

MIKE OEHLER

DISTRIBUTION, MOVEMENTS, HABITAT USAGE, FOOD HABITS,
AND ASSOCIATED BEHAVIOR OF REINTRODUCED ELK IN
THEODORE ROOSEVELT NATIONAL PARK

by

Field Investigator

Mark G. Sullivan, Graduate Research Assistant,
Fish and Wildlife Management

Principle Investigators/Project Coordinators

Lynn R. Irby, Associate Professor of Fish and
Wildlife Management

Clayton B. Marlow, Associate Professor of Range
Science

Harold D. Picton, Professor of Fish and Wildlife
Management

January 1988

Montana State University
Bozeman, Montana

Submitted to the National Park Service, P.O. Box 25287,
Denver, Colorado 802225, in compliance with contract No.
CX1200-5-A051.

TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
LIST OF FIGURES	vi
ABSTRACT	vii
INTRODUCTION	1
STUDY AREA	3
Geology	3
Climate	5
Vegetation	5
Land Use	6
Methods	7
Distribution and Movements	7
Population Dynamics	9
Habitat Use	9
Elk Impacts on Vegetation and Other Herbivores	11
Food Habits and Elk Carrying Capacity	14
RESULTS AND DISCUSSION	21
Seasonal Distribution	21
Annual Distribution by Sex	26
Home Ranges	30
Pellet Group Survey	34
Population Dynamics	35
Activity and Behavior Patterns	37
Habitat Use	44
Seasonal Habitat Use	47
Food Habits	53
Damage to Park Resources	57
Elk Carrying Capacity	67
SUMMARY	75

TABLE OF CONTENTS - CONTINUED

	Page
APPENDICES	78
APPENDIX A	79
APPENDIX B	87
APPENDIX C	91
APPENDIX D	107
APPENDIX E	117
APPENDIX F	134
REFERENCES CITED.....	142

LIST OF TABLES

Table		Page
1	Annual production for shrubs in hardwood draws in TRNP, 1986.....	16
2	Percent contribution of species and food items to the diet of elk in TRNP, 1985-86....	18
3	Seasonal, annual, and total home range sizes (km ²) for marked animals in TRNP during the study. Number of relocations (N) is given in table.....	31
4	Percent overlap between combined overall home ranges of marked elk in TRNP 1985-87....	32
5	Population structure of elk introduced into TRNP.....	36
6	Percent diurnal habitat type use by elk in TRNP 1985-87, for all seasons (including two summers).....	44
7	Percent diurnal physiographic class use by elk in TRNP 1985-87, for all seasons (including two summers).....	45
8	Percent coverage, diurnal use (%D Use), and projected 24-hr use (%T Use) of habitat types, mapping units, and complexes available to elk in TRNP.....	46
9	Percent coverage, diurnal use (%D Use), and projected 24-hr use (%T Use) of physiographic classes available to elk in TRNP.....	46
10	Season lengths and the number of days and minutes elk were observed each season.....	48
11	Percent of elk minutes observed in habitat types, mapping units, and complexes for Winter 1985-87, Spring 1986, Summer 1985, Summer 1986, and Fall 1985.....	49

LIST OF TABLES - CONTINUED

Table		Page
12	Percent of elk minutes observed in physiographic classes for Winter 1985-87, Spring 1986, Summer 1985, Summer 1986, and Fall 1985.....	49
13	Percent of elk minutes spent in grassland flats, breaks, ridge & ravine, prairie dog town, upland grassland, scoria hills, and sagebrush bottoms physiographic classes during each season for four time periods.....	52
14	Seasonal diet composition (%) for forage items comprising >3% of any seasonal diet for elk in TRNP, 1985-87.....	54
15	Mean canopy coverage in ground stratum for hardwood and Rocky Mountain juniper draws within and outside the range of elk in TRNP.....	58
16	Mean density and utilization of shrubs, saplings, and trees within and outside the range of elk in TRNP.....	59
17	Percent diurnal use of physiographic classes by large herbivores in TRNP.....	61
18	Percent composition of graminoids, browse, and forbs in the diets of large herbivores in TRNP 1985-86.....	62
19	Total annual production, the proportion each species or plant type contributed to the spring/summer diet, and elk carrying capacity estimates for primary and secondary ranges in the South Unit.....	68
20	Total annual production, the proportion each species or plant type contributed to the spring/summer diet, and elk carrying capacity estimates for marginal ranges in the South Unit.....	69

LIST OF TABLES - Continued

Table		Page
21-23	Description of physiographic/vegetational classes, habitat types, and mapping units.	80-86
24-29	Percent of elk minutes spent feeding, bedding, and other in each habitat type and physiographic/vegetational class for each season.....	88-90
30-44	Percent of elk minutes spent feeding, bedding, standing, moving, and other in physiographic/vegetational classes and habitat types for each season during four time periods.....	92-106
45-51	Means of vegetation transects in hardwood draws within and outside the range of elk in TRNP.....	108-116
52-63	Means of individual transects in hardwood draws and juniper draws within and outside the range of elk in TRNP.....	118-133
64-67	Food items in the biseasonal diets of elk, mule deer, white-tailed deer, and feral horses in TRNP.....	135-141

LIST OF FIGURES

Figure		Page
1	Map of South Unit, TRNP.....	4
2	Seasonal distribution of elk in TRNP, 1985-87	24
3	Locations of marked elk in TRNP, 1985.....	28
4	Locations of marked elk in TRNP, 1986.....	29
5	Sightings of all elk and marked elk in TRNP 1985-87.....	33
6	Trail survey of pellet groups in TRNP.....	34
7	Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP during the study.....	39
8	Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in summer 1985-86.....	40
9	Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in fall 1985-86.....	41
10	Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in winter 1985-86.....	42
11	Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in spring 1985-86.....	43

