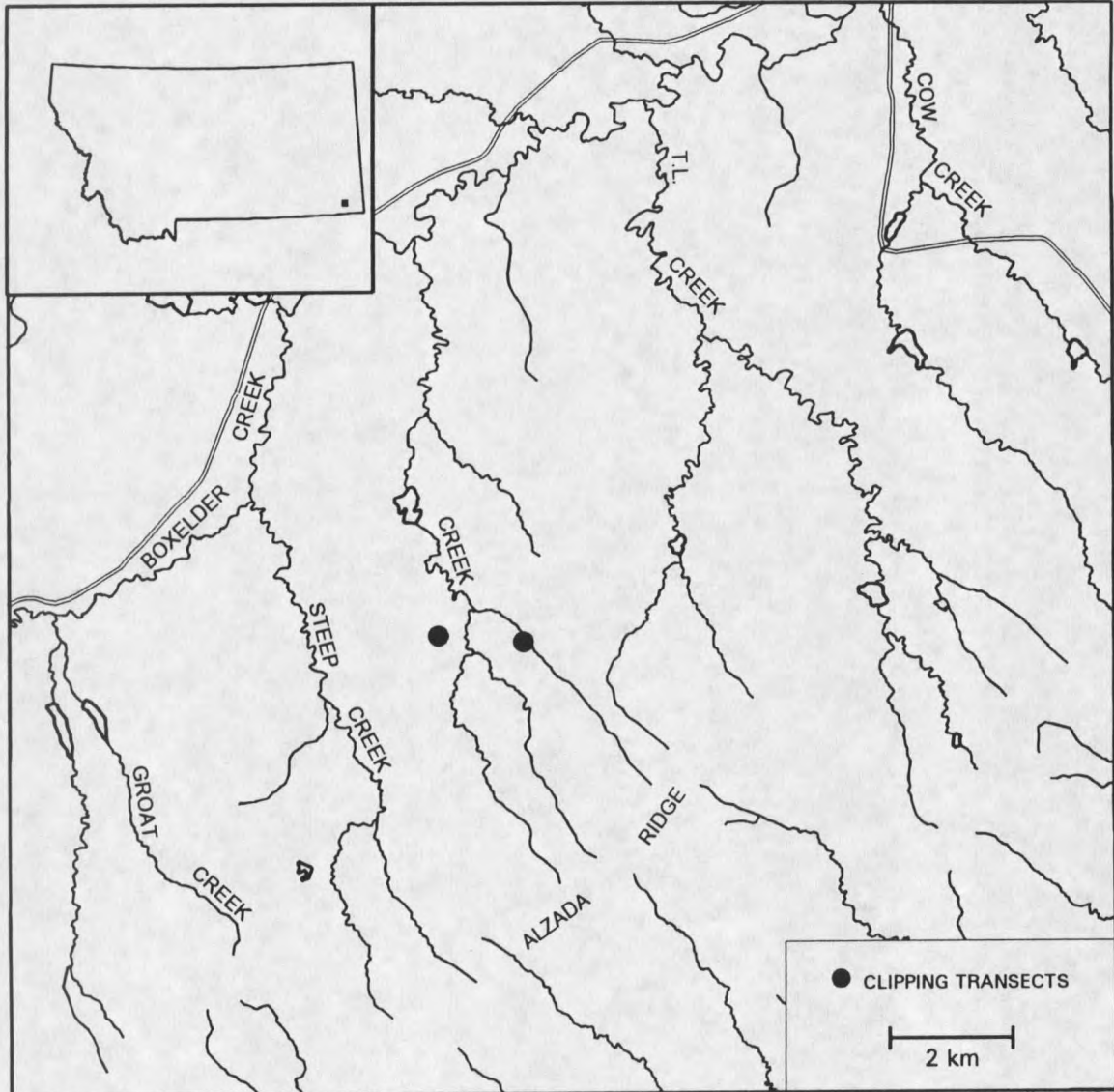


Figure 1. Map of the Boxelder study area showing drainages and locations of clipping transects.

the study area. Water flow generally occurs only in spring or after heavy rainfalls.

During summer, temperatures were often cooler in the bottoms of ephemeral streams. On 1 occasion, I measured a temperature of 27°C in a creek bottom compared to 57°C in the sun on the adjacent bank.

Boxelder Creek flows northeast through the study area into the Little Missouri River. Flows were yearlong from at least 1950 to the early 1980's, but have been only seasonal since the early 1980's (Ralph Brownfield, pers. comm.).

Vegetation on the study area is predominantly a sagebrush-grassland community. Climax grass species include western and thickspike wheatgrass (Agropyron spp.), green needlegrass (Stipa viridula), little bluestem (Andropogon scoparius), bluebunch wheatgrass (Agropyron spicatum), and prairie junegrass (Koeleria macrantha) (Ross and Hunter 1976). Big sagebrush (Artemesia tridentata) is present throughout the study area.

Saltbush (Atriplex gardneri) dominates ridges and the sides of many buttes. The occurrence of greasewood (Sarcobatus vermiculatus) increases in the southeast portion of the study area. Various shrubs and hardwood trees are common along Boxelder Creek but occur only in scattered areas along side creeks. Important species include snowberry (Symphoricarpos spp.), rose (Rosa woodsii),

cottonwood (Populus deltoides), and boxelder maple (Acer negundo). Fragrant sumac (Rhus aromatica) [fragrant sumac (Rhus aromatica)=skunkbush (Rhus trilobata)] occasionally occurs in draws on the sides of some buttes. Big sagebrush reaches a height of over 75 cm along creeks, with reduced height farther away. Yellow sweetclover (Melilotus officinalis), a biennial of widely varying occurrence, was common on the study area during the summer of 1990. Plant nomenclature follows Dorn (1984).

Land ownership consists of approximately 51% private land, 43% public land administered by the Bureau of Land Management (BLM), and 5% state-owned land. Cattle and sheep ranching is the major land use. Livestock are wintered along Boxelder Creek. The current grazing management allows grazing over virtually the entire area at some point during the year. Roughly 30 stock ponds are located on the study area.

Pronghorn antelope (Antilocapra americana) and red fox (Vulpes vulpes) were commonly seen, and limited numbers of white-tailed deer (Odocoileus virginianus) were present. Coyote (Canis latrans) populations are rigorously controlled by landowners and I observed only 1 individual during the study.

Deer hunting on private land within the study area is controlled by landowners, with over half receiving some form

of pay hunting. Hunting on BLM land is probably minimal due to limited access.

Mean monthly temperature on the Boxelder area is estimated to range from -8.3°C in January to 20.6°C in July. Mean annual precipitation is 356-406 mm with 60% of it occurring between April and July (Fig 2). The frost-free season lasts approximately 110-120 days, although most plant growth is normally completed by mid summer (July). All weather data are extrapolated values from the Montana State University MAPS (Montana Agricultural Potential System) computer program.

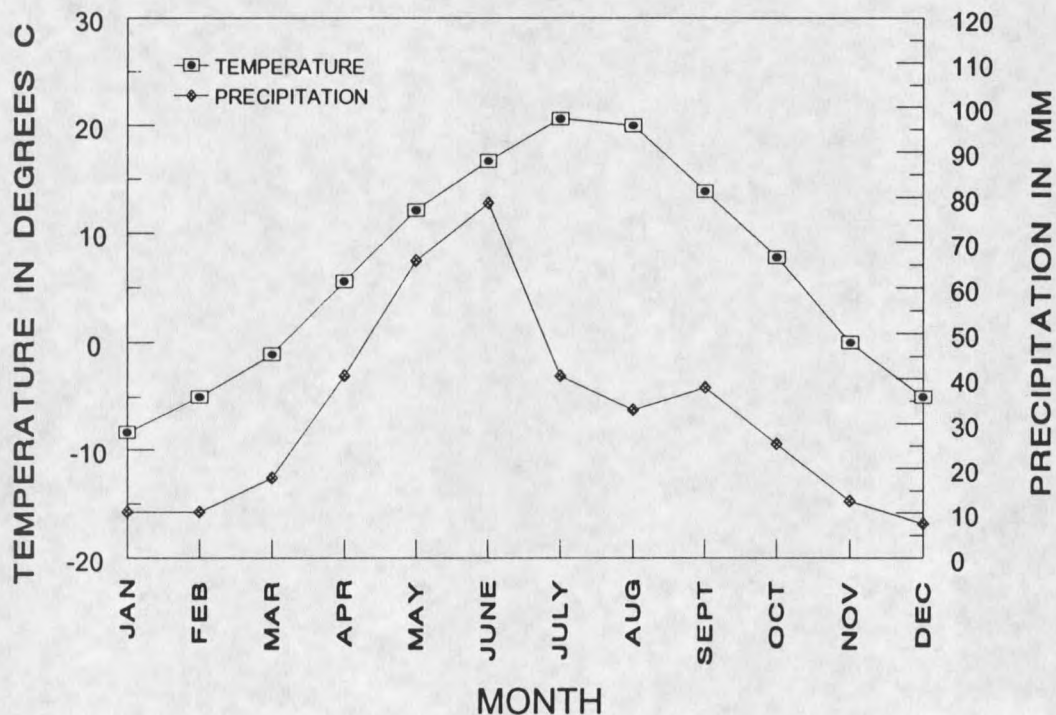


Figure 2. Mean monthly temperature and precipitation on the Boxelder study area (MAPS).

Snowfall during the winter averages 127-245 cm (MAPS). Maximum monthly snowfall during 1952-1989 at 3 nearby weather stations (Broadus, Ridgeway, and Albion, Montana) has never exceeded 76cm. Mean monthly snowfall values are all below 22 cm, with highest readings occurring in March or April (NOAA 1952-89).

Ashland Study Area

The 357 km² Ashland study area is located northwest of the Boxelder study area, near Ashland, in Rosebud and Powder River counties, Montana. Boundaries consist of State Highway 212 on the north, Otter Creek road on the east, and Cow Creek road to the south. The western boundary includes portions of the Tongue River, O'Dell Creek, and Stocker Branch road (Fig. 3). Deer populations have been monitored by MDFWP on a portion of this area (Otter Creek trend area) since 1979 (Fig. 3).

Topography varies throughout the study area. A distinct north-south ridge reaching an elevation of 1,265 m runs through the middle of the study area. This becomes a high plateau along the southern boundary, with rolling terrain over the rest of the area. A low point of 890 m is reached along the Tongue River to the west.

Steeply-eroded ephemeral streams similar to those on the Boxelder area are present throughout the rolling

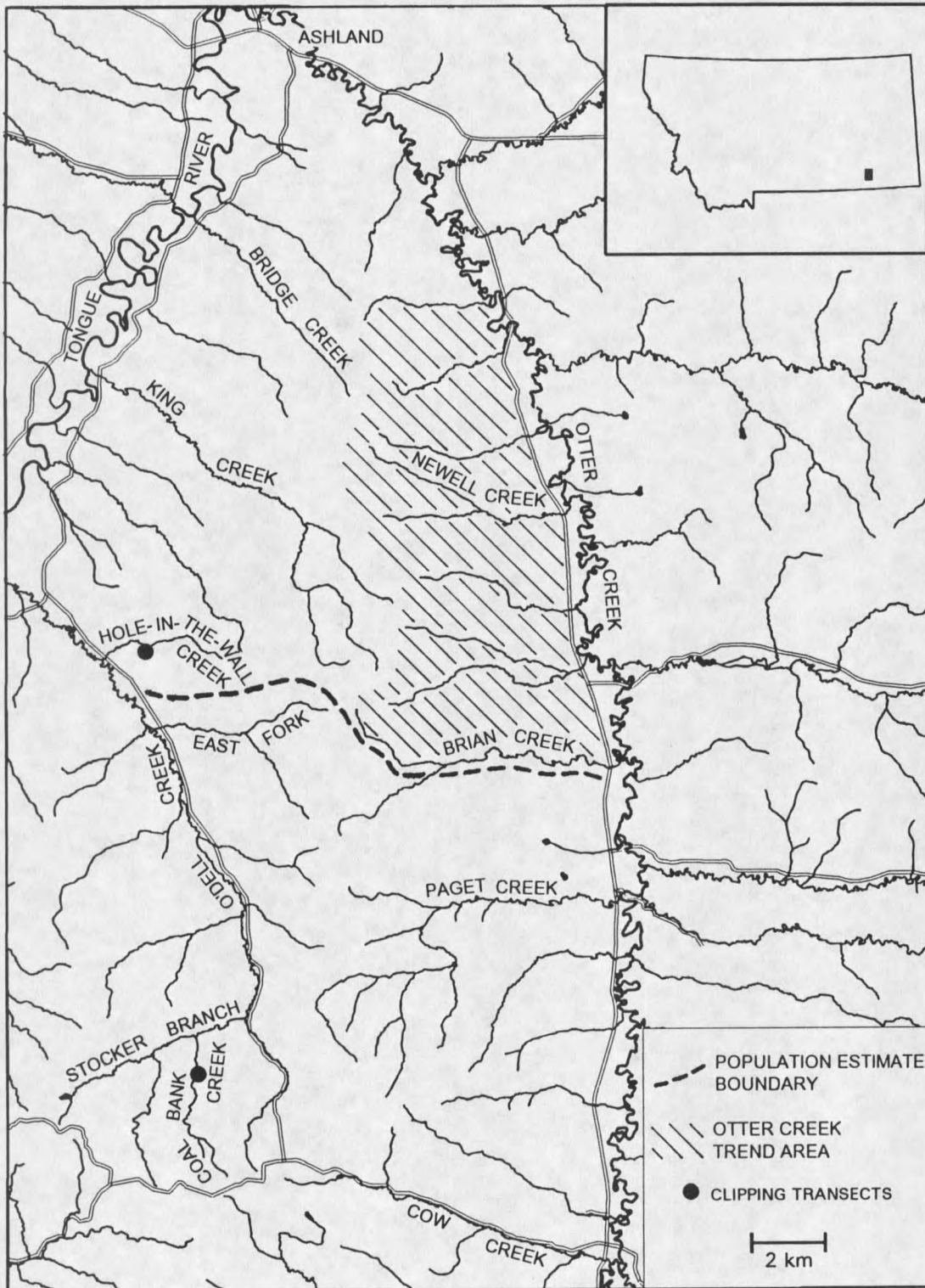


Figure 3. Map of the Ashland study area showing drainages, location of the Otter Creek trend area, boundary of the population estimate area, and locations of clipping transects.

portions, but they are less abundant than on the Boxelder area. Water flows yearlong in the Tongue River and Otter Creek. Numerous stock tanks and a few developed springs also occur.

The higher portions of the central and southern parts of the area are dominated by ponderosa pine (Pinus ponderosa) interspersed with grassland. This gives way to a mixture of pine, juniper (Juniperus scopulorum), big sagebrush, and mixed grassland at intermediate elevations. Grassland and sagebrush-grassland is most common at lower elevations and in northern portions of the area, although patches of pine and juniper also occur. Climax grasses in lower areas are similar to those on the Boxelder study area. Idaho fescue (Festuca idahoensis), sideoats gramma (Bouteloua curtipendula), big bluestem (Andropogon gerardii), and prairie sandreed (Calamovilfa longifolia) are found under the pine canopy at higher elevations (Ross and Hunter 1976).

Chokecherry (Prunus virginiana), serviceberry (Amelanchier alnifolia), buffaloberry (Shepherdia canadensis), and snowberry were present in more mesic areas, and fragrant sumac occurred on hillsides throughout the study area. Yellow sweetclover was common during the summer of field work.

Land ownership is about 63% national forest, 32% private, 3% BLM, and 2% state land. Hay and grain are grown along the Tongue River and Otter Creek. Only a small portion is irrigated. A rotational grazing system allows cattle use on practically the entire area at some point during the year. No sheep are present. Numerous roads exist throughout the study area.

I often observed coyotes, antelope, white-tailed deer, red fox, and bobcats (Felis rufus) on the study area. Two credible mountain lion (Felis concolor) sightings were reported during the summer of 1990.

The southern part of the study area is cooler and wetter than the northern portion. Mean temperature near Ashland is -7.2°C in January and 21.7°C in July. The number of frost-free days is about 100-125. Mean annual precipitation ranges from 305-356 mm in the north to 406-457 mm near Coal Bank Creek in the south, with approximately 57% occurring between April and July (Fig. 4). Annual snowfall on the northern portion averages 64-127 cm, whereas that on the southern part ranges from 64 to 254 cm. All weather data are from MAPS.

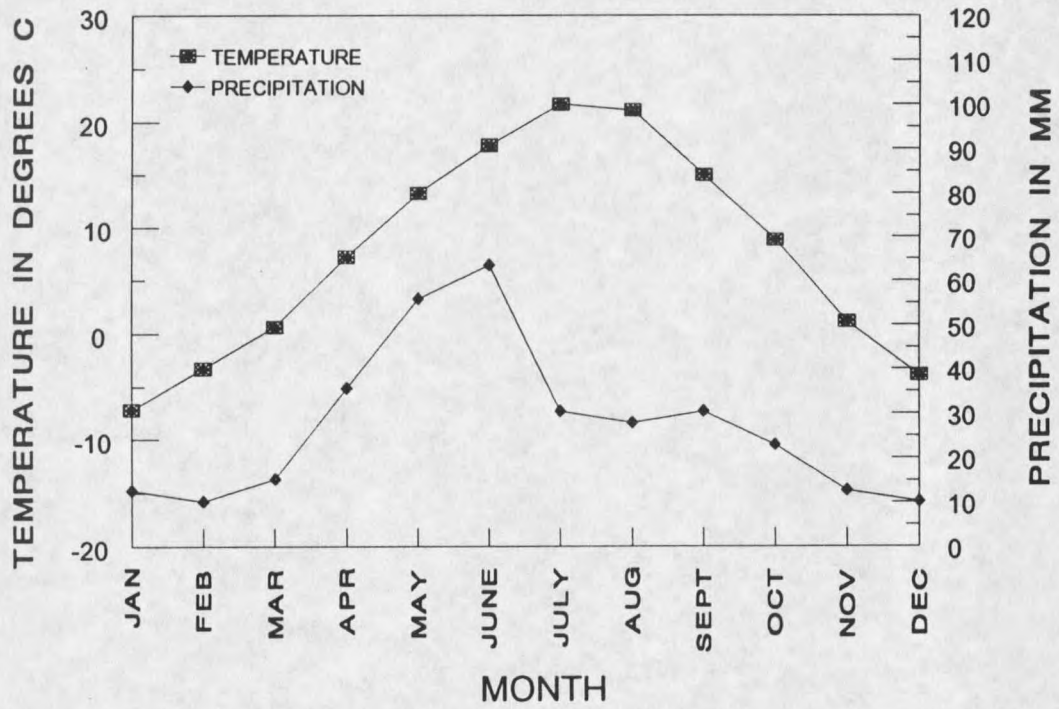


Figure 4. Mean monthly temperature and precipitation on the Ashland study area (MAPS).