ABSTRACT

This study was initiated to determine the effects of elk (Cervus elaphus) on flora and fauna in the South Unit of Theodore Roosevelt National Park (TRNP). Elk were reintroduced into TRNP in March 1985. In two years the population grew from 47 to 80 animals with no known mortality. The range of elk increased in the Park from 35 km² the first year to 75 km² the second year. As elk increased their range, they utilized a wider variety of habitats. Hardwood draws received heavy diurnal use during the first summer for cover and forage. Diurnal use shifted to Rocky Mountain juniper (Juniperus scopulorum) draws the second summer. Grassland habitats were primarily used during evening from late spring through early fall and throughout the day in winter when elk did not seek out wooded habitats for cover. Feeding peaked in the early morning and evening for all seasons while bedding was the dominant midday activity. Fecal samples were collected for elk, mule deer (Odocoileus hemionus), white-tailed deer (O. virginianus), and feral horses (Equus caballus) for microscopic determination of diet composition. Elk used browse heavily in summer when it constituted 60% of the seasonal diet. Use of browse decreased in late fall corresponding to an increase in graminoid use. Graminoids were the major food item for elk in the fall, winter, and spring. Forbs were utilized heaviest in summer when they accounted for 22.3% of the diet. Fecal analysis indicated an overlap of food habits between elk, mule deer, and white-tailed deer in summer, between elk and feral horses in fall, and between elk, bison (Bison bison), and feral horses in winter and spring. The greatest potential for competition exists between elk and mule deer due to close similarities in habitat use and the high use of browse in the summer diets for both ungulates. A carrying capacity of 150 elk was calculated (without consideration of other large herbivore species) for the South Unit of TRNP. An elk population of this size should help reduce litter accumulation in grassland habitats without causing serious overbrowsing problems on preferred shrub species.

INTRODUCTION

Elk were once one of the most widely distributed members of the deer family in North America (Boyd 1978). Early reports of explorers speak of vast herds of elk roaming the Great Plains. These elk, belonging to the subspecies C. elaphus manitobensis, were quickly extirpated when European man settled the Great Plains in the 1800's. In North Dakota, elk were relatively abundant until the 1870's. By 1881 elk were scarce and in 1883 the last official report of elk in North Dakota occurred when six elk were killed in Cavalier County (Kruckenberg 1973).

In 1942, 25 Rocky Mountain elk were released in western North Dakota in an unsuccessful attempt to reintroduce elk (Byrant and Maser 1982). No other attempts were made to reestablish elk; however, in 1979 a small herd of elk escaped from a holding pen on an Indian reservation into river breaks near the North Unit of Theodore Roosevelt National Park. Within several years elk numbers had increased enough to allow a limited hunt aimed at removing 25 - 30 animals a year.

In 1984, personnel at Theodore Roosevelt National Park began to formulate plans for reintroducing elk into the South Unit of the Park. The reintroduction was initiated to restore one of the major herbivores in the badlands

environment. A recent bison study in the South Unit determined that excess forage existed in the Park and elk might help alleviate suboptimal range conditions due to underuse of some habitat types (Marlow et al. 1984). Forty-seven Rocky Mountain elk (C. elaphus nelsoni) captured and transported from Wind Cave National Park, South Dakota, were released in the South Unit in March 1985.

This study, conducted from June 1985 to January 1988, represents the first phase of a four year study to determine distribution, movement, habitat use, food habits, and associated behavior of reintroduced elk in Theodore Roosevelt National Park. The second phase of the study is currently underway and is expected to be completed in August 1989.

STUDY AREA

The study was conducted in the South Unit of TRNP in western North Dakota (Fig. 1). Originally created as Theodore Roosevelt National Memorial Park in 1947, the name was changed to Theodore Roosevelt National Park in 1978. The Park consists of a South Unit (SU), located in southwest North Dakota near Medora, and a North Unit (NU), located 80 km north of Medora. The SU covers 18,756 hectares and is surrounded by Forest Service land intermixed with private holdings.

Geology

Geological features of TRNP have been described in detail by Laird (1950) and Hanson (1980). Both units of the Park are comprised of unglaciated badlands topography bisected by the Little Missouri River. The badlands were formed by the down cutting of the Little Missouri River and its tributaries into the soft sedimentary rock of the Great Plains upland prairie. Relics of the upland prairie still exist as grassland plateaus and buttes in the badlands.

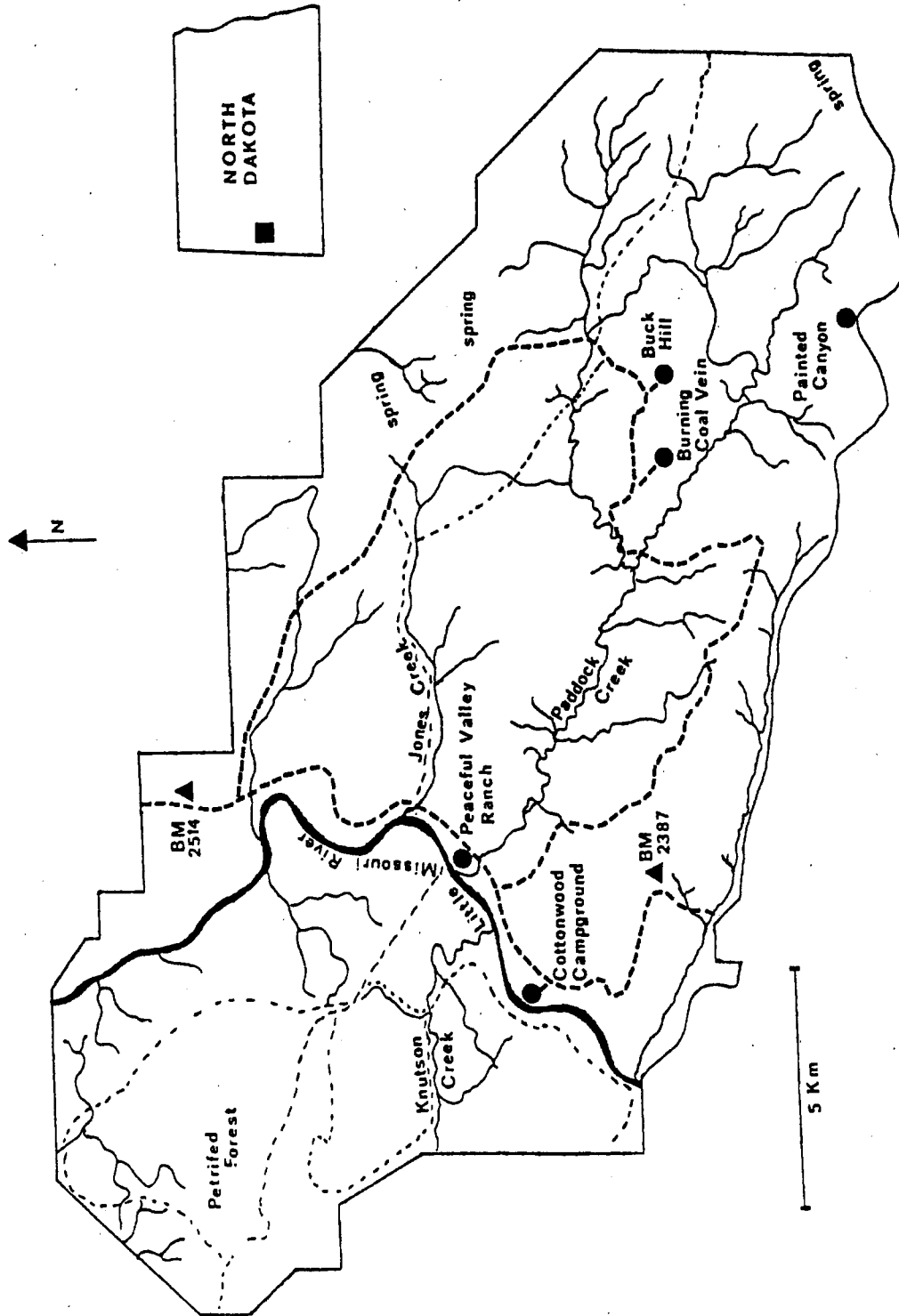


Figure 1. Map of South Unit, Theodore Roosevelt National Park.

Climate

Climate for Western North Dakota is Continental, characterized by short arid summers ($\bar{x}$ July Temp.= 22 C) and long cold winters ($\bar{x}$ Jan. Temp.= -11 C). Average annual rainfall is about 35.5 cm, most of which occurs in spring and summer in the form of thunderstorms (TRNP Resource Management Plan and Environmental Assessment 1984).

Vegetation

Detailed descriptions of vegetation and habitat types in or adjacent to TRNP are given by Nelson (1961), Whitman (1978), Hanson (1980), Girard (1985), and Hirsch (1985). Vegetation in this area is considered to be mixed grass prairie. The combination of mixed grass prairie and the rugged topography of the badlands has resulted in a mosaic of habitat types in TRNP. Norland (1984) used two schemes to describe vegetation in TRNP. A system of physiographic/vegetational classes was developed based on terrain form and vegetational structural characteristics. The Park was also classified by habitat types. The habitat type system followed Whitman (1978), Hanson et al. (1980), Hirsch (1985), and Girard (1985). Disturbed areas or early stages of succession were classified as mapping units. Appendix A gives descriptions of physiographic

vegetational classes, habitat types and mapping units in the Park.

Areas having very small intermixed habitat types or mapping units were classified as complexes (Norland 1984). The three complexes in the South Unit and the percent of each habitat type (HT) or mapping unit (MU) making up each one is shown in Appendix A.

Land Use

Domestic livestock grazing and mineral development (oil and gas) are principle land uses in the badlands surrounding TRNP. This country was originally homesteaded in the late 1800's, but the federal government reacquired much of the land following the 'dust bowl' years of the 1930's (J. Bradybaugh pers. comm. 1987). TRNP is situated mostly on reacquired land set aside for a state park and recreation demonstration area before the establishment of a national park in 1947 (J. Bradybaugh pers. comm. 1987).

METHODS

Distribution and Movements

Four elk, two males and two females, were equipped with radio-collars prior to the release of elk into TRNP in March 1985. Two of these elk were recaptured and fitted with new radio-collars in March 1986, using a net gun fired from a helicopter (Barrett et al. 1982). A yearling bull was also radio-collared at this time. All radio-collars were color coded and the yearling bull was eartagged. Four additional animals (one bull and three cows) were captured with a net gun in March 1987 for the second phase of this study. Color coded radio-collars were placed on these elk and the ear tag number from each elk was recorded.

Each radio-collared animal was relocated from the ground during summer and fall 1985 and spring and summer 1986 using a 2-element pack antenna or a 3-element Yagi antenna. The locations and daily movements of all elk observed were plotted on 1:24,000 topographic maps. In June 1985, a fixed winged aircraft equipped with a 3-element Yagi antenna was used to locate two elk which had moved out of the Park. Attempts were made to relocate these elk during subsequent flights in summer and fall 1985 by a researcher working on a mule deer study south of the

Park using the same aircraft and equipment. (B. Jensen pers. comm.).