METHODS

Forage Succulence

During the summer of 1990, vegetation clipping sites were established on 1 sagebrush-grassland site and 1 mesic site on each study area. I selected sites that appeared to best represent vegetation across the study areas. The Boxelder sites were located less than 1 km from each other along Park Creek (Fig. 1). Clipping sites on the Ashland area were about 12.5 km apart (Fig. 3) because the southern portion contains more mesic vegetation while the northern portion contains more sagebrush. Additionally, I moved the sagebrush-grassland site (northernmost site) on the Ashland area about 1.5 km after the first clipping because I felt the new location was more representative of the area.

Each clipping site consisted of two 25 m transect lines. All forbs and grasses in five 2x5 dm plots along each transect line were clipped biweekly to a height of approximately 2 cm. This resulted in 10 total plots from each clipping site. Plots were spaced 4.7 m apart, and locations were shifted 4 dm at each clipping to avoid clipping the same spot more than once.

To assess the characteristics of the lushest forage available to deer, beginning in July I clipped 5 plots in the most succulent appearing vegetation on each study area. I refer to these plots as "reference plots". On the

Boxelder area, reference plots were on small bends along Park Creek that were too small to run a transect line. On the Ashland area they were located in a dry creek bed adjacent to the sagebrush-grassland site. All reference plots were clipped within 1 km of transect lines.

Forbs clipped from the 10 plots on each clipping site were combined; grasses were also pooled. Reference plots were treated in the same manner. This resulted in one sample each of forbs and grasses from the mesic site, the sagebrush-grassland site, and the reference clippings for each study area. Fresh weights and dry weights were determined for each sample. Dry weights were measured after oven drying at 90° C (Milner and Hughes 1968) for 24 hours to remove all moisture. Forage succulence (percent moisture) was determined by dividing the difference between fresh and dry weights by fresh weight.

Fecal Nitrogen

Fecal pellets were periodically collected from both study areas for analysis of fecal nitrogen (FN) content. Only pellet groups considered fresh, (moist appearance and texture) were collected. For convenience, I define "sample group" as a collection of fecal pellets from 5 different pellet groups.

During the summer, sample groups were collected near (<3 km) vegetation clipping sites and within 2 days

following clipping. Fecal collection near transects allowed a comparison between FN values and forage succulence of adjacent areas. Distance between clipping sites resulted in 2 sample groups from the Ashland area and 1 from the Boxelder area. To avoid mistakenly collecting domestic sheep droppings on the Boxelder area, no pellets were collected within 1 km of areas sheep were observed feeding. Beginning in August, a second sample group was collected from hayfields along Boxelder Creek where deer often were observed feeding. One additional sample group was collected in September from an irrigated hayfield on the Ashland study area.

Sample groups were collected during the winter from the same general areas as during the summer. Two sample groups were again obtained from each study area. Pellets from within the fenced area surrounding haystacks replaced those obtained from hayfields on the Boxelder area during the summer, but were only collected on 2 different occasions.

Throughout the study, pellets were obtained from deer of known sex or age whenever possible. This was done when deer were seen defecating, or when an animal was disturbed from a bed and fresh pellets were found. Age of males was estimated according to antler growth as yearling, 2-year old, or older. These samples were analyzed separately for nitrogen content.

Jenks et al. (1989) found no difference in nitrogen values between pellet groups analyzed separately and taking a mean value, or those obtained by combining equal amounts of each pellet group and making a single measurement. Therefore, after cleaning of foreign debris and air drying in paper bags, 2.0 gm from each pellet group in each sample group was ground with a mortar and pestle and combined into a 10.0 gm sample.

Nitrogen content is calculated on a percent weight basis. Thus, all fecal samples were simultaneously oven dried and sealed in plastic bags before being sent to the Montana State University Chemistry Station Analytical Laboratory for analysis by the Kjeldahl technique (Williams 1984). Moisture content of 2 random sample groups was obtained as an estimate of moisture content for all sample groups. Gross energy was determined by Parr Bomb method (Williams 1984) for several sample groups to determine if any seasonal trends were evident.

Physical Attributes Of Individual Deer

Seven deer were collected on the Boxelder area and 6 on the Ashland area during the 1990 hunting season. Kidneys with attached fat were removed and kidney fat index (KFI) was calculated according to the method described by Riney (1955). Both a combined KFI value for both kidneys (Anderson et al. 1972) and individual KFI for each kidney

were obtained. Field-dressed animals were weighed and aged according to tooth replacement and wear (Robinette et al. 1957).

Fecal and rumen samples were collected from each deer and analyzed individually for nitrogen content. Fecal samples were cleaned, dried, and analyzed as described above. Rumen samples were washed through a filter to remove endogenous nitrogen and retain only consumed forage. Forage samples were simultaneously air dried and analyzed separately by the Montana State University Chemistry Station Analytical Laboratory (Kjeldahl technique, Williams 1984). Percent moisture was obtained for 1 sample.

Twelve additional deer were collected during January 1991 when the MDFWP area biologist obtained a kill permit to alleviate deer depredation on a ranch about 45 km northwest of the Boxelder study area. Habitat of the ranch was similar to the Boxelder area. Weights, ages, kidney fat index, and fecal nitrogen values were obtained from these animals.

Classification Of Cover Types

Cover types on each study area were identified according to land use and type and quantity of observed vegetation. Differences in habitat types between the 2 study areas resulted in a distinct classification system for each one.

I separated the Boxelder study area into 2 zones and identified 6 cover types within each zone. Zone 1 (main drainage) consisted of all land within approximately 1 km of Boxelder Creek (Fig. 1), and was the largest continuous source of the most mesic vegetation on the study area. All area >1 km from Boxelder Creek was designated zone 2 (upland zone). Lengths of all creeks were measured on 1:24000 U S Geological Survey (USGS) topographic maps with a cartometer.

The Ashland area was not separated into zones. All cover types identified could have occurred anywhere on the study area.

Capture of Deer

During February 1991, 57 deer were captured by helicopter drive-netting (Beasom et al. 1980) on the Ashland and Boxelder study areas. Telonics model 500 radio transmitters with mortality sensors and individually recognizable neckbands were fitted on 25 females $\geq 1 \frac{1}{2}$ years of age. All remaining females, including fawns, were marked only with individually recognizable neckbands. Fawn neckbands were made to expand as the animal grew by stapling adult-size neckbands to a smaller circumference. These staples pulled out as the animal's neck became larger. All deer caught, including males, received metal eartags in both ears and were aged using tooth replacement and wear (Robinette et al. 1957).

Chest girth has been shown to provide a good estimate of live mass (Weckerly et al. 1987, Watkins et al. 1991). Girth was recorded for all fawns captured and used to estimate live weight according to Anderson et al. (1974). Eartag numbers, ages, and neckband identification symbols are listed in Appendix Table 18 and 19.

Visual Observations Of Marked And Unmarked Deer

I selected specific roads on each study area as routes for visual observations of deer (1 deer = 1 observation). Two survey routes were designated on each study area. Within the Boxelder area, 1 route was established in each zone. These routes were alternately driven except when weather made the route through the upland zone impassable. The occurrence of all identified cover types on both Ashland route made alternating routes less important, but this procedure was generally followed. Radio telemetry was not used in these surveys, but observations of marked animals were noted. Routes were driven within 2 hours after sunrise or during the last 2 hours before sunset.

Location, activity, sex and age when possible, and cover type used were recorded for every deer observed. Deer were classified as male, female, or fawn during the summer, and as adult or fawn during the winter. Activities were categorized as feeding, bedding, or traveling. Locations were recorded in Universal Transverse Mercator (UTM)

coordinates on USGS topographic maps. Cover types were for the specific microsite being used. Ground observations made in addition to those on survey routes were recorded in the same manner.

Aerial surveys, using a Piper Supercub, were flown for complete coverage on each area during fall 1990 and winter 1991. Surveys began approximately 1/2 hour before sunrise and were completed within 2 hours after sunrise. Flight paths generally followed drainages, a method similar to previous surveys flown by MDFWP biologists on these areas, and used elsewhere in Montana (Mackie et al. 1981). This method provided the best observability of all terrain, and reduced the chance of double-counting deer because they generally ran along the drainage when disturbed by the airplane. Complete coverage was obtained by flying more than 1 pass when width of the drainage or dense vegetation required closer coverage.

Location (UTM coordinates on USGS topographic maps), sex and age class when possible, and number of deer were recorded during aerial surveys. For flight observations on the Ashland area, cover types were the same as during ground observations. On the Boxelder area, I recorded deer in 3 general categories (Boxelder Creek, ephemeral streams, rest of area) because the large number of deer and disturbance from the airplane made it difficult to use the same cover types as for ground observations. The "Boxelder Creek"

category was identical to zone 1 used in ground observations. Aerial observations within 100 m of an ephemeral stream were categorized as "ephemeral streams", and any observations made on the rest of the area were listed as "rest of area".

Telemetry Relocations

I located marked deer using radio telemetry during complete aerial surveys and on specific relocation flights in May, July, and October 1991. Relocations were also made from the ground whenever time permitted. Ground relocations were considered valid when either visual contact was made or when triangulation from a half-circle indicated a specific point.

Deer had been previously marked on the Boxelder area during 1983-86, and on the Ashland area during 1986-87. Relocations of these animals (1601 relocations of 128 does on the Boxelder area, 522 relocations of 47 does on the Ashland area) were obtained from MDFWP area personnel (Steve Knapp, Greg Risdahl, pers. comm.). Current status of as many of these deer as possible was determined (Appendix Table 20).

Population Estimates

Population estimates (mark-recapture) were made on both study areas during late winter 1991. Each area was flown at

sunrise without the use of radios, counting total number of deer seen and noting any marked animals. After completing the survey, radios were used to determine if there were radio-marked deer on the study area that were not seen. The northern part of the Ashland area (Fig. 3) was divided into 2 sections with 1 section completed each day; the entire Boxelder area was surveyed on a single flight. Any neck-banded deer seen on the areas within 5 days before or after flights were included in the number of marked deer present. I observed little movement by deer at the time of year estimates were made, and assumed these deer were on the study area during the estimates. I also assumed that no movement occurred between the 2 sections of the Ashland area during the 2 day period. Population estimates for the same portion of the Ashland area were made for 1986-90 using relocations of deer marked during 1986-87.

Mortality

During May 1991, a deer mortality survey was conducted on a portion of the Boxelder study area that received heavy use by deer during the previous winter. Remains of deer that died during winter were generally found near ephemeral streams. Therefore, the survey searched areas adjacent to these streams. The proportion of the area searched was estimated by measuring the total length of survey routes with a cartometer on USGS 1:24000 topographic maps and

dividing by total length of all upland streams beds. Age and sex were determined, and femur marrow was examined for signs of malnutrition whenever possible. Remains of deer found during the course of other field work on both study areas were examined in the same manner. A survey of landowners was conducted on the Boxelder area to determine hunting mortality during the 1990 season. Neither survey was conducted on the Ashland study area.

Weather Conditions

Beginning in January, 1991, a thermograph and wind recorder were used to record minimum and maximum temperatures and wind speed on the Boxelder study area. The wind recorder was placed at a height of 1 m, the approximate height of a standing mule deer (Leckenby and Adams 1986). A precipitation gage was also set up, but use was abandoned after erroneous readings during windy conditions were noted. Weather data was recorded until mid July.

Analytical Methods

All statistical tests were made using SAS (SAS Institute 1987). Unless noted otherwise, *P*-values less than 0.05 were considered significant.

Forage Succulence And Fecal Nitrogen

Stepwise regression (SAS Institute 1987) with an entry-exit value of 0.20 was used to predict summer fecal nitrogen content from the 4 forage succulence values and time (Julian date). Only forage succulence values from transects and FN values from sample groups collected adjacent to the transects were used in regressions. Variance inflation factor (VIF) (Neter et al. 1985) was used to detect multicollinearity between factors. Any model with a VIF greater than 10.0 was rejected.

Certain biological criteria were required of acceptable regression equations. Regression models were required to have an intercept at or below any observed summer FN value so that higher FN resulted from an increase in succulence. Therefore, models containing only negative coefficients or those having larger absolute values of negative than positive coefficients were rejected.

Fecal nitrogen values were also graphed against time. A t-test was used to compare seasonal FN means between locations when graphs did not indicate declines over time, and when stepwise regression did not predict a decline due to forage succulence.

Physical Attributes Of Deer

A paired t-test was used to compare KFI values between pairs of kidneys and between a summed value from both

kidneys to each individual side. A paired t -test also was used to determine any difference between bare kidney weights. Correlation analysis was used to compare eviscerated weight to a summed value of bare kidney weights for each animal.

Simple linear regression was used to predict KFI from FN, and KFI from rumen forage nitrogen. Logarithmic or inverse transformations were used to account for curvilinear relationships. Because body fat content of young deer is confounded by growth (Anderson et al. 1990), KFI from animals <1 1/2 years were not used in these regressions. Deer collected in January were also excluded due to the decline of KFI values that occurs during the winter.

Anderson et al. (1974) determined no difference in weights between male and female fawns until 12-17 months of age. Therefore, after using a t -test to discern any difference in girth between sexes for each study area, fawn girth measurements were combined and a t -test was used to determine any difference in mean girth measurements between study areas. Girth measurements were used to estimate live weights according to Anderson et al. (1974).

Population Estimates

All population estimates were made using the computer program MRPE (Dan Gustafson, Montana State University Dept. of Biology, pers. comm.). MRPE calculates a maximum

likelihood estimate identical to the Lincoln index (Davis and Winstead 1980), a median, and an unbiased estimate of population size. It also can compute the probability that one population estimate is larger than either another estimate or a fixed value. Confidence intervals are based on the Bayesian approach (Johnson 1977).

Use of Cover Types

All ground observations of deer were used to calculate percent use by activity in each cover type on a monthly basis for both study areas. Because field work was completed shortly after deer were radio-collared, all telemetry locations from the ground that included visual contact were included in these calculations. Aerial observations were used to estimate percent use of cover types for each flight.

Chi-square analysis was used to compare cover type use between summer and winter. Air and ground observations were separately determined on the Boxelder area; only ground observations were used in chi-square analysis for the Ashland area because flight data were inadequate for comparison. Seasonal differences in deer use of zones was also tested on Boxelder. Requirements of chi-square analysis (Siegel 1956) were met by combining cover types when appropriate.

March and September observations were included in winter and summer observations, respectively. Any observed differences during March and September that may be associated with a change in season were described qualitatively.

Availability of cover types was not measured, so use versus availability was not determined. Comparisons are presented to show general trends on the study areas, and for general comparisons with findings of studies in similar habitats elsewhere.

Home Ranges

Relocations obtained during this study were combined with those obtained from previously-marked deer to estimate minimum convex polygon home ranges (Mohr 1947) and average activity radii (Robinette 1966) using the computer program TELDAY (Lonner and Burkhalter 1986). Relocations were plotted to determine seasonal movements.

Estimates of home range size generally increase as the number of relocations increase (Jenrich and Turner 1969), and the closer relocations occur in time, the less likely they are to be independent (White and Garrot 1990). Deer marked by MDFWP during 1983-87 were used to determine observability of deer during aerial surveys. Flights were generally flown on 2 consecutive days during most months of that study. Some deer were located both days; others were

located only when radios were used. This resulted in the same number of relocations for some deer in 6 different months as for other animals in 12 different months. Deer with 12 relocations over 12 different months would provide a better estimate of home range size than deer with 12 relocations over 6 months. To avoid any bias in home range estimates due to the timing and number of relocations obtained during the observability study, the number of different months in which relocations were made (rather than total number of relocations) was analyzed for a correlation to home range size estimated for each deer. Animals with fewer relocation months were consecutively deleted until a *P*-value greater than 0.10 was reached. Only those animals remaining were used to calculate mean values, but all relocations of these deer were used for estimates. This method was used for each time period a home range estimate was obtained. A *t*-test was used to compare mean home range size between years.

Ephemeral streams on Boxelder generally flowed in a north-south direction; those on Ashland were more variable. To determine if home range shapes followed drainages, a paired *t*-test was used to compare the standard deviation in the north-south direction to the east-west direction for home range estimates.

Dates for all seasonal and annual home range estimates are based on movements of animals. Hamlin and Mackie (1989)

found no difference in life home range size after 29 relocations were made over 24 consecutive months. This same time period was used for lifetime estimates on these 2 areas, although the minimum number of relocations was dependent on the method described above.

Weather

Minimum and maximum daily temperatures measured during the winter on Boxelder were compared to NOAA weather stations at Broadus, Ridgeway, and Albion, Montana. Simple linear regression was used to determine which station provided the best prediction (highest R^2) of temperatures on the study area.

RESULTS

Succulence and Dry Weight of ForageBoxelder Study Area

Moisture content of all forage from the Boxelder transect lines was highest during the first clipping in June (Fig. 5 and 6, Appendix Table 21). Succulence declined thereafter with only a slight upward shift at the end of summer.