Nocturnal movement patterns of elk were investigated during five 12-hour night radio relocation periods in summer 1985, three in fall 1985, and five 24-hour radio relocation periods in summer 1986. Two to three 5-meter towers, each equipped with two 3-element Yagi antennas, were used during these periods. Radio-collared elk were located at 1/2-hr intervals by an observer at each tower. Radio relocation bearings from each tower were plotted on a 1:24,000 topographic map and locations for radio-collared elk were determined by triangulation. Correction factors were determined from visual sightings of radio-collared elk during relocation periods.

A survey of pellet groups on trails was conducted in August 1986 to aid in determining yearlong distribution of elk in TRNP. The Park was divided into 9 sections and all pellet groups were noted on 8 to 14 km of trails walked in each section.

Seasonal and annual home range sizes were determined using the Telday computer program developed by Terry N. Lonner, Mont. Dept. of Fish, Wildlife and Parks, and D. E. Burkhalter, Envirotech Consulting. Telday determines home range size by forming a minimum convex polygon (Mohr 1947) using animal relocations on the perimeter of all relocations (Burkhalter 1983). Total home range sizes were

calculated by using all the relocations for each radio collared animal during this study.

Population Dynamics

Complete or near complete ground counts of elk in the Park were obtained in September 1985, March and August 1986, and January 1987. At these times the elk had either coalesced into one large group or into separate bull and cow/calf groups. Age and sex composition was noted during these observations.

Habitat Use

Habitat use was determined by observation of elk during 1 to 6 hour diurnal observation periods. Elk were observed with 7x35 mm binoculars and a 15-60X spotting scope. Elk were observed at distances of 200-4000 m.

The following information was collected at 5-minute intervals during the observation period: 1) the location of elk (plotted on 1:24000 topographic maps); 2) the number of cows, bulls, and calves observed; and 3) the activity and habitat use of animals in each sex and age class. Activity was classified as feeding, bedding, moving, standing, other, or unknown. Other included grooming, nursing, mating activity, and other social behavior.

In many instances the habitat type being utilized by elk was identified in the field during the observation

period. If this was not possible, the habitat type was determined by overlaying a habitat type map (Norland 1984) over a topographic map of the Park on which the location had been marked.

Although observations were made throughout the day, the tendency of elk to occupy dense cover during midday hours resulted in low numbers of observed elk in wooded habitat types during midday hours. To minimize this bias against woodland habitat use, wooded draws were observed during periods when elk were not visible but had been observed moving into the draw. If elk could not leave the draw without being observed, elk activity within the draw was classified as unknown and notes were included in habitat use analysis.

Projected 24-hour habitat use was estimated from data obtained during night radio-relocation of elk and from daytime observations taken during the first hour of light in the morning and the last hour of light in the evening.

Spearman's Rank Correlation test (Snedecor and Cochran 1980) was used to test differences in availability and habitat use. Differences in availability and habitat use of individual habitat types and physiographic classes were tested using Bonferroni's inequality test (Byers and

Steinhorst 1984). The Chi-square test for independence (Zarr 1984) was used to test for differences in habitat use between age and sex classes of elk.

Elk Impacts On Vegetation and Other Herbivores

Vegetation

Twelve permanent vegetation transects were placed in hardwood and in Rocky Mountain juniper (Juniperus scopulorum) draws in summer 1985. Half of the transects were placed in or near regions heavily utilized by elk. The rest of the transects were placed in regions of the Park which the elk were not expected to reach by summer 1986. These transects were measured in summer 1985 and 1986 to determine changes attributable to elk. Additional transects were established in summer 1986 in cottonwood (Populus deltoides) draws and in open, shrubby habitats along hillsides.

Transects placed in hardwood, juniper, and cottonwood draws were 20 m long and marked with metal stakes. Canopy coverages of all grasses, forbs, and shrubs less than 50 cm in height were estimated at 1-m intervals along each transect using 2x5 dm plots (Daubenmire 1959). Canopy coverage was estimated only for plants growing within the plot. Because canopy coverage was estimated for plant strata up to 1-m in height, total canopy coverage may exceed 100% within a plot. Canopy coverage classes were:

class 0 = 0%; class 1 = >0-1%; class 2 = 1-5%; class 3 = 5-25%; class 4 = 25-50%; class 5 = 50-75%; class 6 = 75-95%; and class 7 = 95-100%. The percent canopy coverage of each plant species for individual transects (Appendix E) was calculated by summing the midpoints of canopy coverage classes recorded by individual plots and dividing by 20 (the number of plots/transect). Canopy coverage for hardwood draws within and outside elk use areas (Appendix D) was calculated by averaging the mean canopy coverage for individual transects located either within or outside the range of elk in the Park.

Shrub (woody vegetation <2 m in height) density was measured in seven 1-m² plots spaced 3 m apart along the transect. The number of individual shrubs by species in three height classes were counted within each 1-m² plot. Height classes were: 1 = 0-50 cm; 2 = 50-100 cm; and 3 = 100-200 cm.

Utilization of annual growth in individual shrubs was classified as: light = <10% browsed; moderate = 10-50% browsed; and heavy = >50% browsed. The percent utilization of each plot was calculated by averaging the midpoints of the utilization classes for individual shrubs of each plant species. Summing the percent utilization of each species for all plots within a transect and dividing by 7, the number of plots within a transect, gave percent utilization for individual species within a transect (Appendix E).

Total utilization for each species within and outside elk use areas (Appendix D) was calculated by averaging the mean utilization values for individual transects within or outside the range of elk in TRNP.