Moisture in forbs on the sage site declined faster than the creek site and was lower in all but 1 clipping. Reference clippings were consistently higher in moisture content and generally exceeded both transects.

Grass was consistently more succulent on the creek than sage transect. However, clippings from reference plots had higher moisture content than either transect during all sampling periods. Succulence of all 3 types of grass clippings reached their lowest values on the same date.

Average dry weight of grass on the sage site increased from the first to second clipping before remaining fairly constant the remainder of the summer (Table 1). On the creek site, grass weight increased over the first 3 clipping

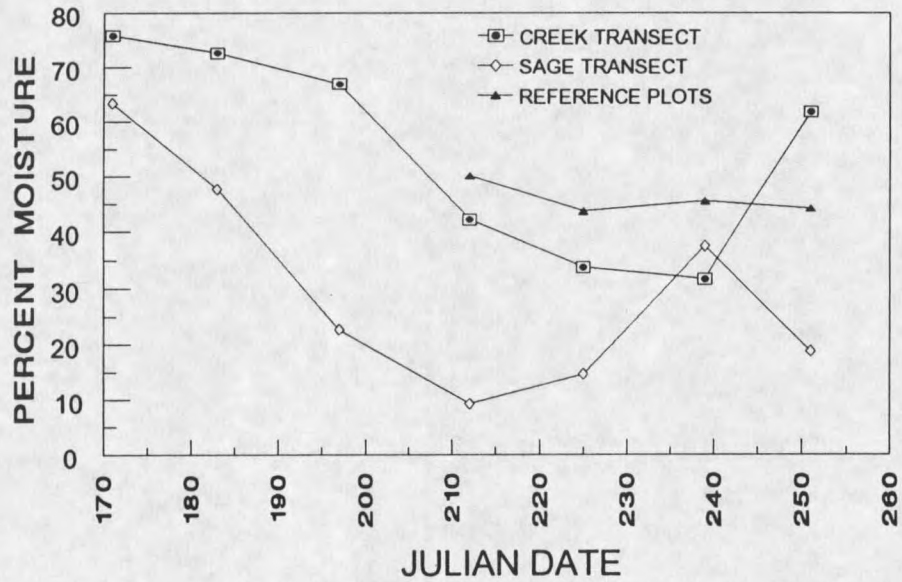


Figure 5. Average moisture content (%) of forbs from plots clipped on the Boxelder study area.

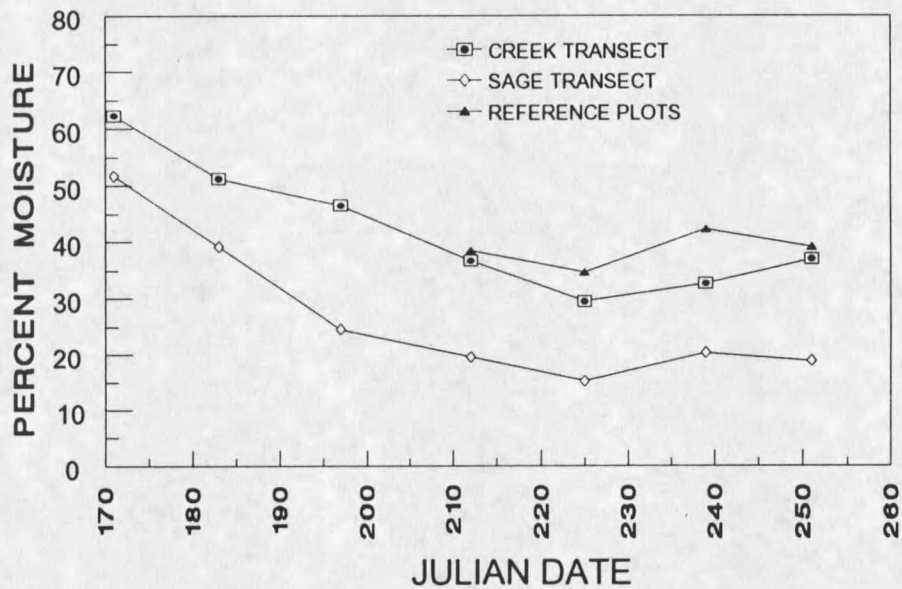


Figure 6. Average moisture content (%) of grass from plots clipped on the Boxelder study area.

periods and then declined. This decline was concurrent with use of the pasture by cattle. Average dry weights from the reference plots also declined from the first to last clipping. Overall, average dry weights were greatest for the reference site, followed by the creek and sage site.

Table 1. Average dry weight (grams) of grass and forbs for clipping sites on the Boxelder study area. Sage and creek sites are averages for 10 plots, reference site is the average for 5 plots.

Julian date	Grass			Forbs		
	Sage	Creek	Reference	Sage	Creek	Reference
171	5.12	18.84	--	1.91	5.77	--
183	9.08	23.41	--	1.39	5.67	--
197	8.99	28.16	--	0.41	3.57	--
212	7.91	22.80	24.04	0.35	2.35	6.24
225	9.26	19.65	22.12	0.35	0.65	5.80
239	7.71	17.48	19.08	0.10	0.65	2.74
251	7.90	18.23	19.34	0.13	0.34	3.18

Average dry weight of forbs on transect lines showed the same trend as grass; an early increase followed by a decline the remainder of the summer. Forb weight on the creek transect was greater than the sage transect in every

case. However, reference plots were greater than both transects in every period they were collected.

Ashland Study Area

Moisture content of all forage on the Ashland area declined through the summer similar to the Boxelder area (Figures 7 and 8, Appendix Table 21). However, little if any increase in succulence occurred at the end of summer at Ashland. For both grass and forbs, moisture content of the sage transect declined faster and was always lower than the creek transect. Forage succulence was always higher on reference plots than on the adjacent sage transect, but percent moisture was often greater on the creek transect than reference plots.

Percent moisture of grass and forbs on Ashland were initially higher than corresponding values at Boxelder. Thereafter, percent moisture of grass from the creek transect remained higher through summer at Ashland, whereas succulence of both forbs and grass from the sage transect were generally higher at Boxelder. Succulence of forbs from the creek transect and reference plots were fairly comparable between the 2 study areas except for an increase

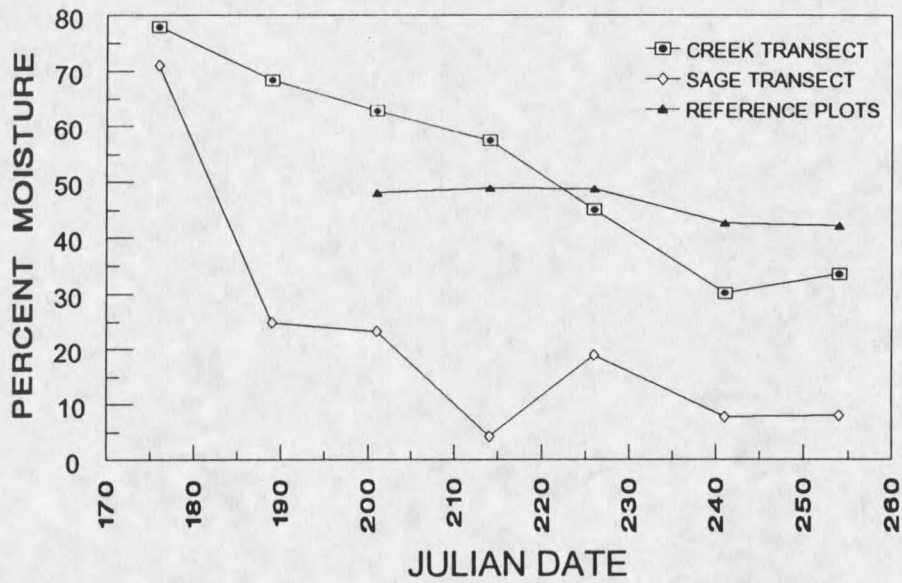


Figure 7. Average moisture content (%) of forbs from plots clipped on the Ashland study area.

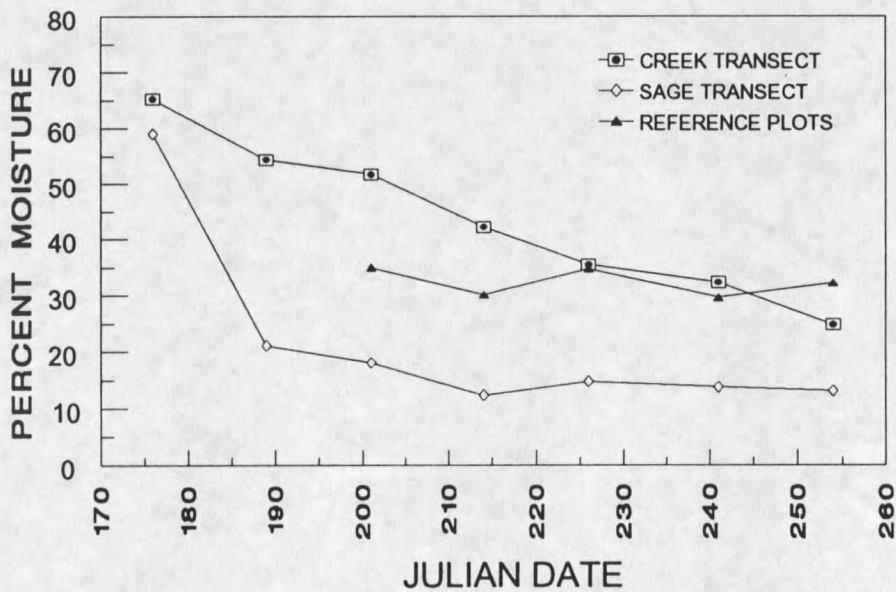


Figure 8. Average moisture content (%) of grass from plots clipped on the Ashland study area.

in succulence of forbs from the creek site on Boxelder during the last clipping.

Average dry weight of grass and forbs from reference plots were generally greater than either transect (Table 2). Weights of forbs were greater on the creek transect than on the sage transect, but weights of grass were similar for both.

Table 2. Average dry weight (grams) of grass and forbs for clipping sites on the Ashland study area. Sage and creek sites are averages of 10 plots, reference site is the average of 5 plots.

Julian date	Grass			Forbs		
	Sage	Creek	Reference	Sage	Creek	Reference
173	9.78	6.94	--	0.09	2.42	--
189	13.67	10.87	--	0.71	2.57	--
200	10.40	11.50	9.94	0.23	2.22	4.02
214	12.83	11.58	15.44	0.55	3.60	6.06
227	11.52	10.09	14.58	0.34	3.24	2.48
241	9.59	9.83	16.58	0.12	1.34	4.80
253	8.56	11.41	14.36	0.16	0.97	2.44

Average dry weight of grass from the sage transect at Ashland was always greater than the corresponding transect at Boxelder, whereas grass from the creek transect was

greater at Boxelder. Weights of forbs from creek transects were greater at Boxelder the first half of the summer and then declined to a point lower than Ashland the second half. All reference clippings were greater on Boxelder except for one instance of forbs.

Fecal Nitrogen Content During Summer

Boxelder Study Area

FN content from the Park Creek collection area on Boxelder generally declined throughout the summer, from 3.5% at the initial collection in June (day 171) to 1.7% at the second to last collection (day 239) in August (Fig. 9, Appendix Table 22). FN in hayfield samples declined from 2.8% on day 219 to 2.3% on day 251.

Pellets from 4 deer of known sex and age were collected during the summer. Fecal samples from 2 yearling bucks collected along Park Creek on days 239 and 242 had nitrogen values of 2.1% and 2.2% respectively. Pellets collected from 2 fawns, one from Park Creek on day 212 and the other from a hayfield on day 251, both had a FN content of 2.7%.

Stepwise regression predicted FN values at the Park Creek site on Boxelder with the following model:

$$Y=1.71+(0.087 \text{ S-grass})-(0.045 \text{ S-forbs}), \quad R^2=0.93.$$

Factors are expressed in percent moisture where S-grass and

S-forbs equal moisture content of grass and forbs from the sage clipping transect respectively. The variance inflation factor was less than 10 (VIF=5.75). The model passed all biological criteria with the intercept at or lower than all observed FN values and the absolute value of the positive factor was greater than the negative one.

Ashland Study Area

FN content in samples from the Coal Bank Creek site on the Ashland study area varied between 2.0% and 2.7% throughout summer. For the Hole-in-the-Wall (HIW) site, FN ranged between 2.0% and 3.0% (Fig. 10, Appendix Table 22). Little if any seasonal decline was noted at either location.

A sample from an adult male near the HIW site had a FN value of 3.2%. Collection of a sample group from an irrigated hayfield near the HIW site on day 241 contained 2.9% nitrogen.

Regression analysis did not provide an acceptable prediction of FN on the Ashland study area, either for collection areas individually or by using a mean value from both sites. Combining FN values from the 2 collection sites into a single data set did not provide an acceptable model either. Because FN from the 2 sites did not decline during summer, they were compared with a t-test. Mean FN content

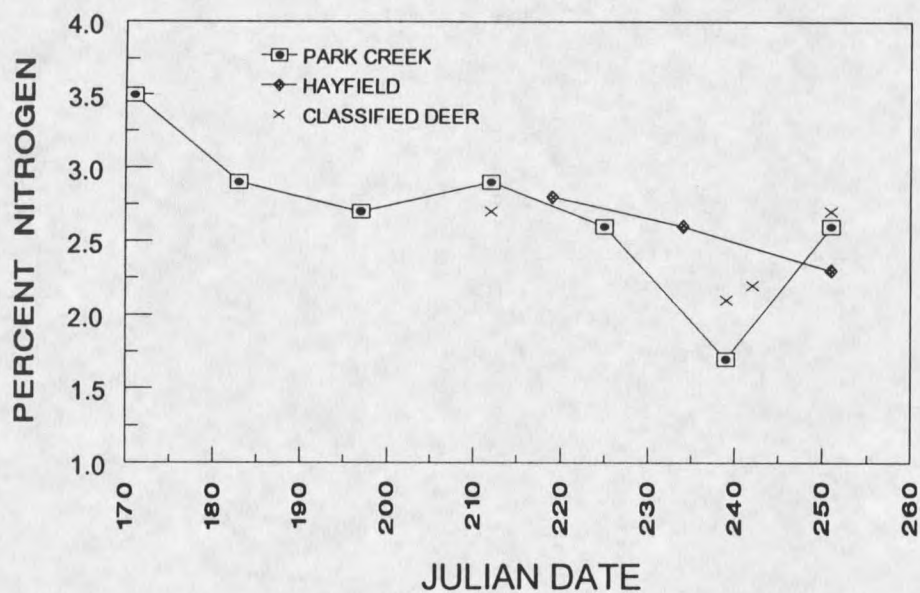


Figure 9. Percent nitrogen of fecal samples collected during summer on the Boxelder study area.

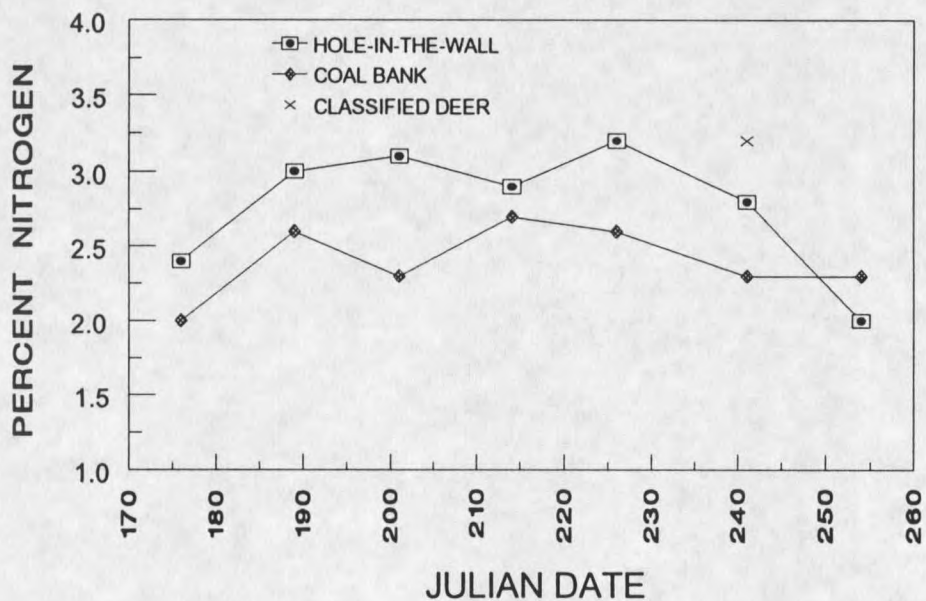


Figure 10. Percent nitrogen of fecal samples collected during summer on the Ashland study area.

from the HIW site was not significantly greater than the CB site at the 0.05 probability level ($P=0.069$).

Fecal Nitrogen Content During Winter

Boxelder Study Area

FN content of sample groups collected during winter on the Boxelder study area showed little variation. Samples from the Park Creek collection site ranged from 1.2 to 1.4% nitrogen, and the 2 sample groups from the haystack site had identical values of 2.2% (Fig. 11, Appendix Table 22). The low number of haystack samples precluded a statistical comparison between the 2 sites.

Ashland Study Area

Winter sample groups from Ashland showed more variation in FN content than Boxelder, ranging from 1.4 to 1.9% nitrogen on both the north and south collection sites (Fig. 12, Appendix Table 22). All FN values from the Ashland samples matched or exceeded those from Park Creek, but were less than FN values from haystacks on the Boxelder area. There was no significance difference ($P=0.754$) in percent FN between the two Ashland sites, but FN was significantly greater ($P<0.05$) on both Ashland sites than the Park Creek site on Boxelder.

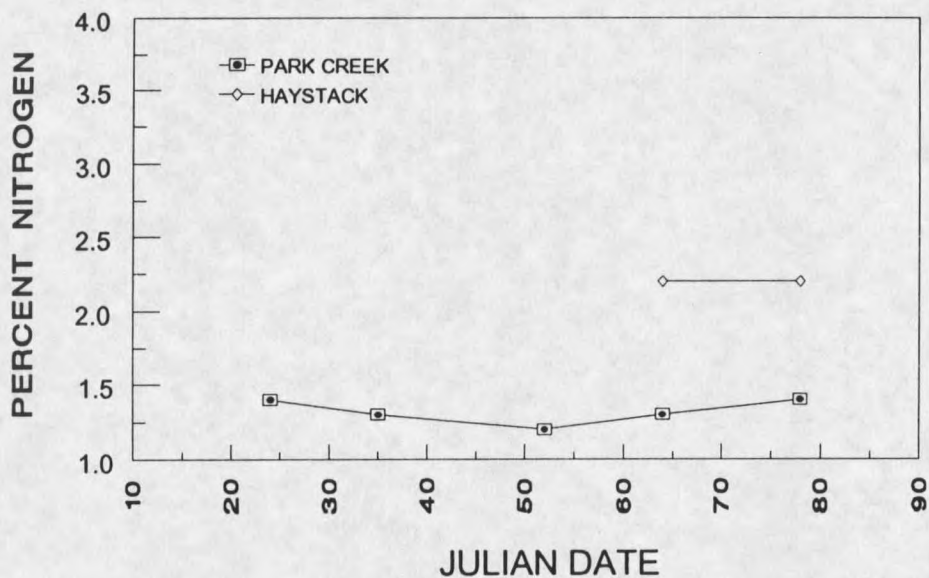


Figure 11. Percent nitrogen of fecal samples collected during winter on the Boxelder study area.

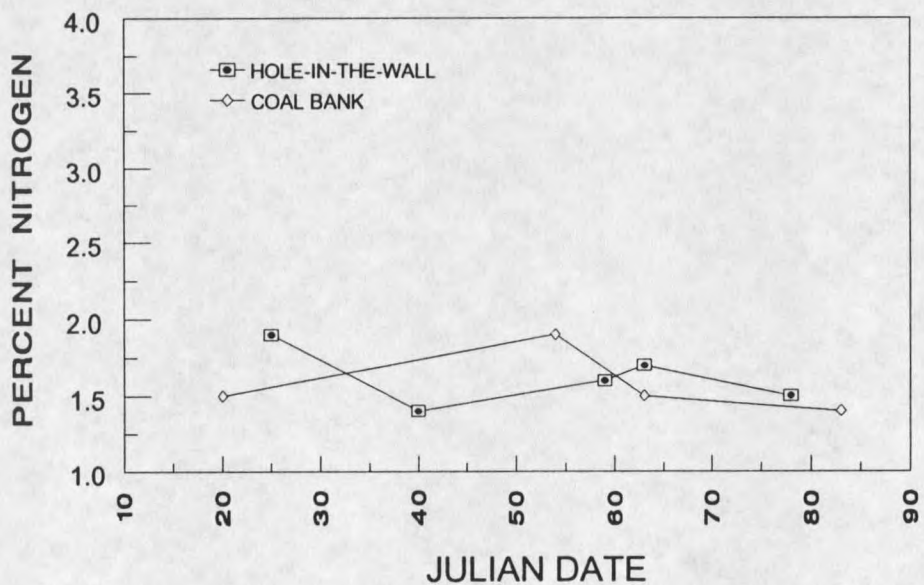


Figure 12. Percent nitrogen of fecal samples collected during winter on the Ashland study area.

Gross Energy and Moisture Content of Fecal Samples

No trend was observed in gross energy for the 5 fecal sample groups analyzed (Appendix Table 23). Gross energy for the Park Creek samples was highest in September and lowest in March, with the same value for June and February. The single hayfield sample had a lower energy level than the Park Creek sample for the same date.

Moisture content of 2 randomly selected fecal sample groups collected for FN analyses was 4.3% and 4.8%. All FN values in tables, figures, and text are reported for an "as is" basis and are not adjusted for moisture, but were handled the same and should be of similar moisture content. Adjusting FN values to a dry weight basis according to the amount of moisture found in the 2 random samples would raise all values by approximately 0.1%, with little if any increase in reported values due to round-off error.

Attributes Of Collected Deer

Fecal Nitrogen

FN in pellets of 7 animals collected during the hunting season on the Boxelder area ranged from 1.5 to 3.2% (Table 3). Deer #BE4, with the lowest FN content, was taken approximately 5 km from the main drainage near the head of Park Creek. All other deer were taken within 2 km of the main drainage. The average FN content for deer collected

during fall (2.3%) was lower than all but 1 of the summer sample groups and higher than all winter values.

Samples from 2 additional animals were collected during the winter. A yearling doe that died during drive-netting near the head of Park Creek on day 43 had a FN value of 1.5%, and a 2 1/2 year-old male found shot along Boxelder Creek on day 82 had a FN value of 2.8% (Table 3). By comparison, fecal sample groups collected from Park Creek on similar dates during the winter had FN values of 1.3% and 1.4%, respectively.

Table 3. Sex, age, eviscerated weight in kg (lbs), fecal and rumen forage nitrogen (%), and kidney fat index (KFI) of deer collected on the Boxelder study area during fall and winter 1990-91.

Collection period			Characteristics			
ID#	Sex	Age	Weight	Fecal N	Rumen N	KFI
Hunting Season						
BE1	M	2 1/2	286	3.2	2.05	241.2
BE2	F	1/2	70	2.5	1.74	4.3
BE3	F	1 1/2	200	2.1	1.95	221.9
BE4	F	3 1/2	200	1.5	1.20	63.5
BE5	F	1/2	48	2.8	2.08	4.2
BE6	F	1/2	84	1.9	--	5.5
BE7	F	1 1/2	196	2.1	1.71	161.3
Winter						
BE8	F	1 1/2	--	1.5	--	61.9
BE9	M	2 1/2	--	2.8	2.34	24.1

FN percentages for deer collected during the hunting season on the Ashland area ranged from 1.5 to 2.0% with an average of 1.7% (Table 4). The average was lower than any summer composite for the Ashland area. All animals except AS1 were taken within 2 km of each other on the same date. AS1 was collected 2 weeks earlier in a different location on the study area, but all were taken from habitats containing a mixture of pine-grass and juniper cover types.

Table 4. Sex, age, eviscerated weight in kg (lbs), fecal and rumen forage nitrogen (%), and kidney fat index (KFI) of deer collected on the Ashland study area during fall 1990.

ID#	Sex	Age	Weight	Fecal N	Rumen N	KFI
AS1	M	1 1/2	191 (87)	1.7	1.42	155.6
AS2	F	7 1/2	187 (85)	1.5	1.03	14.6
AS3	F	1/2	106 (48)	1.6	0.97	23.0
AS4	M	1 1/2	200 (91)	1.5	0.89	81.6
AS5	F	3 1/2	191 (87)	1.6	1.07	31.4
AS6	F	2 1/2	183 (83)	2.0	1.26	33.9

FN from deer collected by permit at the end of January averaged 1.7% (1.5-1.8%) (Table 5). All deer were taken within 1 km of each other near a haystack.

Kidney Fat Index

Kidney fat index (KFI) for deer collected from the 2 study areas during the hunting season ranged from 4.2 to 241.2 (Tables 3 and 4). Adult males and yearling females

tended to have the highest KFI, and fawns were lowest. The single fawn from the Ashland area had a higher KFI than all 3 fawns from the Boxelder area.

Fawns collected in January (Table 5) had greater KFI than fawns collected on the Boxelder area in November, but lower than the single fawn from Ashland. Yearling males and females taken in January had lower indexes than comparable animals from both study areas in fall. No trend was noted for older animals.

Table 5. Sex, age, eviscerated weight in kg (lbs), fecal nitrogen (%), and kidney fat index (KFI) of deer collected during January 1991.

ID#	Sex	Age	Weight	Fecal N	KFI
KP1	F	2 1/2	205 (93)	1.6	12.1
KP2	F	>1 1/2	183 (83)	1.7	36.3
KP3	M	1 1/2	183 (83)	1.5	29.8
KP4	M	1 1/2	187 (85)	1.8	14.7
KP5	F	1/2	97 (44)	1.8	9.5
KP6	M	1 1/2	207 (94)	1.8	12.6
KP7	F	2 1/2	209 (95)	1.7	43.1
KP8	F	1/2	108 (49)	1.7	10.6
KP9	F	1 1/2	161 (73)	1.6	23.8
KP10	F	1 1/2	167 (76)	1.5	43.8
KP11	F	1/2	86 (39)	1.6	6.1
KP12	M	1/2	114 (52)	1.7	10.4

KFI values in Tables 3, 4, 5, are calculated from the summed weight of both kidneys and the associated fat. A comparison between bare kidney weights and KFI values for each side (Appendix Table 24) showed no difference in weights between left and right kidneys or between KFI calculated for each side ($P>0.05$). Also, no difference ($P>0.05$) was found between the summed value of KFI and each individual value. A positive correlation ($R^2=0.80$, $P=0.001$) was noted between the summed weights of both kidneys and eviscerated deer weights.

Rumen Forage Nitrogen

Percent nitrogen of rumen contents from deer taken on both study areas during November ranged from 0.89 to 2.08% (Tables 3 and 4). Nitrogen content of rumen forage from Ashland deer was less than all Boxelder deer except BE4. The single winter sample on Boxelder (BE9) exceeded all fall values. Species composition of rumen forage was not determined, but BE9 was noted to have a large amount of corn present.

FN increased curvilinearly as rumen forage nitrogen increased, with a log transformation of both variables providing the best fit for a regression (Fig. 13). FN and nitrogen content of rumen forage from deer collected on each study area were combined for this regression.

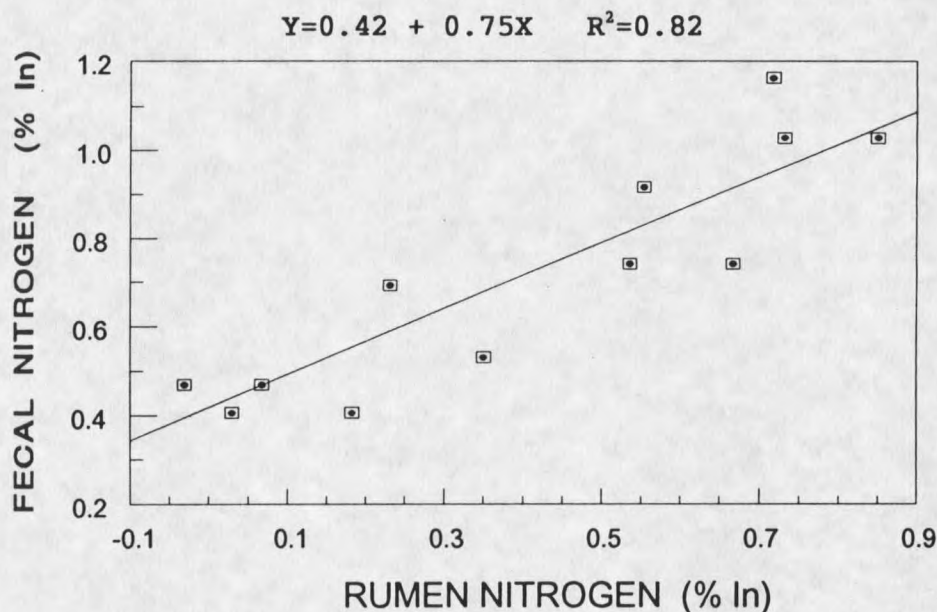


Figure 13. Regression of nitrogen content of rumen forage to FN for all deer collected on the Ashland and Boxelder study areas during fall 1990.

Data from adults collected during fall on each study area were combined and used to compare KFI to rumen forage nitrogen and KFI to FN. KFI increased linearly as rumen nitrogen increased (Fig. 14). KFI increased curvilinearly as FN increased, with an inverse transformation of FN providing the best fit of a regression (Fig. 15).

The single rumen sample analyzed for moisture contained 85.2% water. FN and rumen forage nitrogen used in tables and regressions are not adjusted for moisture. Intercepts and coefficients of regression equations would change when moisture weight is accounted for, but the relationship between variables would not be altered.

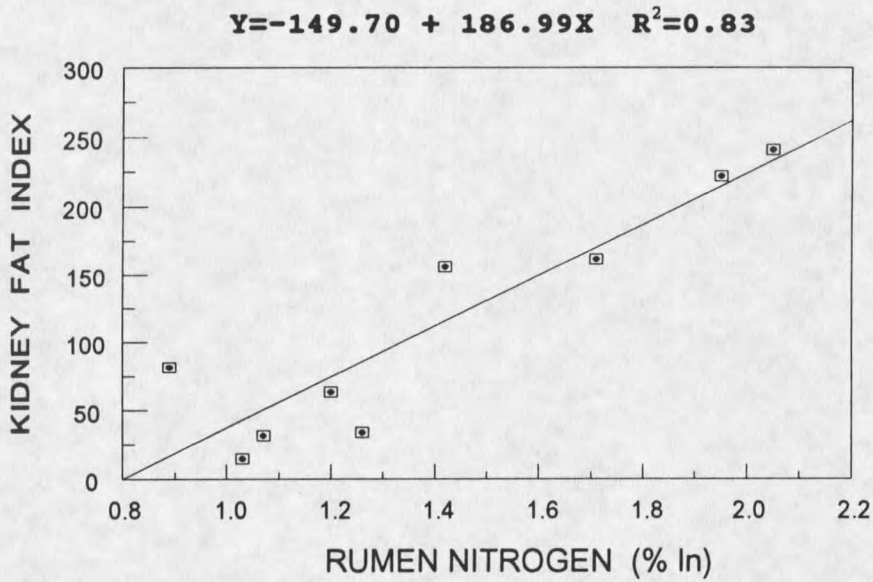


Figure 14. Regression of kidney fat index to rumen nitrogen for all adult deer collected on the Boxelder and Ashland study areas during fall 1990.

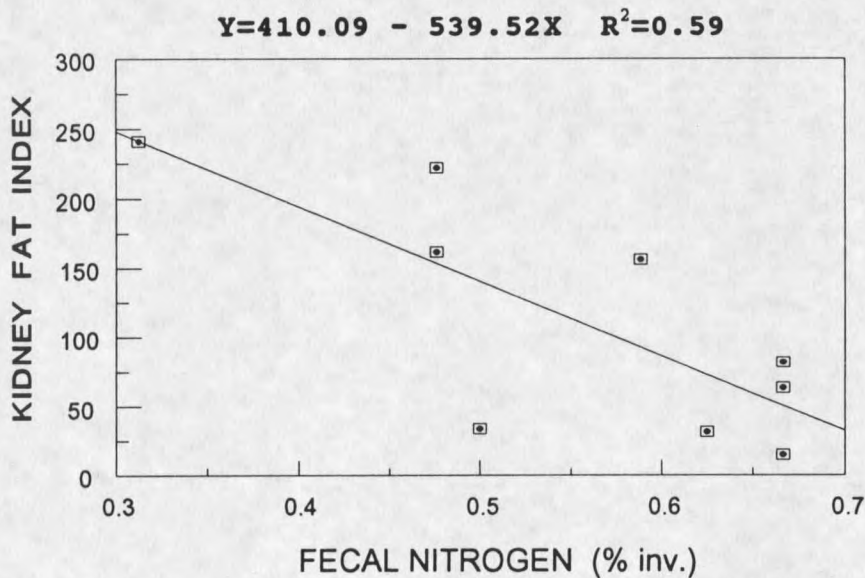


Figure 15. Regression of kidney fat index to fecal nitrogen for all adult deer collected on the Boxelder and Ashland study areas during fall 1990.

Girth Measurements

Girth measurements and corresponding estimates of bled carcass weights from 18 fawns captured during drive netting are listed in Appendix Table 25. The average girth measurement of fawns on the Ashland area ($\bar{x}=82.67$, $SD=6.44$) was significantly greater ($P=0.003$) than that for fawns from the Boxelder area ($\bar{x}=72.50$, $SD=4.32$). A comparison between males ($\bar{x}=82.57$, $SD=8.22$) and females ($\bar{x}=82.80$, $SD=3.56$) from the Ashland area showed no significant difference ($P=0.96$). Only 2 female fawns were captured on the Boxelder area, but no difference ($P=0.37$) was seen between males ($\bar{x}=73.75$, $SD=5.66$) and females ($\bar{x}=70.00$, $SD=3.77$).

Population Characteristics

Fawn Ratios

Observed numbers of fawns per 100 does increased during the summer on both study areas, with the highest ratios observed in September (Table 6). Ratios of fawns were higher on Boxelder than at Ashland throughout summer. In winter, numbers of fawns per 100 adults increased from January to March for both areas, with March ratios similar for the 2 areas.

Observations of bucks tended to fluctuate throughout the summer. The highest buck:doe ratios on each area were recorded in July and August, with ratios at Ashland exceeding those at Boxelder during both months.

Table 6. Monthly fawn ratios from air and ground surveys for the Boxelder and Ashland study areas. n includes unclassified animals.

Ratio Month	Location	
	Boxelder	Ashland
Buck:doe:fawn ratios		
June	34:100:0 (n=63)	20:100:0 (n=17)
July	44:100:35 (n=170)	86:100:14 (n=106)
August	66:100:73 (n=276)	57:100:43 (n=216)
September	34:100:98 (n=358)	39:100:77 (n=255)
Adult:fawn ratios		
January	100:23 (n=801)	100:22 (n=118)
February	100:51 (n=426)	100:27 (n=151)
March	100:56 (n=1331)	100:53 (n=89)

Population Estimates

The estimated population size for the Boxelder study area on 16 March 1991 was 865 deer (Table 7). This estimate was greater ($P < 0.05$) than all except 1 estimate made between 1983-1987 (Knapp 1987, MDFWP unpublished data). The single exception ($P = 0.09$) was an estimate of 750 made on 20 April 1983.