Sapling and tree densities were measured in a 60-m² plot parallel to the transect base line. Saplings were classified as woody species >2 m, but having a dbh (diameter at breast height) <10 cm. Woody species >2 m having a dbh >10 cm were classified as trees. The total numbers of individual sapling or trees by species within the 60-m² plot were recorded. We also noted whether the sapling or tree had vegetation available for elk or deer use (leaves and stems less than 2-m from the ground) and if this material had been utilized. We did not classify the percent of utilization. Means for transects in areas used by elk and areas not used by elk were calculated in the same manner as that described for shrubs.

Open, shrubby habitats were sampled using a 30-m line. The line intercept technique (Canfield 1941) was used to obtain canopy coverage for low shrubs. Herbaceous cover was measured using 2x5 cm microplots at 1-m intervals along the transect. Basal coverage was recorded in the microplots using the same classes as those used for 2x5 dm plots in wooded areas.

Scientific plant names used are from the USDA 1982 National List of Scientific Plant Names. The Chi-square

test for independence was used to test differences in utilization of saplings and shrubs between transects and years.

Other Herbivores

Locations of mule deer, bison, feral horses, and white-tailed deer sighted while observing or searching for elk were plotted on 1:24,000 topographic maps. Additional locations were made by driving through the Park in the evenings 2-4 times per month and recording all sightings of animals. Age and sex of these animals were noted when possible. In many cases the physiographic class in which the animals were sighted was noted at the time of the sighting. If this was not possible, the physiographic class was later determined using an overlay of physiographic classes on the Park map.

Spearman's rank correlation test was used to compare similarities in habitat use and diet between large herbivores in TRNP.

Food Habits and Elk Carrying Capacity

Fecal samples were collected for elk, mule deer, white-tailed deer, and feral horses. Samples consisted of 1-g subsamples from 10 different fecal piles. Two samples were collected each season (fall 1985, winter 1985-1986, spring 1986, and summer 1986) from a variety of habitat types used by each species. Samples were frozen, oven

dried, and shipped to the Wildlife Habitat Lab. at Washington State University for microscopic determination of diet composition. Reference samples from 104 plant species collected at TRNP were also shipped to aid in identifying plant fragments in the fecal samples.

Methods used in calculating elk carrying capacity in TRNP are the same as those used by Marlow et al. (1984) for bison in TRNP. In both cases the following formula was used:

$$\frac{TAP_j \times AUF_j \times PF}{PD_j \times YI} = \text{No. of Elk/Year}$$

Where:

- j = the value for the species or plant type under consideration.
- TAP = total annual production for each species or plant type for an average year.
- AUF = allowable use factor - the amount of plant material which can be grazed without affecting plant survival.
- PF = production factor - dependent upon climatic conditions.
- PD = the proportion each plant species or type contributes to the animals diet.
- YI = the amount of forage consumed by an average animal throughout one year.

Our estimates of carrying capacity were based on plant species that comprised >3% of a seasonal diet. Total annual production for common graminoids, forbs, and shrubs have been calculated for grassland habitat types in TRNP by

other researchers. These values are given in Marlow et al. (1984). Production values for shrubs in hardwood draws were determined by clipping 4 plants from each of 2 - 4 size classes (depending upon the species) at 4 sites in August 1986 (Table 1). Values for green ash (Fraxinus pennsylvanica), chokecherry (Prunus virginiana), and serviceberry (Amelanchier alnifolia) were determined during this study. Values for western snowberry (Symphoricarpos occidentalis) and woods rose (Rosa woodsii) are from Butler (1983).

Table 1. Annual production for shrubs in hardwood draws in TRNP, 1986. Production for Rosa woodsii and Symphoricarpos occidentalis is from Butler (1983).

Species	Production (kg/ha)
<u>Amelanchier alnifolia</u>	94
<u>Fraxinus pennsylvanica</u>	559
<u>Prunus virginiana</u>	386
<u>Rosa woodsii</u>	35
<u>Symphoricarpos occidentalis</u>	912
Total	1986

An allowable use factor (AUF) of 0.5 (50% utilization) is used for most cattle grazing schemes (Sampson 1952, Bell 1973). Because maintenance of the Park vegetation rather than maximizing animal numbers was the primary objective of our carrying capacity estimate, we used a conservative AUF of 0.35.

A production factor (PF) was used to adjust the model for year to year variation in weather (Marlow et al. 1984). An average year would have a PF of 1.0, a dry year 0.4, and a wet year 1.5. Because short arid summers are typical in Western North Dakota and we wanted a conservative estimate of carrying capacity to protect vegetation, a PF of 0.4 was used.

Carrying capacity was calculated from the spring and summer diet (Table 2) because grazing during the growing season is most detrimental to plant survival (Sampson 1952, Bell 1973). Perennial grasses which comprised <3% of any seasonal diet were grouped into the perennial grasses category. The annual grasses category was comprised primarily of Japanese brome (Bromus japonicus) and cheatgrass (Bromus tectorum).

The yearly forage intake for an average elk in TRNP was determined by calculating the weight of an average elk in the Park and estimating how much forage an elk of this size would consume. Average weights for Rocky Mountain elk are given in Murie (1951), Boyd (1978), and Byrant and Maser (1982). Weights vary widely between season and locality, but cow, bull, and calf weights average approximately 236 kg (520 lb), 317 kg (700 lb), and 100 kg (220 lb), respectively, during summer. Using the 1986 sex ratio of 36:100:60 (bulls:cows:calves), we calculated an average elk weight of 227 kg (500 lb). This value is

Table 2. Percent contribution of species and food types to the diet of elk in TRNP, 1985-86.