Table 7. Population estimates, standard deviation (SD), and confidence intervals (CI) for the Boxelder and Ashland study areas.

Location		95% CI		
Date	Estimate	SD	Low	High
Boxelder				
3/16/91	865	71.15	789	1036
Ashland				
*3/15/86	311	56.45	248	444
10/7/86	85	27.31	67	153
*12/14/86	133	84.25	82	333
10/20/87	217	98.46	138	456
12/26/87	278	--	102	2134
*2/27/88	253	48.19	210	373
*3/31/89	222	43.0	193	332
9/25/89	186	298.46	93	768
1/4/90	236	--	77	7949
*2/7/91	161	52.62	114	289

* = dates used for comparison of population estimates

Population estimates on the Ashland area ranged from 85 to 311 deer (Table 7). The 5 dates in Table 7 indicated by an asterisk are for time periods excluding the hunting season and are for periods when seasonal migratory movements by deer would have had a similar influence on the number of deer present on the study area. These dates also exclude 2 times when the numbers of recaptured animals were considered too low to give a reliable estimate (Appendix Table 28). Probabilities of higher estimates between any 2 dates were

calculated for all possible combinations of these 5. The estimate of 15 March 1986 was greater than the estimate of 7 February 1991 ($P < 0.05$), while all other combinations were not significant ($P > 0.05$).

Mortality on Boxelder

The remains of 29 deer were found on the Boxelder study area between November, 1990 and May 1991. Four were fawns found during early November, with femur marrow depleted (red-gelatinous) in the single sample examined. Of 11 animals (8 fawns, 3 adults) found between January and March, marrow was depleted in all except 1 fawn.

Nine fawns and 3 adults were found in a spring mortality survey encompassing approximately 6% of the upland ephemeral streams. Marrow was not depleted in 2 adults, 1 of which was a previously radioed doe between 10 and 11 years old. The condition of 1 fawn was not determined because neither femur was found.

Two deer captured in February 1991 died during this study. One was found during May with depleted femur marrow, the other was found dead during July. The doe found in July had been alive during the May relocation flight, and condition of the carcass indicated it had probably died about the beginning of July. At least 2 marked deer were shot during the 1991 hunting season.

Approximately 122 deer (59 bucks, 63 does) were killed on the study area during the 1990 hunting season (pers. comm. with landowners). The estimates obtained from landowners were said to be typical of most years. The 7 deer used in this study are not included in these totals.

Mortality at Ashland

Three carcasses were found on the Ashland study area. One was a fawn found dead of unknown causes in August, and the other 2 were adults found during the winter. One of the adults was a 9 1/2 year-old female (previously radio-marked in 1987) found close to a road, indicating a possible road-kill. Condition of femur marrow could not be made for these 3 deer.

Classification and Characteristics Of Cover Types

Cover types identified on the Boxelder and Ashland study areas are described in Tables 8 and 9 respectively. Cover types are specific for each study area, although similarities exist in certain types identified on both. For example, the riparian type on both study areas consists of land adjacent to creeks, but species composition and plant abundance was often greater for riparian cover on the Ashland area.

Classification of ephemeral streams on the Ashland area was based on vegetation within and along the stream bank.

Table 8. Cover types identified on the Boxelder study area.

Zone	
Cover type	Description
Zone 1 - main drainage	
Agriculture	About 370 acres of land cultivated for grain production.
Riparian	Mesic areas contiguous to Boxelder Creek containing hardwood trees and shrubs. Length of Boxelder creek through the study area is about 23.5 km., with an additional 17.4 km of short gullies adjacent to Boxelder Creek containing similar vegetation.
Grass-hay	1,450 acres of grass and alfalfa cut for hay. Approximately 200 acres are irrigated.
Haystacks	Haystacks and stack yards.
CRP land	About 100 acres in the conservation reserve plan. Except for Riparian, this type contained the tallest vegetation on the area.
Grass-1	Areas containing a mixture of grass and sagebrush.
Zone 2 - upland areas	
Mesic	Mesic areas along ephemeral streams and adjacent to stock ponds. Width 2-30 m. Length of creekbeds and short washes that feed them is about 227.2 km. Generally contains the tallest big sagebrush.
Tall sage	Areas not contiguous to creeks where big sagebrush is >45 cm and has >35% canopy coverage.
Short sage	Big sagebrush <45 cm tall, but still >35% canopy coverage.
Grass-2	Grass dominates, with <35% canopy coverage of shrubs. Includes grassy coulees on sides of buttes. Occasionally, fragrant sumac and yucca occur.
Greasewood	Scattered greasewood mixed with sagebrush, generally along the southeast portion of the study area.
Saltbush	Exposed ridges containing almost exclusively saltbush and bare ground.

Table 9. Cover types identified on the Ashland study area.

Cover type	Description
Agriculture	Grain and alfalfa fields along the Tongue River and Otter Creek. A small portion is irrigated.
Riparian	Uncultivated mesic areas along the Tongue River and Otter Creek.
Mesic-sage	Land along and within ephemeral streambanks through sagebrush-grassland. Mixed forbs, grass, snowberry, and occasional juniper may be present.
Mesic-pine	Ephemeral streams within areas containing ponderosa pine. Mixed forbs, chokecherry, snowberry, and pine usually occur.
Sumac	Open stands of fragrant sumac <15m in diameter surrounded by grass. Stands occur throughout the study area and contain from 1 to many plants.
Sagebrush	Various heights of big sagebrush with >35% canopy coverage. Grass also present.
Grass	Areas dominated by grass with <35% canopy of trees or shrubs. Includes grassy areas within sagebrush and meadows surrounded by pine. Alfalfa, yucca, and yellow sweet-clover may be present.
Pine	Dense stands of pine <12 cm diameter with little or no understory.
Pine-grass	Mature stands of Ponderosa pine with an understory of grass and forbs.
Juniper	Areas containing an overstory of >25% juniper. Ponderosa pine and big sagebrush also present.

Therefore, a stream could be classified by 2 different cover types over its entire length depending on surrounding vegetation.

Use Of Cover Types

Boxelder Study Area

Ground Observations. Deer were observed using all cover types except haystacks during summer (Table 10), with the main drainage zone accounting for 56% of the total number of observations. The mesic type received the greatest total use (25.8%); riparian, grass-hay, CRP land, and grass-2 all received >10% use. Less than 5% of all observations were made in each of the remaining cover types.

Ninety-one percent of feeding observations during summer were made in 4 cover types. Grass-hay was used most in August when the greatest number of feeding observations was made and also received the highest use in September. Riparian and mesic received the most number of feeding observations in July. In June, feeding observations were distributed about equally among 4 different cover types. The 100 acres of CRP land were consistently used throughout the summer with the highest use in August.

Mesic and grass-2 types received similar use for bedding, with 90% of the observations occurring in these 2 types. Many grass-2 observations were in grassy coulees on

Table 10. Mule deer cover type use (% of all visual ground obs.) by activity for each month and summer overall, 1990, on the Boxelder study area.

Zone	Month and activity												June-September total			
	Cover type ^a	June			July			August			September			All activities		
		F ^b	B	T	F	B	T	F	B	T	F	B	T	F	B	T
Main drainage zone																
AG	--	--	--	0.5	--	--	0.5	--	1.0	--	--	--	1.0	--	1.0	0.9
R	1.5	--	--	9.8	--	1.0	7.0	6.3	1.0	2.8	--	--	21.1	6.3	2.0	16.0
GH	2.3	--	--	2.0	--	2.0	21.2	--	4.9	5.1	--	5.9	30.6	--	12.7	23.9
CRP	2.0	1.6	--	3.5	--	--	13.1	--	3.9	--	--	--	18.7	1.6	3.9	14.1
HS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G1	--	--	--	--	--	--	1.5	--	--	--	--	--	1.5	--	--	1.1
Upland zone																
M	2.3	25.4	12.7	11.9	11.1	3.9	6.8	9.5	15.7	--	--	--	21.0	46.0	32.4	25.8
SS	--	--	--	0.5	--	7.8	--	--	1.0	1.8	--	--	2.3	--	7.8	3.0
TS	--	--	--	0.3	1.6	6.9	--	--	2.0	--	--	--	0.3	1.6	8.8	2.0
GW	--	--	--	--	--	2.0	--	--	--	--	--	--	--	--	2.0	0.4
G2	--	--	--	1.0	17.5	9.8	0.3	27.0	14.7	2.3	--	--	3.5	44.4	24.5	11.9
SLT	--	--	1.0	--	--	--	--	--	3.9	--	--	--	--	--	4.9	0.9
N=	32	17	14	117	19	34	200	27	49	47	0	16	396	63	102	561

56

^a AG= Agriculture, R= riparian, GH= grass-hay, CRP= land in CRP program, HS= haystacks, G= grass, M= mesic, SS= short sage, TS= tall sage, GW= greasewood, SLT= saltbush. See Table 8 for complete description of cover types.

^b F= feeding, B= bedded, T= traveling.

the sides of buttes. Overall, observations of bedded deer occurred in fewer cover types than of feeding or traveling deer.

Frequencies of observations in each cover type were significantly different ($X^2=690$, $P<0.001$) between winter (Table 11) and summer, as were numbers of observations in each zone ($X^2=321$, $P<0.001$). The upland zone accounted for 85% of the total winter observations. All cover types in this zone received greater use than the most used cover type in the main drainage zone.

The grass-2 cover type received the largest number of feeding observations during February and March as well as the greatest total number of winter feeding observations. However, 91% of all deer observed feeding during February were seen the last week of the month. Haystacks received the greatest use in January.

Mesic and grass-2 were important types for bedding, both in winter and summer. These 2 cover types accounted for just over half the bedded observations during the summer and over 90% during winter. Most other observations of bedded deer occurred in tall sage, greasewood, and saltbush types.

March observations occurred in a greater diversity of cover types and activities than recorded for any other winter month. Use of cover types in the upland zone accounted for this increase, because the number of

Table 11. Mule deer cover type use (% of all visual ground obs.) by activity for each month and winter overall, 1991, on the Boxelder study area.

Zone Cover type ^a	Month and activity									January-March total			
	January			February			March			All activities			
	F ^b	B	T	F	B	T	F	B	T	F	B	T	
Main drainage zone													
AG	--	--	--	2.2	--	--	3.3	--	--	5.5	--	--	2.5
R	0.4	--	0.9	1.8	--	--	--	--	--	2.2	--	0.9	1.2
GH	2.4	--	--	--	--	--	--	--	--	2.4	--	--	1.1
CRP	--	0.2	--	3.9	--	4.4	0.2	--	--	4.0	0.2	4.4	2.7
HS	8.4	--	--	1.8	--	--	1.3	1.1	--	11.6	1.1	--	5.6
G1	3.7	--	--	0.6	--	--	--	--	--	4.2	--	--	1.9
Upland zone													
M	2.2	2.7	--	4.2	21.9	5.3	6.2	9.8	5.7	12.7	34.4	11.0	20.2
SS	5.3	--	16.2	2.8	--	3.5	4.0	--	13.2	12.1	--	32.9	11.6
TS	--	--	--	--	9.1	--	7.2	17.8	19.3	7.2	26.9	19.3	16.6
GW	--	--	--	--	--	--	0.6	8.4	14.4	0.6	8.4	14.5	6.0
G2	3.1	4.6	--	16.5	8.0	2.2	10.3	7.5	14.9	30.0	20.1	17.1	23.9
SLT	--	--	--	6.6	--	--	1.1	8.7	--	7.7	8.7	--	6.6
N=	139	33	39	220	171	35	186	234	154	545	438	228	1211

^a Ag= agriculture, R= riparian, GH= grass-hay, CRP= land in CRP program, HS= haystacks, G= grass, M= mesic, SS= short sagebrush, TS= tall sagebrush, GW= greasewood, SLT= saltbush. See Table 8 for complete description of cover types.

^b F= feeding, B= bedded, T= traveling.

combinations of types and activities recorded in the main drainage zone decreased in March. Only 2 of the possible use-type combinations were not observed in the upland zone during March, compared to 12 and 8 for January and February respectively.

Flight Observations. Flight data showed a similar seasonal distribution of deer in relation to drainages as ground observations (Table 12), with significant differences ($X^2=489$, $P<0.001$) between survey dates. The greatest number of observations along Boxelder Creek occurred in September, and the fewest seen during March when deer dispersed from Boxelder Creek to the upland zone.

Table 12. Percent of mule deer observed in each of 3 areas on the Boxelder study area during complete coverage aerial surveys.

Location	Date		
	Sept. 90	Jan. 91	March 91
Boxelder creek	31.1	5.6	2.4
Ephemeral streams	56.4	77.8	41.3
Rest of area	12.5	16.6	56.3
N=	305	590	757

Weather conditions during the January flight were sunny, with light wind and temperatures ranging from -21°C (-6°F) along Boxelder Creek to -26°C (-15°F) on the ridge

forming the southeast boundary of the study area. Over 5 cm of snow had fallen the previous day. Many deer were observed bedded and partially covered by snow, indicating they had not moved since the snow stopped falling the previous evening. Weather during the September flight was overcast and breezy with mostly brown groundcover. The March flight was conducted under sunny conditions, with temperatures of -1°C (30°F), and about 3 cm of new snow on the ground.

Ashland Study Area

Ground Observations. At least 1 observation was recorded for each cover type on the Ashland area during the summer (Table 13). The greatest total use for all activities was recorded in the mesic-sage type; riparian received the least ($<1\%$).

Agriculture cover type received the most feeding observations during the summer with 29%. Most of these occurred in August, with 12% of all feeding observations recorded 1 night when a full moon made it possible to observe animals after dark. The grass type became important for feeding in September. Fragrant sumac and mesic-sage cover types were consistently used by deer for feeding throughout the summer.

Bedded deer were seen most often in the pine cover type during summer, followed by mesic-sage, juniper, and

Table 13. Mule deer cover type use (% of all visual ground obs.) by activity for each month and summer overall, 1990, on the Ashland study area.

Cover type ^a	Month and activity												June-September total			
	June			July			August			September			All			
	F ^b	B	T	F	B	T	F	B	T	F	B	T	F	B	T	activities
P	--	1.1	--	--	0.8	0.6	--	0.2	--	--	0.2	--	--	2.3	0.6	3.0
PG	--	0.2	0.4	1.9	0.4	1.5	1.5	0.2	1.5	--	--	--	3.4	0.8	3.4	7.6
AG	0.2	--	--	0.8	--	--	10.6	--	0.8	3.8	--	0.4	15.5	--	1.3	16.8
FS	1.5	--	--	2.8	0.2	0.2	3.6	0.2	0.4	1.1	--	--	8.9	0.4	0.6	10.0
R	--	--	--	0.2	--	--	--	--	--	--	--	--	0.2	--	--	0.2
MS	--	--	0.2	3.0	0.2	1.5	5.9	1.1	0.6	1.3	--	11.7	10.2	1.3	14.0	25.5
MP	--	--	--	1.7	--	0.8	--	--	0.4	0.6	--	--	2.3	--	1.3	3.6
S	--	--	--	1.5	--	1.3	--	--	3.8	2.1	--	2.5	3.6	--	7.6	11.3
G	--	--	--	1.1	--	1.5	0.6	--	5.7	7.2	--	0.8	8.9	--	8.1	17.0
J	--	--	--	0.4	--	--	--	0.8	3.8	--	--	--	0.4	0.8	3.8	5.1
N=	8	6	3	63	8	35	105	12	81	76	1	73	252	27	192	471

^a P= pine, PG= pine-grass, AG= agriculture, FS= fragrant sumac, R= riparian, MS= mesic-sage, MP= mesic-pine, S= sage, G= grass, J= juniper. See Table 9 for complete description of cover types.

^b F= feeding, B= bedded, T= traveling.

pine-grass types. Pine was the only cover type in which deer were not seen feeding.

Deer were observed in only 5 of 10 cover types on the Ashland area during winter (Table 14). For the small sample observed, the grass type received the highest total winter use with all observations coming in March. Sagebrush ranked second and received consistent use each month.

Table 14. Percent of mule deer ground observations in each cover type during winter on the Ashland study area.

Cover type	Month			Season total
	January	February	March	
Pine	--	--	--	--
Pine-grass	3.5	--	2.6	6.1
Agriculture	--	1.8	--	1.8
Sumac	--	--	--	--
Riparian	--	--	--	--
Mesic-sage	--	--	--	--
Mesic-pine	--	--	--	--
Sagebrush	5.3	10.5	3.5	19.3
Grass	--	--	59.6	59.6
Juniper	0.9	--	12.3	13.2
N=	11	14	89	114

For a statistical comparison of relative use between seasons, riparian, mesic-sage, and mesic-pine types were combined in a general riparian category. Also, types in

which ponderosa pine dominated (pine and pine-grass) were combined, as were grass and fragrant sumac types. Use of all other types was kept separate. Using these combinations of cover types, observations occurred in all but 1 category or type, and all requirements for statistical testing were met. Chi-square analyses indicated a significant difference ($X^2=93$, $P<0.001$) in use of cover types between summer and winter (cover type seasonal totals, tables 13 and 14).

Flight Observations. Aerial surveys during September, January, and February indicated similar use (>30%) of the pine-grass cover type (Table 15). Mesic-sage and grass received more observations during September's flight; sage and juniper received more during January and February. Percent use of other cover types never exceeded 6.5% for any flight.

September flight data indicated greater use by deer of pine-grass and less use of agriculture and sumac types than summer ground observations, while use of mesic-sage was high for both. Use of other cover types was similar between September air observations and all summer ground observations.

In winter, air and ground observations were in the same 5 cover types, though frequencies of use were different. As in summer, both winter flights indicated greater use of pine-grass than ground observations. Use of sage was higher

in air survey data, with increased use from January to February.

Table 15. Percent of mule deer flight observations in each cover type on the Ashland study area.

Cover type	Date		
	September 90	January 91	February 91
Pine	--	--	--
Pine-grass	37.4	39.3	31.4
Agriculture	--	--	2.2
Sumac	--	--	--
Riparian	--	--	--
Mesic-sage	31.7	6.5	--
Mesic-pine	4.9	--	--
Sagebrush	5.7	19.6	54.0
Grass	17.1	6.5	4.4
Juniper	3.3	28.0	8.0
N=	123	107	137

Distribution, Movements and Home Ranges of Radio-marked Deer

Boxelder Study Area

Relocations during 1983-85 indicated radio-marked deer tended to move toward the main drainage between 15 July and 15 November (Fig. 16 and 17). Timing and pattern of movement varied by individual animal and year. Some deer moved >4 km to Boxelder Creek annually, whereas others

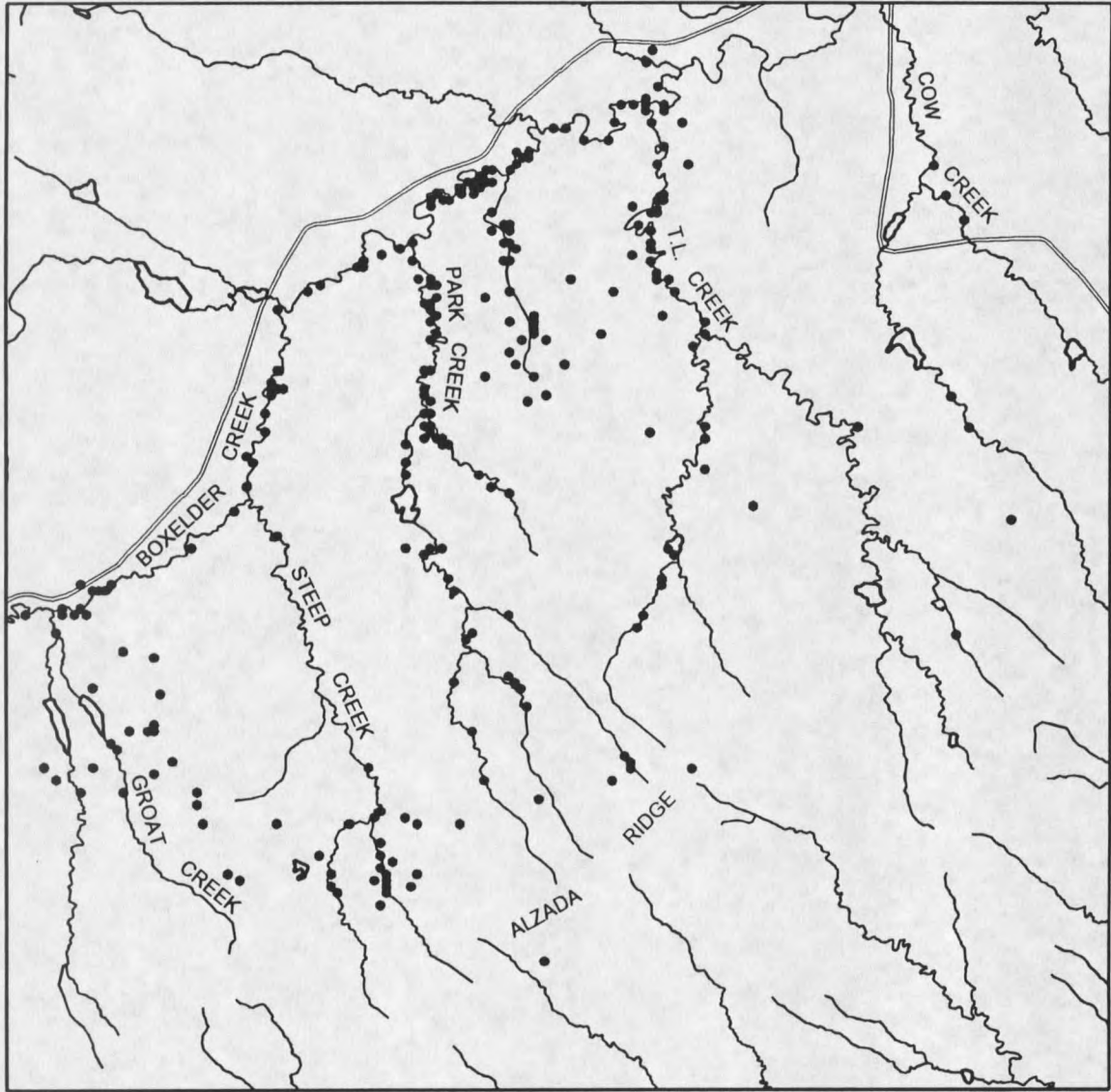


Figure 16. Telemetry relocations (n= 373) made between 16 July and 14 November during 1983-86 on the Boxelder study area.

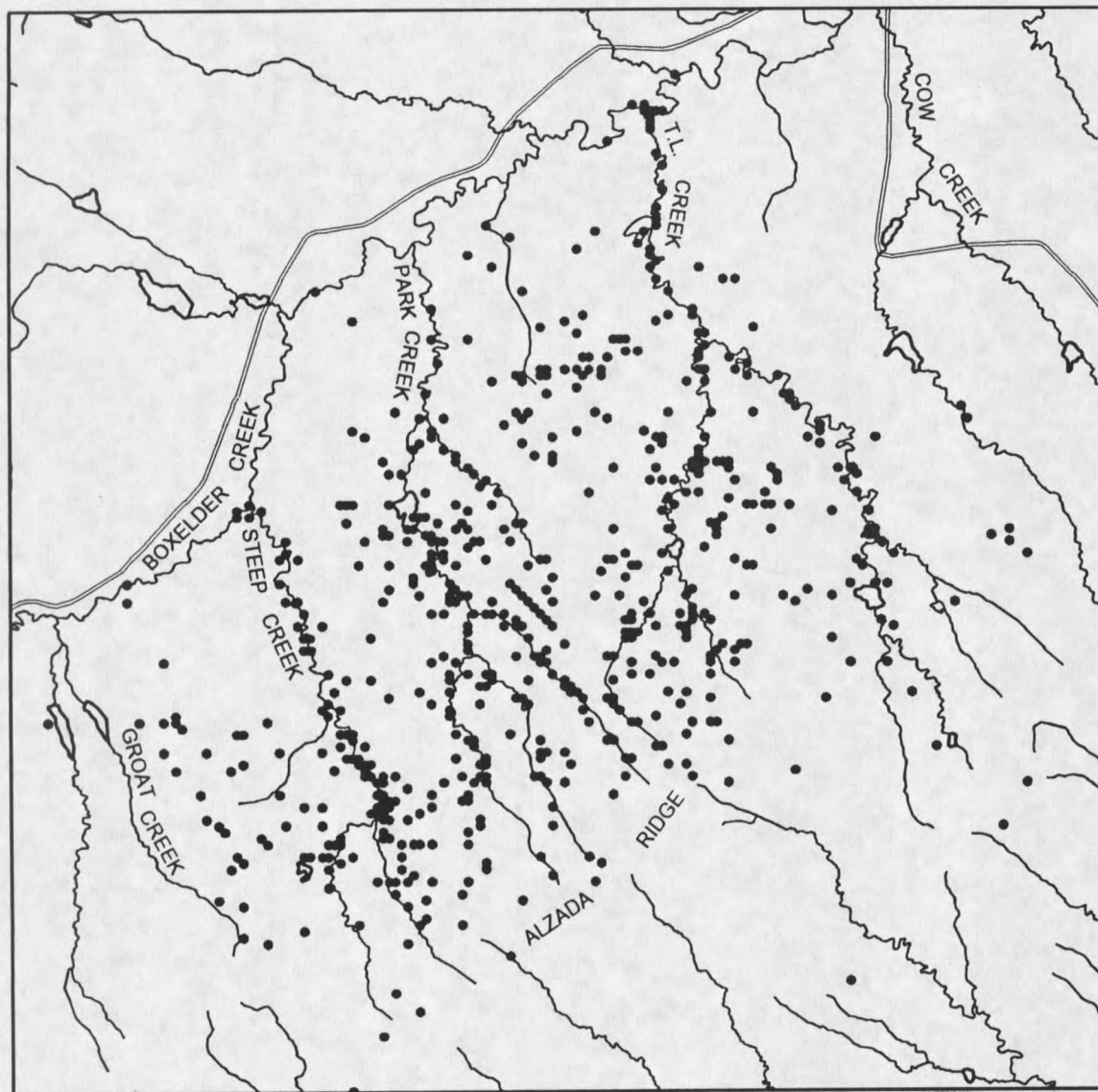


Figure 17. Telemetry relocations (n= 1176) made between 15 November and 15 July during 1983-86 on the Boxelder study area.

showed this movement only during certain years. Relocations after mid-November were generally near those made prior to 15 July.

Deer that did not show distinct movements (approximately >2 km) between July and November were often located in the part of their home range closest to Boxelder Creek during this period. Some deer were relocated near the main drainage during other months, especially early spring, but monthly geographic activity centers (GAC) of all radio locations between 1983 and 1986 indicate this movement occurred most consistently between July and November (Appendix Table 26).

Some deer may have moved off the study area during summers of 1983-86. Nine deer were relocated on the study area only between September and May in at least 2 consecutive years; 2 others were found on the study area only between October and April.

Movements of deer captured during 1991 were consistent with those recorded during 1983-85. During October 1991, 2 deer marked the previous February were located east of the study area on Boxelder Creek, at least 8 km from the GACs of their previous locations. One of these does moved between 7 July and 9 October, the other doe moved sometime between 16 May and 9 October.

Two additional marked does were also located on the main drainage during the October flight. One was also

located on Boxelder Creek during May and July flights, whereas the other one had moved about 4 km from the GAC of all previous locations.

Among other deer radio-marked in 1991, 3 were located approximately 1 km closer to Boxelder Creek during the October flight than at any previous time. No change was noted in 4 others, and 1 deer was consistently located within 2 km of the main drainage after capture in February.

Mean annual polygon home range (PHR) size and average activity radius (AAR) were larger than seasonal periods that excluded the period between 15 July and 15 November when deer moved toward Boxelder Creek (Table 16). The larger annual PHR and AAR may reflect the greater number of relocations used to calculate annual values. However, correlation analysis indicated the number of relocations was significantly correlated ($P < 0.05$) to PHR size only during 1983-84 and 1985-86. This correlation was determined by combining data for seasonal and annual estimates of PHR and correlating the number of months relocations were made to the PHR estimates.

Seasonal and annual values for 1991 are for the same 12 individuals. Estimates for 1983-86 included all marked animals.

The standard deviation of relocation distances from the GAC in the north-south direction was significantly greater ($P < 0.05$) than the east-west direction for all home range

Table 16. Annual, seasonal, and life polygon home range (PHR in km²) size and average activity radius (AAR in km) for deer on the Boxelder study area.

Type ^a		PHR				AAR		
Year	N	No. months relocated	Mean	SD	Range	Mean	SD	Range
Annual								
1983-84	29	6-12	6.92	5.70	1.79-30.07	1.73	0.75	0.75-3.29
1984-85	28	6-11	7.18	4.82	1.28-21.66	1.90	0.68	0.81-3.14
1985-86	16	5-7	10.04	6.44	1.61-20.79	2.24	0.55	1.27-3.36
1991	12	4-5	9.54	6.21	1.80-20.36	2.23	0.65	1.44-3.22
Seasonal								
1983-84	30	4-8	3.20	2.03	0.15-8.48	1.36	0.62	0.28-3.04
1984-85	10	6-7	5.49	2.58	1.05-8.70	1.69	0.62	0.59-2.71
1985-86	28	3-5	3.32	2.24	0.46-10.35	1.47	0.52	0.59-2.42
1991	12	3-4	6.72	4.13	0.60-15.49	1.92	0.50	1.08-2.90
Life	38	15-42	16.86	7.84	4.06-48.52	2.01	0.53	0.79-3.09

^a Annual= 15 July to 15 July. Seasonal= 15 November to 15 July. Life= relocations over at least 24 months.

values except 1985-86 ($P=0.093$). This is the general direction of all secondary drainages on the study area and indicates deer moved primarily along rather than across drainages.

Seasonal PHR for 1984-85 and 1991 were both greater ($P<0.05$) than 1983-84 and 1985-86, but no difference was observed between any other combination of years. No difference in annual PHR was observed amongst years either.

Moisture did not appear to be correlated with differences in PHR size between years. The 2 years with lowest seasonal PHR estimates had the greatest winter precipitation one year and the least the other. Spring moisture did not suggest a difference either.

The mean seasonal AAR for 1991 was greater ($P<0.05$) than 1983-84 or 1985-86, whereas annual AAR was greater in 1985-86 than 1983-84. No other differences in AAR were detected. Numbers of months used to calculate annual estimates of PHR and AAR during 1985-86 and 1991 were less than 1983-84 and 1984-85, but the 2 years with the least number of relocation months had the largest estimates.

I relocated individuals more than once per day on 11 occasions during March 1991. Distance between relocations on the same day ranged from 0.28 to 3.23 km ($\bar{x}=2.28$), with 5 distances >2 km. The time period between these relocations did not exceed 4.5 hours.

On 4 occasions, the same individual was relocated on 2 consecutive days. Distance between daily relocations varied from 1.02 to 2.27 km (\bar{x} =1.85).

Ashland Study Area

Use of distinct summer and winter ranges separated by >8 km (migratory movements) was exhibited by 7 of 58 deer marked during 1986-87 on the Ashland study area. Known dates on summer range for these animals were 31 May to 25 September, and known dates for winter range were 21 October to 31 March. Movements are described by Griffiths (1990).

For non-migratory animals, PHR and AAR estimates did not differ ($P < 0.05$) between summer and winter (Table 17). Dates used for these calculations were derived from seasonal movements of migratory animals. Home range estimates for 1991 animals were made during an 8 month period spanning both seasons and were not statistically comparable to other home range data.

Standard deviation of relocation distances from the GAC was not significantly different ($P > 0.05$) in either direction for home range estimates on the Ashland area. Although animals were captured directly adjacent to the Otter Creek trend area, few deer were relocated within its boundaries.

Weather

Mean daily minimum temperatures measured on the Boxelder study area between 23 January 1991 and 31 March

Table 17. Seasonal, annual, life, and partial 1991 polygon home range (PHR in km²) and average activity radius (AAR in km) for non-migratory deer on the Ashland study area.

Type ^a	N	No. months relocated	PHR			AAR		
			Mean	SD	Range	Mean	SD	Range
Summer	16	5	2.33	2.15	0.0-7.50	1.23	0.79	0.0-2.83
Winter	12	4-5	3.15	1.74	0.79-5.52	1.59	0.57	0.89-2.43
Annual	12	8-10	7.15	3.74	1.74-15.88	1.76	0.94	0.79-4.13
Life	13	12-25	10.26	13.90	2.32-53.41	1.34	0.73	0.77-3.61
1991	11	5	3.81	2.34	0.64-7.17	1.50	0.66	0.59-2.56

^a Summer= 16 April 1986 to 30 September 1986. Winter= 1 October 1986 to 15 April 1987. Annual= 1 June 1986 to 31 May 1987. 1991= 20 February 1991 to 10 October 1991. Life= at least 12 months of relocations over a minimum 24 month period.

1991, were higher than 3 nearby NOAA weather stations (Appendix Table 27). Mean daily maximum temperatures were greater than 2 of these 3 stations. Data from the Broadus NOAA weather station provided the most accurate prediction of temperatures measured on the study area with the following regressions:

$$\text{Boxelder min.}_x = 5.93 + 0.80 \text{ Broadus min.}_x \quad (R^2=0.81).$$

$$\text{Boxelder max.}_x = -4.10 + 1.01 \text{ Broadus max.}_x \quad (R^2=0.82).$$

Wind speed at 1 m above ground averaged 12.93 kph (7.7 mph) for 169.25 hours between 22-29 January 1991. During the first half of February (367.33 hours between 4 Feb. and 14 Feb.), wind speed averaged 7.08 kph (4.4 mph), while the first 23 days of March (521.58 hours) averaged 7.89 kph (4.9 mph). From 23 March to 16 May (1295.42 hours), wind speed averaged 9.98 kph (6.2 mph). Three periods of at least 3 hours were recorded between 22 January and 23 March when average speed was greater than 16.09 kph (10.0 mph). Wind speeds may be conservative due to the occasional inability of the wind recorder to register gusts in excess of approximately 32 kph (20 mph).

DISCUSSION

Fecal Nitrogen

Summer trends of FN values on the Boxelder area and seasonal differences on both study areas were consistent with plant phenology. Griffiths (1990) reported similar FN values and trends on these same areas during 1987-88. Trends between growing season and FN also have been reported for elk (Gates and Hudson 1981, Leslie 1983), black-tailed deer (Leslie 1983), bighorn sheep (Hebert et al. 1984), and white-tailed deer (Beier 1987).

Stepwise regression of forage succulence to FN may have predicted FN values on the Boxelder area by reflecting the seasonal decline in nutritional quality of forage as moisture content also declined. A relationship between forage moisture and FN was also suggested by Griffiths (1990). All forage classes are generally higher in nutrition during early growth, with a decline in advanced growth. A decrease in digestibility due to calcification and lignification occurs in addition to the decrease in actual chemical content (Cook 1972). Rates and magnitude of change, however, depend on species and site-specific factors such as moisture, temperature, and soil quality.

A decrease in forage succulence additionally may explain the decline in FN values from samples collected in the dryland hayfields on the Boxelder area. These samples

were presumably from deer that consistently used these hayfields during summer, thereby decreasing any influence from a change of forage species. A decline in forage succulence may have paralleled the decline in FN. A difference in succulence would also explain the higher value from an irrigated hayfield on the Ashland area compared to a Boxelder dryland hayfield on a similar date.

The regression of forage moisture and FN on the Boxelder area indicated a strong relationship between variables and a predictable decline in FN values during the summer. The actual usefulness of this regression, however, is probably limited to the prediction of general trends in FN rather than exact values. Fecal nitrogen values from hayfields were always higher than those from Park Creek (both Boxelder areas), even though forage succulence from both sites probably exhibited similar trends. A regression may predict FN for animals that use each area exclusively, but would not account for any movement between these areas such as occurred.