Plant Species	Spring & Summer	Fall & Winter	Yearly Average
Graminoids			
<u>Agropyron cristatum</u>	5.20	0.00	2.60
<u>Agropyron smithii</u>	4.75	11.95	8.35
<u>Bouteloua gracilis</u>	1.38	4.65	3.01
<u>Bromus inermis</u>	5.98	0.00	2.99
<u>Carex</u> spp.	3.33	4.64	3.99
<u>Elmus virginicus</u>	1.38	1.98	1.68
<u>Oryzopsis micrantha</u>	2.13	5.58	3.85
<u>Poa</u> spp.	3.98	8.80	6.39
<u>Schizachirium scoparium</u>	3.15	2.73	2.94
<u>Stipa comata</u>	4.00	8.10	6.05
<u>Stipa viridula</u>	1.95	7.75	4.85
Annual grasses	0.00	0.93	0.46
Perennial grasses	1.92	4.50	3.21
Total Graminoids	42.80	66.24	54.52
Forbs (total)	15.70	0.88	8.29
Browse			
<u>Artemisia frigida</u>	2.30	4.38	3.34
<u>Betula occidentalis</u> ^a	3.05	0.00	1.53
<u>Eurotia lanata</u>	15.80	15.13	15.47
<u>Prunus virginiana</u>	8.23	3.73	5.98
<u>Ribes setosum</u>	1.75	1.53	1.64
<u>Shepherdia argentea</u>	4.25	0.00	2.13
<u>Symphoricarpos occidentalis</u>	2.88	2.45	2.66
<u>Yucca glauca</u>	0.00	3.78	1.89
Browse (<3%)	3.28	1.98	2.63
Total Browse	41.50	32.88	37.19

^aFraxinus pennsylvanica has similar plant fragments and may represent a portion of this percentage (B. Davitt pers. comm. 1988)

probably a slight over-estimate of mean weight, but it serves to keep the carrying capacity estimate conservative.

Information on forage consumption rates for elk is given in Murie (1951) and Nelson and Leege (1982). We estimated average forage consumption to be 1.1 kg/45 kg body weight/day. Therefore, a 227 kg elk would consume 5.7 kg of forage per day or 2086 kg per year.

Carrying capacity was calculated for primary (physiographic classes used more than availability), secondary (physiographic classes used in proportion to their availability), and marginal ranges (physiographic classes used less than their availability would indicate). The old river terrace physiographic class was included in the primary and secondary range category although it was not used in 1985-86. This class is found only on the west side of the Little Missouri River and is very similar to grassland physiographic classes heavily used by elk on the east side of the Little Missouri River. When elk eventually move across the river into the west side of the Park, the old river terrace physiographic class is expected to be heavily used.

Total production for forage items was calculated by multiplying production/ha X the area for each habitat type or mapping unit. These values were then summed for production on primary and secondary ranges and for marginal ranges. If one species or plant type occurred in 6 habitat types on the primary and secondary range, or on the

marginal range, total annual production would be:

$$\begin{aligned} \text{TAP}_i &= [(\text{kg/ha in H.T.\#1}) (\text{ha of H.T.\#1})] + \\ &\quad [(\text{kg/ha in H.T.\#2}) (\text{ha of H.T.\#2})] + \\ &\quad \dots [(\text{kg/ha in H.T.\#6}) (\text{ha of H.T.\#6})] \end{aligned}$$

where i = species or plant type under consideration.

For example, the number of elk which can be supported by bluegrass (Poa) species on primary and secondary ranges would be determined by first calculating the TAP of blue grass on these ranges:

$\text{TAP}_{\text{bluegrass}}$ = annual production for bluegrass in all habitat types within the breaks, sagebrush bottoms, upland grassland, old river terrace, grassland flats, ridge & ravine, and scoria hills physiographic classes.

$$= 139,470 \text{ kg}$$

Elk/Year				
from		(139,470)	(.35)	(.4)
Bluegrass	=			
Species				
		(.04)	(2086)	= 215

RESULTS AND DISCUSSION

Seasonal Distribution

Sightings of elk in TRNP are shown in Figure 2 for summer and fall 1985, spring and summer 1986, and winter 1986-1987. Distribution was limited to the eastern edge of the Park in summer 1985. Heaviest use occurred in the southeast corner, presumably due to the presence of readily available water from a dish tank maintained for wildlife in this area and the availability of several large hardwood draws which provided both forage and thermal cover.

In early fall, cows and bulls coalesced into a single large herd which remained intact throughout the fall and winter. Although bulls attempted to isolate small bands (harems) of cows during the rut, these efforts were unsuccessful. The herd range increased at this time but remained limited to the eastern half of the Park (Fig. 2).

Several factors may have been responsible for the increase in range, including cooler temperatures, increased availability of surface water, and increased movements associated with rutting activities. The reduced traffic in the Park and the closure of the Park loop road (Fig. 1) in November may have influenced distribution. In late fall elk were frequently observed on and around Buck Hill, an

area heavily used by tourists when the loop road is open. Shultz and Bailey (1978) believed that elk avoided roads in Rocky Mountain National Park when traffic was abundant but this trend was not statistically significant. Morgantini and Hudson (1979) found that a hunted population of elk in western Alberta used large grasslands within sight of roads only between evening and early morning. Elk in TRNP are unhunted and have become habituated to traffic on roads outside the Park. In time elk should also become habituated to traffic within the Park (Ward et al. 1973).

In spring 1986, total elk distribution increased to include areas within the Park loop road near the center of the Park (Fig. 2). The first elk to move into this area were cows which entered in late spring immediately prior to calving. The tendency for pregnant cows to separate from herds before calving is a common phenomenon in elk (Geist 1982).

Cows and yearling bulls remained in one or two large herds along the eastern edge of the Park through early May. Elk formed into small groups shortly after calving in early June and reformed into one or two herds by late summer.