The general mathematical form of the regression equation does consider the influence of 2 important factors. During very early growth, the high moisture:nutrient content of forage can limit its utilization by ruminants. The negative coefficient of the variable S-forb allows a lower predicted value of FN at this time.

Fall green-up, generally more pronounced in grass than forbs or browse, may also influence nutritional availability to deer. The regression equation allows higher predicted values when this occurs. However, all predictions are dependent on the ratio of the 2 variables.

The lack of a significant regression equation on the Ashland area may be due to several reasons. Timing of the sampling period may be the most important. Griffiths (1990) determined peak values of FN for these study areas to occur around May 20 during 1988, with a higher peak and faster rate of decline on the Boxelder than Ashland area. Eustace (1971) found highest deer rumen protein levels during May for 2 areas in southeastern Montana. Collection of fecal samples for my study began at the end of June, after the reported dates of greatest protein in the above 2 studies. The start of collection after peak values, along with a slower rate of decline on the Ashland area may have prevented the development of a significant regression equation at Ashland.

Summer values of FN were greater on the northern part of the Ashland study area. Griffiths (1990) reported higher values on the northern part when she shifted her collection area during fall to correspond to movements of several radio-equipped deer. Several factors may have contributed to this difference. An irrigated hayfield was relatively close

to the northern collection area and may have been used by deer for increased nutrition.

Excluding any benefits from irrigated hayfields on the northern part of the Ashland study area, forage on the southern part of the Ashland area may have been of lower quality under the Ponderosa Pine canopy. Moir (1966) found less nitrogen in plants beneath a ponderosa pine canopy than in plants from a more open area. Because the fresh-cast needles contain only 0.57% nitrogen on a dry weight basis (Daubenmire 1953), the high carbon:nitrogen ratio may immobilize nitrogen in the soil by micro-organisms and reduce its availability to plants. Low nitrogen availability also could explain the relatively low forage dry weights obtained from the creek clipping site compared to the sage and random sites, even though the creek site generally receives more precipitation.

Differences in habitat may be a reason for the differences in summer trends and FN values between the 2 study areas. The Ashland area is much more complex than Boxelder, characterized by a greater number of plant species and more diverse topography. This increases the variability of plant phenology and specific microsites. The habitat on Ashland may have allowed selection of higher quality forage for a longer period. Fecal nitrogen values may reflect a difference in forage selection between the 2 study areas by showing less decline and higher values at the end of the

summer on Ashland. In contrast, the simpler and more consistent habitat on the Boxelder area may have exhibited a faster and more consistent overall decline in forage nutrition as reflected in FN values.

The higher average FN values from deer on Boxelder during the hunting season is an apparent contradiction of the previously explained difference in FN values between the 2 study areas. All deer collected on the Boxelder area except 1 were collected adjacent to hayfields along Boxelder Creek and may have been feeding in these fields. The deer with the lowest value was collected the farthest from hayfields, with a FN value equal to or lower than any on the Ashland area. Deer on the Boxelder area that utilize areas along the main drainage in the fall could have an overall nutritional intake higher than those that remain in the upland zone and equal to or greater than deer on the Ashland area. Dusek (1987) reported condition and body size of white-tailed deer in eastern Montana suggested a higher nutritional plane for deer using agricultural crops than those in a Ponderosa pine habitat.

Winter FN values indicated similar differences due to habitat and forage nutrition as summer values. All winter FN samples on both study areas were lower than summer values and generally more consistent at a time of dormancy in most plants. The greater fluctuation and higher FN values on

Ashland during the winter may again have resulted from a greater selection of forage.

Low winter values of FN may indicate weight loss of deer. Gates and Hudson (1981) found weight loss in elk when FN values were below approximately 1.6%. Hebert et al. (1984) found weight changes in bighorn sheep significantly related to FN values. Fecal nitrogen values are generally higher in smaller animals (Robbins 1983), so weight loss in deer may occur at values less than those for elk reported by Gates and Hudson. Thus, FN values may reflect greater weight loss and stress in deer on the Boxelder than Ashland area.

In particular, an increase in availability and use of browse species may have contributed to a difference between the 2 areas. Generally, browse species contain higher levels of digestible protein later in the growing season than forbs or grasses (Cook 1972), and have often been shown to be important in the diets of eastern Montana mule deer populations (Mackie 1970, Eustace 1971, Knapp 1972, Wood 1987).

Big sagebrush was abundant on both study areas and has often been considered an important winter forage due to its high protein content relative to other winter browse species (Eustace 1971, Trout and Thiessen 1973). Several studies (Nagy et al. 1964, Walmo et al. 1977) have suggested only limited amounts of big sagebrush can be tolerated in mule

deer diets due to essential oils inhibiting microbial digestion, whereas other studies have indicated no decrease in microbial efficiency due to these oils (Pederson and Welch 1982). Cuff et al. (1981) reported a significant decline in amounts of oils present in the rumen verses amounts ingested. Welch and Pederson (1981) thought the decline may possibly be due to vaporization from body heat or through mastication and rumination. Depending on the tolerance of big sagebrush by deer, the availability of more alternate browse species in addition to big sage during winter, as well as their use the rest of the year may give deer on the Ashland area higher quality diets throughout the year.

The usefulness of FN analyses lies in its ability to accurately assess the nutrition of consumed forage. The linear regression of FN to rumen forage nitrogen indicates that FN represented the amount of consumed protein for my study. Other studies have not only shown a relationship between FN and dietary protein (Langlands et al. 1963, Stallcup et al. 1975, Holechek et al. 1981, Howery and Pfister 1990), but also between FN and dry matter intake (Arnold and Dudzinski 1963), dietary digestibility (Holloway et al. 1981), and weight loss (Gates and Hudson 1981, Hebert et al. 1984) for various domestic and wild ruminants. Hodgman and Bowyer (1986) found FN to reflect changes in

habitat quality for 5 adjacent white-tailed deer wintering areas.

The use of FN as an indicator has not been without criticism (Hobbs 1987). The influence of plant secondary compounds (collectively referred to as phenolics), present in 80% of shrubs and 15% of forbs (Rhoades and Cates 1976) has been the most often cited criticism of FN use. These compounds are thought to reduce protein digestibility and increase FN values by combining with dietary and microbial proteins in the rumen and precipitating them out (McLeod 1974, Robbins 1983). Elevated values of FN relative to dietary nitrogen resulted when habituated elk were fed diets of either 100% fireweed (Epilobium angustifolium) or 100% maple leaves (Acer spp.), plant species that are both high in these compounds (Mould and Robbins 1981).

However, as Leslie and Starkey (1985) pointed out, only a small increase was noted when fireweed and maple leaves were reduced to 33% or less in a ration. This indicates that ruminants may tolerate certain levels of these compounds with little or no increase in FN. Additionally, some secondary compounds have been used to increase the efficiency of livestock feeds by inhibiting degradation of proteins in the rumen so that absorption in the small intestine is increased (Church 1991). Thus, the actual effects that plant secondary compounds have on FN values may depend on the amounts and types ingested.

Animal selectivity also may mitigate the effect of secondary compounds. Concentrations of tannins varies both within and between plant species as well as during growth stage (Rhoades and Cates 1976, McKey 1979, Zucker 1983). Animals may select plant tissues lower in these products (Provenza and Malechek 1984, Cooper and Owen-Smith 1985) or avoid them through a learning process (Chapman and Blaney 1979).

The presence of plant secondary compounds may have had minimal influence on FN values for the Ashland and Boxelder study areas. In all cases on both study areas, FN samples obtained from hayfields and haystacks (areas containing higher nutritional forage with low amounts of plant phenolics) were greater than those obtained away from hayfields. Thus, higher FN values reflected the use of a high nutritional forage containing less of these compounds.

The linear regression of FN to rumen forage nitrogen also suggests that influences of secondary compounds on FN values would have been consistent between study areas and animals. Deer from both study areas were combined for this regression. Any significant effect of secondary compounds in the diets of several individuals or all animals from 1 study area would likely have seriously altered the regression.

Attributes of Individual Deer

Attributes of individual deer showed considerable variation for all factors measured. Variation occurred not only between study areas but also within them.

The larger size of fawns on the Ashland area may have resulted from a faster growth rate as determined by higher FN values. Gates and Hudson (1981) found higher growth rates in elk associated with higher FN values. There are generally high correlations between live mass of deer and amounts of gross energy, crude protein, fat, and water (Robbins et al. 1974, McCullough and Ullrey 1983, Watkins et al. 1991). Watkins et al. (1991) also found chest girth correlated with these factors. The larger size of fawns on the Ashland area may indicate greater energy reserves than fawns on the Boxelder area.

Variation in kidney fat index was expected due to differences in ages and sex of deer sampled, with the highest values being obtained from males on each study area. This is similar to results by Dusek (1987) for white-tailed deer in eastern Montana. Increased protein requirements during lactation (Church 1991) could result in lower values of adult females >1 1/2 years old, whereas fawn values were low due to growth requirements decreasing the ability for fat deposition (Sadleir 1980).

The lack of difference between left and right side values of kidney fat index was in contrast to Anderson et

al. (1972) who found right side values greater in mule deer, but was similar to Watkins et al. (1991) who reported no difference between sides for white-tailed deer. No difference was found in kidney weights between sides either, whereas Anderson (1974) found left sides significantly heavier.

The large differences in FN and rumen nitrogen values observed among deer collected within each study area was probably due to individual diet selection. Beier (1987) found a difference in FN values due to sex, with higher values for females. The small sample size in my study precluded a comparison based on classification, but no apparent trend was evident.

In reality, the regression of FN to rumen forage nitrogen compared forage consumed at a previous time (FN) to that currently in the rumen. This would require animals with higher values to have selected feed containing higher protein on 2 occasions, suggesting the ability of some deer to select a diet higher in protein on a regular basis.

Diets of all animals collected during the hunting season were apparently above the minimum crude protein requirements. Verme and Ullrey (1972) estimated protein requirements of consumed forage to be 16-17% (dry weight basis) for all deer, including growing fawns and lactating females. All collected values exceeded 25% on a dry weight

basis when rumen forage nitrogen was converted to protein (N x 6.25).

Movements And Use Of Cover Types

Boxelder Study Area

The movement of deer toward the main drainage in fall may be attributed to searching for succulent forage.

Griffiths (1990) came to similar conclusions on these study areas, as did Jackson (1990) on a study area in northeastern Montana.

If FN accurately reflected dietary nutrition, the area adjacent to Boxelder Creek contained higher quality forage than Park Creek throughout the summer. Fecal nitrogen values from both areas declined, but the upland zone may have reached a value low enough to trigger this movement. Short (1975) concluded that fat deposition in white-tailed deer depends on good nutrition during late summer and early fall. Movement to the main drainage, fall green-up, or a combination of the 2 may be especially important for fat deposition of deer on the Boxelder area as they head into the winter.

Several factors may have caused movement of deer back to the upland zone in late fall. Livestock (sheep and cattle) are wintered along Boxelder Creek and deer may have moved to avoid competition. Competition may occur between

deer and sheep for food (Smith and Julander 1953) or between deer and cattle for space (Firebaugh 1969, Mackie 1978).

Movement back to the upland zone also may have been in response to hunting pressure. Swenson (1982) found use of hillsides by deer and an avoidance of bottoms and ridges during hunting season. The upland zone on the Boxelder area contains more hillsides and ridges than along the main drainage, and deer may have moved to the upland zone for this reason.

Deer that moved onto the main drainage during July-November generally moved back in winter to parts of adjacent drainages they had been previous to moving. This was similar to findings by Wood (1987) who indicated a high fidelity of deer to individual drainages.

The importance of creeks and mesic areas was similar to findings of studies in other prairie environments (Edwards 1977, Severson and Carter 1978, Wood 1987, Griffiths 1990, Jackson 1990). These areas probably best supplied all necessary requirements.

Forage succulence and dry weights indicated creek areas provided the highest quality and quantity of forage on the study area during summer. Hiding cover was usually greatest there also. Another requirement that may be important is thermal cover during the summer. Creek beds areas provide a place out of the sun that is much cooler than surrounding areas.

The cover type that probably received the greatest use relative to availability was CRP. Although only about 100 acres were of this type, 14.1% of all activities were observed there. Use of it at the end of summer may have been increased by its location near Boxelder Creek and movement of deer toward the main drainage at that time of year. However, it contained the tallest vegetation and may have provided both food and cover.

The large overall use of the Grass-2 cover type during summer may have been selection of a particular microsite rather than this general cover type. Many observations were of bedded deer in grassy coulees on the sides of buttes and deer may have been selecting them for the shade and cover they provided.

The increasing use of the Grass-2 cover type during winter probably resulted from the early green-up of grasses that began about the end of February. Use of grass often increases in spring diets of deer (Mackie 1970, Eustace 1971, Dusek 1975) and deer I observed may have been selecting it at this time.

The decreased use of creek bottoms during winter was similar to findings by Jackson (1990) and Griffiths (1990), with most use consisting of ephemeral streams in the upland zone. Griffiths (1990) found deer closest to these creek beds during colder days. Wood (1987) found the greatest use of leeward slopes for feeding and bedding during winter.

The areas along creeks provided the steepest relief on the study area (although not the greatest vertical distance) and deer may have been selecting them for the thermal cover they provided.

Use of creek beds may vary among winters, depending on a combination of wind, snowfall, and temperature. The winter of 1990-91 was mild, with above average temperatures and below average snowfall. Under the above conditions, snow had drifted to depths >1 m deep in portions of all creek beds. During other years creek beds have drifted almost completely full (Ralph Brownfield, pers. comm.). Accumulation of snow may therefore limit the use of creek beds and their ability to provide shelter during the winter.

Although drifting-in of creek beds may decrease the availability of shelter during the winter, drifts may be beneficial in the spring. The melting snow may increase moisture availability above that which comes in the form of rain or snow.

Deer were observed at haystacks only a moderate number of times but haystacks appeared important for certain individuals. Deer were observed continuously bedded in some haystacks, indicating some may rely heavily on them.

Ashland Study Area

Use of cover types by mule deer during the summer at Ashland was similar to results reported by Griffiths (1990).

Based on air and ground surveys, the mesic-sage and pine-grass types were most important with little use of riparian and medium use of the sumac and agriculture cover types. The last three mentioned, however, may have been more important than indicated by the number of observations.

Fragrant sumac seemed to be a highly selected forage. I often observed deer feeding on it, and by the end of August, most plants on the study area were almost completely defoliated. This included areas where cattle were excluded. Griffiths (1990) suggested the importance of fragrant sumac to deer on the study area, and Knapp (1972) found it to be the most important summer browse species on a study area adjacent to my study area. Mackie (1970) and Eustace (1971) reported use of fragrant sumac in other studies in eastern Montana.

I suspect that greater use of agriculture and riparian areas along the Tongue River and Otter Creek may have occurred, especially at night. The single night survey indicated heavy use of an irrigated hayfield, and a game trail with indications of heavy deer use was found crossing the Tongue River onto the Cheyenne Indian Reservation. Deer may have been using mesic vegetation along the river or grain and hayfields on either side. Many deer also were seen in vehicle headlights crossing the road towards Otter Creek at nightfall, just after completion of ground surveys.

Hayfields and mesic areas along the Tongue River and Otter Creek may have been especially important in the fall after other vegetation dried out. Egan (1957), Knapp (1972), and Griffiths (1990) all found greater use of hayfields in late summer or early fall.

The limited number of deer observations from survey routes during the winter make it difficult to draw any conclusions. Observations were made in half the number of cover types as during the summer. This was similar to the findings of Knapp (1972), Dusek (1975), and Jackson (1990), who all reported fewer cover types used by deer in winter than summer.

The pine-grass and sagebrush cover types were probably the most important for deer in winter, as determined by the number of observations and the consistency of use each month for both air and ground observations. Swenson et al. (1983) reported pine-dominated types were the most used during winter in their study of southeastern Montana mule deer populations. The use of grass may be attributed to green-up because most use occurred in March after new growth began.

The difference in use of pine-grass between air and ground surveys may be due to an observability bias. Biggins (1982), in a study including part of the Ashland area, showed up to 136% greater observability in untimbered areas of gentle relief compared to more rugged areas with coniferous overstory. Because ground surveys only offer a

limited view adjacent to roads, they may have underestimated use of pine-grass more than air surveys. This may have resulted in the observed difference between air and ground surveys.

Winter observations on the Otter Creek trend area (Ashland study area) were generally limited to the northern portion. This was in contrast to many observations throughout the trend area during summer. Spring aerial surveys flown since 1979 by MDFWP have often been much lower than fall surveys. An aerial survey of the trend area at a time of 100% snow cover (January 1991) resulted in few observations of deer or tracks, and only a limited number of radio relocations were ever made on the trend area. Thus, I feel that some deer that use the trend area during the summer may move off of it during the winter.

Home Ranges

Annual home range estimates for both study areas were generally larger than those reported from a literature review by Wood (1987:83) for various habitat types. Home ranges of deer from prairie habitats are larger than those from mountainous habitats (Severson and Carter 1978), and this may be reflected in the size of home range estimates for the Boxelder and Ashland study areas.

Annual home range estimates between my 2 study areas appeared similar in size, but the strategy of use by deer

was different. Deer on Boxelder exhibited a movement between July and November that accounted for a large portion of their home range size. Except for migratory movements described by Griffiths (1991) and Biggins (1982), deer on the Ashland area did not show distinct movements to account for similar home range sizes.

Variation in seasonal home range estimates amongst years on Boxelder may have been due to a combination of climatological factors, as differences in precipitation alone could not be linked to them. A combination of precipitation and temperatures during the growing season, and possibly also the amount of snow accumulated in the creek beds during the winter, may have changed the availability of succulent forage amongst these years. This in turn may vary movements and home range size if succulent forage is important.