Elk distribution in summer 1986 resembled spring distribution but areas of concentrated use differed (Fig. 2). Distribution was more clumped in the summer, probably as a result of hotter temperatures, decreased water availability, and the presence of calves.

In 1986, elk utilized a summer range over twice as large as the previous summer's range. Reasons for this may include: increased familiarity with the Park, the greater number of elk in the Park during the second year, and increased water availability and cooler summer temperatures in 1986.

Elk distribution increased in western regions of TRNP in winter 1986-87. Elk were observed in two distinct groups during the winter, one comprised of branch antlered bulls and the other of cows, calves, and yearling bulls. The bulls utilized a small area in the southeastern region of the Park, while the large cow herd moved throughout the center of the Park to within several kilometers of the Little Missouri River on one occasion. No elk were seen or reported along the Little Missouri River or west of the river.

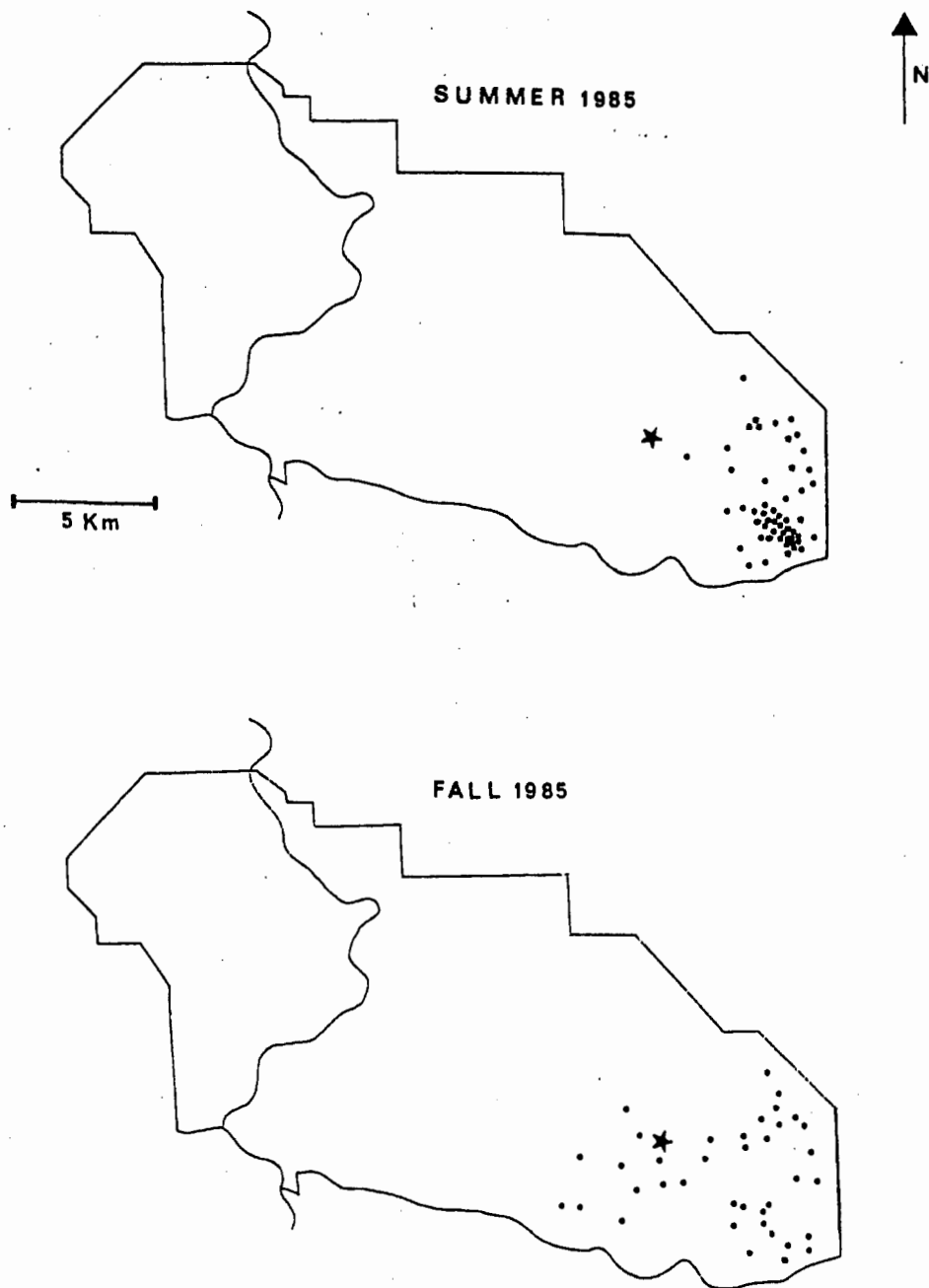


Figure 2. Seasonal distribution of elk in TRNP, 1985-87.
★ = release site of elk

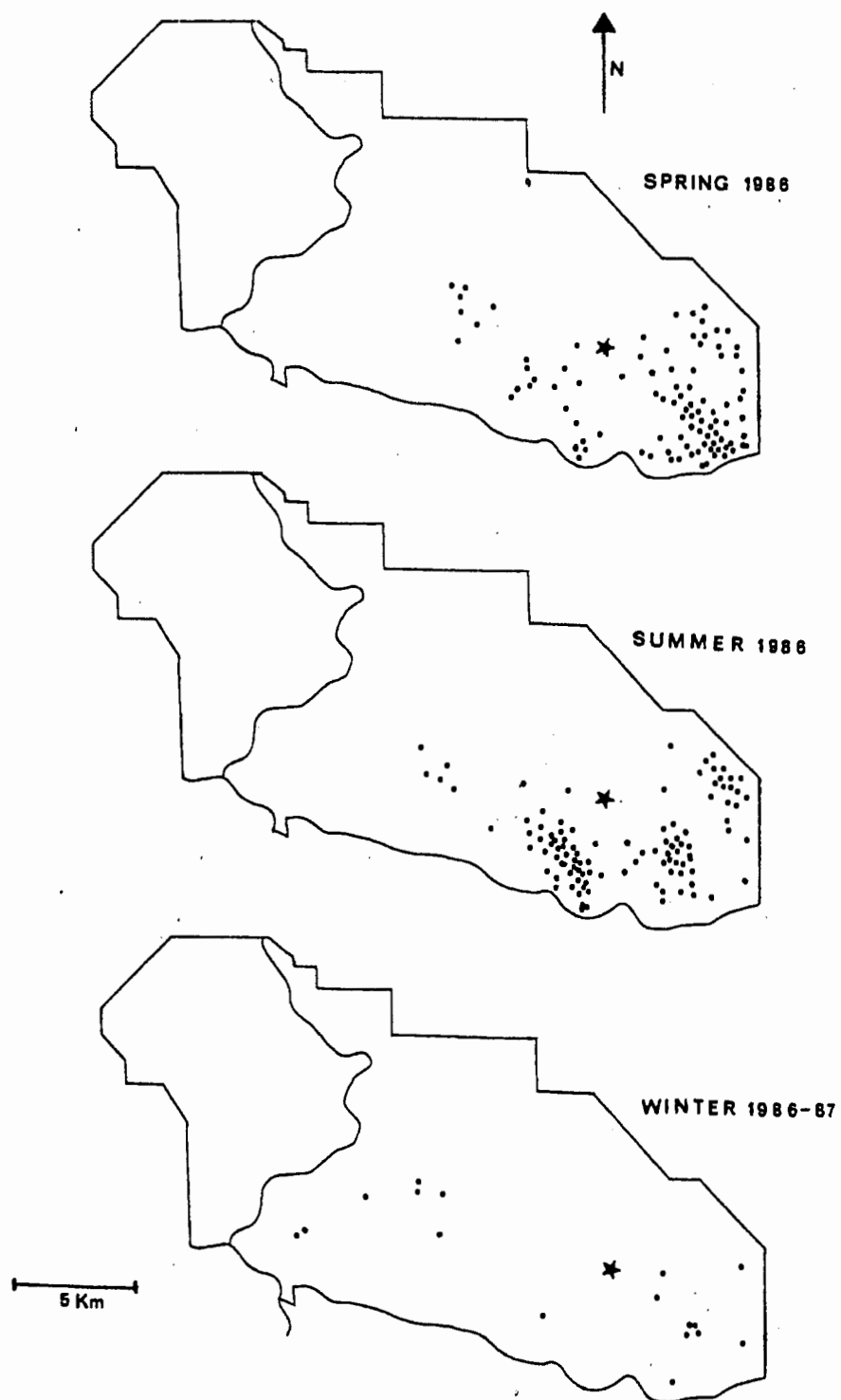


Figure 2. Continued

Annual Distribution By Sex

Bull distribution within TRNP was identical to cow distribution during 1985 (Fig. 3). This may have been due to the young age of bulls in the Park. Of the nine bulls released into TRNP, eight were 2-year-olds and one was a yearling. Bulls belonging to these younger age classes (especially yearlings) tend to associate with cow herds (Geist 1982). In addition, no radio-collared bulls were present in TRNP during summer, making bull observations dependent upon random sightings and sightings of bulls associating with cow herds.

Two bulls were equipped with radio-collars before their release into TRNP, but these animals escaped from the Park prior to the study. Both bulls were located outside the Park on July 15, 1985 from a fixed-wing aircraft. One bull, 8047, had moved approximately 45 km south of the Park to a location near Amidon, ND. This bull was relocated on July 25 