All home range estimates from both areas may have been bigger than those obtained. Jackson (1990) found nocturnal movements to increase home range sizes from those acquired during daylight hours. Nocturnal movements may have been especially true for the Ashland area where I seemed to observe deer with more regularity before and after daylight hours than on the Boxelder area.

Population Characteristics

The increasing numbers of fawns per 100 does that I observed during the summer on both areas has typically been seen in other studies (Wood 1987, Edwards 1977, Griffiths 1990). The reason may be due to greater mobility of fawns by late summer resulting in easier observation of them.

Higher observed fawn:doe ratios on Boxelder than Ashland have been the case since surveys began in 1979 (MDFWP unpublished data). Differences in habitat between the areas may account for this difference. Picton and Mackie (1980) reported higher ratios in areas of less cover in Montana. Mackie (1983) attributed higher fawn production of a breaks habitat than a mountainous habitat to decreased complexity.

The increased natality on the Boxelder area may not explain the differences in trends suggested by the population estimates. Higher adult losses (predation, emigration, etc.) due to less cover should also be seen in a more open habitat (Picton and Mackie 1980, Mackie 1983), resulting in higher adult losses on Boxelder. Differences in land practices between the 2 study areas may prevent higher adult loss on Boxelder from occurring. Private ownership of much of the land and little public access may result in less hunting loss of deer on the Boxelder area. Sheep ranching has eliminated most predators. In contrast,

the Ashland area contains easy access for hunting on a large amount of public land. Predation may be higher on Ashland due to the large number of coyotes I observed during this study. The Cheyenne Indian Reservation is adjacent to the study area, and with its more liberal hunting regulations may increase mortality on the study area through hunting loss of animals crossing onto it. These differences may have kept population levels on Ashland more constant whereas populations on Boxelder increased.

The increase in fawn ratios during the winter on both study areas is somewhat misleading and probably does not reflect greater mortality by adults over fawns. Griffiths (1990) reported a similar increase during winter on the Boxelder area in 1988. This increase may have resulted from either errors in classifying animals or from an observability difference during the winter.

Biggins (1982) indicated increased observability of bucks during early winter (through February), with a decrease in March. Because winter fawn ratios were based on the number of adults instead of does, any decrease in numbers of adults seen would inflate the fawn ratios during late winter. Additionally, the movement of deer onto more open areas during green-up may have made it easier to classify them.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Fecal nitrogen analysis is by no means an exact method for qualitative assessment of mule deer diets. A combination of intrinsic factors (endogenous nitrogen loss, urea recycling, and needs for specific dietary requirements other than protein), extrinsic factors, and different strategies of habitat use by individual deer may make comparisons among habitat types or regions/areas unreliable. The real use of FN may be to compare quality of nutrition on the same area between years.

Several approaches exist for making comparisons between years. Peak values and rate of decline in FN values may indicate length and magnitude of energy gain amongst summers. Likewise, it could show energy loss during winter.

Variation in FN samples may be another way of determining differences amongst years. The difference noted amongst samples obtained at the end of the growing season indicated either differences in ability of deer in selecting high quality diets, or marginal home range use by others. Earlier in the growing season, or during exceptionally moist years, the amount of variation between samples may be less than when succulent forage is more readily available. As availability decreases, variation may increase. The amount of variation or rate of change in variation may also be a useful comparison amongst years.

A relationship was observed between kidney fat index and FN that may be useful as a relative index for classifying the percent of animals in good condition, poor condition, etc. This relationship should be verified prior to management use in view of the small sample sizes used in this study.

The regression of forage succulence to FN that was found on the Boxelder area may be of little use from an actual predictive standpoint. However, it may indicate the importance of succulent forage in diets of deer.

Information obtained in this study may be useful for developing predictive capability of populations on these study areas or testing/adapting the Hobbs model. The major input of the Hobbs model is minimum and maximum daily temperature, and the linear regression I calculated can accurately predict temperatures on the study area from NOAA temperatures at the Broadus weather station. Dry weights of forage, body weight of deer, fat levels of deer, and deer density values can be used to change the default values in this model to make it more site specific. Population trends predicted by the model can then be compared to those calculated in this study.

Mesic areas appeared to be more important on Boxelder than Ashland. Deer in a mixed ponderosa pine habitat type may not depend as much on 1 particular cover type when compared to a prairie habitat, but rather the interspersed

of several different types. Additionally, the greater variation in FN sample groups within and between seasons may indicate greater susceptibility of deer in a prairie habitat to climatological extremes (drought, harsh winters, etc.).

From observations made during this study, I believe some deer may move off the Otter Creek trend area (Ashland) during winter. Further information concerning timing of any such movements may need to be obtained to allow making all trend flights when similar movement patterns exist.

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APPENDIX

Table 18. Identification numbers, ear tag numbers, sex, and age (years) of deer captured on the Ashland area during February, 1990.

ID#	Sex	Age	Ear tag number		Collar code ^a (color/symbols)
			Left	Right	
0191	F	8 1/2	30130	30131	RED/squares
0291	F	2 1/2	30128	30129	RED/daggers
0391	F	5 1/2	30147	30139	GRN/lazy 2
0491	F	2 1/2	30075	30100	GRN/crosses
0591	F	2 1/2	30116	30119	RED/open triangles
0691	F	4 1/2	30123	30122	RED/lazy Y
0791	F	3 1/2	30135	30136	RED/dashes
0891	F	2 1/2	30102	30107	RED/squiggle
0991 ^b	F	10 1/2	30143	30121	GRN/lazy M
1091	F	2 1/2	30141	30140	GRN/stripe
1191	F	2 1/2	30110	30103	GRN/open triangles
1291	F	1/2	30126	30127	YEL/solid dots
1391	F	1/2	30138	30149	YEL/squiggle
1491	F	1/2	30144	30137	YEL/chevrons
1591	F	1/2	30142	30148	YEL/crosses
1691	F	1/2	30101	30111	YEL/slashes
1791	M	1/2	30073	30074	none
1891	M	1/2	30052	30051	none
1991	M	1/2	30053	30026	none
2091	M	1/2	30115	30114	none
2191	M	1/2	30108	30118	none
2291	M	1/2	30134	30132	none
2391	M	1/2	30124	30125	none

^aColor is base color of collar. Symbols are in contrasting colors: green with yellow, red with white, yellow with black.

^bRecapture of a deer captured in 1987. Previously #1287.

Table 19. Identification numbers, ear tag numbers, sex, and age (years) of deer captured on the Boxelder area during February, 1990.

ID#	Sex	Age	Ear tag number		Collar code ^a (color/symbol)
			Left	Right	
3191	F	6 1/2	30106	30117	GRN/solid triangles
3291	F	3 1/2	30071	30070	GRN/slashes
3391	F	1 1/2	Found dead 5/16/91		
3491	F	1 1/2	30099	30098	RED/stars
3591	F	1 1/2	30079	30050	RED/checkerboard
3691	F	1 1/2	30055	30056	GRN/offset dots
3791	F	1 1/2	30024	30025	GRN/large X
3891	F	1 1/2	30047	30048	RED/solid dots
3991	F	3 1/2	30104	30105	RED/lazy H
4091	F	2 1/2	30170	30157	RED/gates
4191	F	3 1/2	30156	30158	RED/bar dash
4291	F	4 1/2	Killed during hunting season		
4391	F	2 1/2	Found dead 7/7/91		
4491	F	4 1/2	30113	30159	GRN/arrows
4591	F	1 1/2	30068	30057	GRN/squares
4691	F	2 1/2	22067	22069	GRN/double stripe
4791	F	3 1/2	30001	30002	RED/dot bar
4891	F	1 1/2	30054	30061	RED/lazy M
4991	F	4 1/2	22070	22068	GRN/dot bar
5091	F	2 1/2	30168	30161	GRN/lazy H
5191	F	3 1/2	22066	30175	GRN/bars
5291	F	3 1/2	30164	30162	GRN/open triangles
5391	F	6 1/2	30163	30166	GRN/solid dots
5491	F	4 1/2	30067	30064	GRN/bar dash
5591	F	3 1/2	30160	30172	RED/chevrons
5691	F	4 1/2	30059	30060	GRN/stars
5791	F	1/2	22155	2206(?)	YEL/triangles

Table 19. Continued:

5891	F	1/2	30154	30165	YEL/bar dash
5991	M	1/2	30173	30169	none
6091	M	1/2	30155	30171	none
6191	M	1/2	30063	30046	none
6291	M	1/2	22173	22158	none
6391	M	1 1/2	22058	22071	none
6491	M	1 1/2	30066	30058	none

^aColor is base color of collar. Symbols are in contrasting colors: green with yellow, red with white, yellow with black.

Table 20. Status of previously marked deer located during this study. All were located on study areas unless otherwise noted.

Study area	
ID#	Status
Boxelder	
0183	Hunter kill, 1990
0583	Winter kill, 1991
0883	Hunter kill, 1990
1184	Died as fawn
1684	Last seen alive 3/14/91
0186	Last seen alive 3/6/91
0286	Last seen alive 3/6/91
0686	Last seen alive 3/6/91
1286	Last seen alive 3/6/91
1586	Last seen alive 3/14/91
2986	Last seen alive 3/6/91
Ashland	
0186	Last seen 5/16/91, radio working
0386	Hunter kill, 1990
0586	Last seen alive 5/16/91, radio working
1286	Last seen alive 2/27/91
1486	Radio found 8/90, deer probably dead
2086	Last seen off study area 2/28/91, radio working
2986	Last seen alive 5/16/91
3186	Died winter 1990 of unknown causes
3286	Last seen off study area 2/28/90, radio working
1287	Captured 2/91, new radio, now ID# 0991
1387	Wounding loss 1990
1587	Radio returned, deer probably dead
2087	Last seen alive 7/15/90

Table 21. Moisture content (%) of forage sample plots on the Boxelder and Ashland study areas during summer, 1990.

Location Date	Creek		Sage-grass		Reference	
	Forbs	Grass	Forbs	Grass	Forbs	Grass
Boxelder						
171	75.8	62.4	63.5	51.7	--	--
183	72.7	51.3	47.7	39.2	--	--
197	67.0	46.5	22.6	24.5	--	--
212	42.3	39.6	9.3	19.5	50.2	38.5
225	33.7	29.4	14.6	15.1	43.7	34.6
239	31.6	32.5	37.5	20.2	45.6	42.3
251	61.8	36.9	18.8	18.8	44.2	39.1
Ashland						
176	77.9	65.3	71.0	59.0	--	--
189	68.4	54.4	24.9	21.1	--	--
201	62.9	51.8	23.3	18.0	48.1	34.9
214	57.5	42.3	4.2	12.3	48.9	30.1
226	45.1	35.4	19.0	14.7	48.8	34.7
241	30.2	32.3	7.7	13.7	42.6	29.6
254	33.6	24.7	8.0	13.0	42.2	32.1

Table 22. Nitrogen content (%) of fecal samples for the Boxelder and Ashland study areas.

Season	Boxelder		Ashland		
	Date	Park Creek	Hayfield ^a	HIW	Coal Bank
Summer 1990					
	171	3.5	--	--	--
	176	--	--	2.4	2.0
	183	2.9	--	--	--
	189	--	--	3.0	2.6
	197	2.7	--	--	--
	201	--	--	3.1	2.3
	212	2.9	--	--	--
	214	--	--	2.9	2.7
	219	--	2.8	--	--
	225	2.6	--	--	--
	226	--	--	3.2	2.6
	234	--	2.6	--	--
	239	1.7	--	--	--
	241	--	--	2.8	2.3
	251	2.6	2.3	--	--
	254	--	--	2.0	2.3
Winter 1991					
	20	--	--	--	1.5
	24	1.4	--	--	--
	25	--	--	1.9	--
	35	1.3	--	--	--
	40	--	--	1.4	--
	52	1.2	--	--	--
	54	--	--	--	1.9
	59	--	--	1.6	--
	63	--	--	1.7	1.5

Table 22. Continued:

64	1.3	2.2	--	--
78	1.4	2.2	1.5	--
83	--	--	--	1.4

^a Samples taken from hayfields during the summer, haystacks during the winter.

Table 23. Gross energy (kcal/kg) of fecal samples for the Boxelder study area.

Season	Location	
	Date	
	Park Creek	Hayfield
Summer 1990		
	172	4,562
	251	4,739
		4,540
Winter 1991		
	35	4,562
	78	4,232
		--

Table 24. Weights of left and right kidneys (g) and associated fat (g) for all deer.

Deer ID#	Kidney		Fat	
	Right	Left	Right	Left
*BE1	105.9	108.3	282.4	234.2
*BE2	38.9	39.9	1.4	2.0
*BE3	48.9	64.6	117.2	134.7
BE4	94.8	78.3	57.1	52.9
BE5	28.4	26.9	1.2	1.1
*BE6	45.7	48.8	2.3	2.9
*BE7	68.2	73.8	95.4	133.6
BE8	51.7	52.3	28.5	35.9
BE9	71.5	74.8	19.6	15.6
AS1	55.7	57.7	95.7	80.7
AS2	99.6	105.1	15.3	14.6
AS3	58.5	62.2	14.4	13.4
AS4	55.2	56.6	44.9	46.3
*AS5	88.9	--	27.9	--
AS6	85.9	93.6	30.2	30.6
KP1	98.9	95.6	12.8	10.7
KP2	53.3	61.3	19.8	21.8
*KP3	74.6	66.8	23.6	18.6
KP4	88.1	78.3	14.2	12.1
KP5	49.8	50.6	4.1	5.4
KP6	73.9	82.5	8.4	11.3
KP7	87.7	98.3	40.3	39.8
KP8	52.4	51.3	6.2	4.8
KP9	62.6	60.4	15.5	13.8
KP10	49.1	60.5	21.7	26.3
KP11	45.9	45.7	2.9	2.7
KP12	52.1	47.6	4.8	5.6

* Denotes samples from unknown sides

Table 25. Girth measurements (cm) and estimated bled carcass weights for fawns captured on the Boxelder and Ashland study areas.

Location			Estimated bled carcass weight ^a	
Deer ID#	Sex	Girth	(kg)	(lb)
Ashland				
1291	F	79	43.7	96.3
1391	F	86	54.1	119.3
1491	F	86	54.1	119.3
1591	F	79	43.7	96.3
1691	F	84	51.0	112.4
1791	M	74	37.0	81.7
1891	M	74	37.0	81.7
1991	M	76	39.6	87.4
2091	M	91	62.4	137.6
2191	M	81	46.5	102.6
2291	M	91	62.4	137.6
2391	M	91	62.4	137.6
Boxelder				
5791	F	66	27.8	61.2
5891	F	74	37.0	81.7
5991	M	79	43.7	96.3
6091	M	71	33.4	73.6
6191	M	74	37.0	81.7
6291	M	71	33.4	73.6

^a Estimates of bled carcass weights from Anderson et al. 1974.

Table 26. Monthly geographic activity center of all relocations in 1,000 meter Universal Transverse Mercator units on the Boxelder Study Area.

Month	1983		1984		1985		1986		1991	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
January	---	---	5014.22	519.55	5013.89	519.86	---	---	---	---
February	5013.36	519.28	5015.14	518.88	---	---	5013.00	519.94	5016.58	521.09
March	---	---	5014.80	520.19	5014.31	519.07	---	---	5014.31	522.89
April	5013.77	520.29	5013.73	519.55	5013.26	519.37	5013.70	518.89	---	---
May	5013.66	518.96	5014.15	519.46	5014.97	518.79	5013.59	520.09	5016.93	521.56
June	5014.98	519.44	5014.41	520.75	---	---	5014.38	519.71	---	---
July	5015.20	518.46	5015.48	520.56	5015.27	518.78	---	---	5017.42	521.49
August	5015.01	517.60	5016.58	519.65	5018.44	518.68	---	---	---	---
September	5016.88	517.07	5017.98	518.35	---	---	---	---	---	---
October	5015.74	517.80	5017.74	518.54	5016.94	517.75	---	---	5019.82	521.69
November	5015.01	519.32	5013.93	519.37	---	---	---	---	---	---
December	5015.20	519.63	5014.85	519.42	5013.38	519.43	---	---	---	---

Mean number of relocations per GAC= 42.6, with a range of 10 to 164. Position becomes closer to the main drainage as latitude increases and longitude decreases.

Table 27. Mean monthly minimum (Min) and maximum (Max) temperatures ($^{\circ}\text{C}$) for the Boxelder study area and nearby NOAA weather stations.

Year			February		March	
Location	Min.	Max.	Min.	Max.	Min.	Max.
Winter 1991						
Boxelder	-14.8	-4.1	-4.4	7.1	-4.2	10.1
Broadus	-17.9	-2.1	-4.9	9.8	-5.3	11.6
Albion	-19.0	-4.6	-7.5	6.3	-6.8	8.8
Ridgeway	-16.2	-4.1	-5.8	6.4	-5.3	9.4
Long Term Average						
MAPS ^b	-15.6	-1.7	-10.8	1.7	-7.2	5.8
Broadus	-15.6	-0.6	-11.1	3.3	-7.2	7.2
Albion	-17.8	-2.2	-13.9	1.7	-9.4	5.6
Ridgeway	-16.7	-2.2	-12.8	1.1	-7.2	6.1

^a Long term average is for entire month of January, winter 1991 is for January 23-31.

^b Predicted value for the Boxelder study area from Montana State University MAPS program.

Table 28. Values used for mark-recapture population estimates on the Boxelder and Ashland study areas.

Location	Number of animals			
	Date	Marked	Captured	Recaptured
Boxelder				
	3/16/91	32	757	28
Ashland				
	3/15/86	27	196	17
	10/7/86	11	62	8
	12/14/86	14	57	6
	10/20/87	21	83	8
	12/26/87	22	38	3
	2/27/88	17	194	13
	3/31/89	13	188	11
	9/25/89	12	62	4
	1/4/90	8	59	2
	2/7/91	21	77	10