in the same area, but other attempts to relocate him during the summer were unsuccessful. The second bull, 8001, was located approximately 3 km south of the Park. Although he was visually observed only on July 15, his signal was picked up in this same area throughout the summer. Several attempts were made to relocate these elk during the summer and fall by a mule deer researcher from a fixed-winged aircraft (B. Jensen pers. comm.); however,

only radio signals from the bull nearest the Park, 8001, could be picked up.

On September 16, bull 8001 moved back into the Park through a gate opened by TRNP personnel. This movement to rejoin the Park elk apparently resulted from the absence of cow elk outside the Park during the rut. No further information is available on bull 8047. The inability to relocate this animal from a fixed-wing aircraft after July 25 may have been due to radio-collar failure or a long distance movement (>50 km) by this elk.

Annual distribution for both cows and bulls increased in 1986 (Fig. 4); however, bull distribution never increased to include areas near the center of the Park. Bulls remained with the cow herd throughout early spring but separated from the cows by midspring, during antler shedding. Only yearling bulls with cow herds were observed using areas near the center of the Park.

Branched antlered bulls remained separated from cow herds during the second summer. Bull use was concentrated in the northeast corner of the Park, while cow use was concentrated in southeast and southcentral regions (Fig. 4) Varland et al. (1978) reported that elk in Wind Cave National Park in South Dakota were organized into as many as six individual herds, comprised of either cows or bulls, which utilized different regions of the Park.

By late August 1986, bulls began to associate with large cow herds. This coincided with the beginning of rutting activities (antler rubbing and bugling) in older bulls.

In winter 1986-87, bulls remained in a small group distinct from the large winter cow herd. This pattern is consistent with reported behavior patterns of adult bull elk (Knight 1970, and Varland et al. 1978, and Geist 1982).

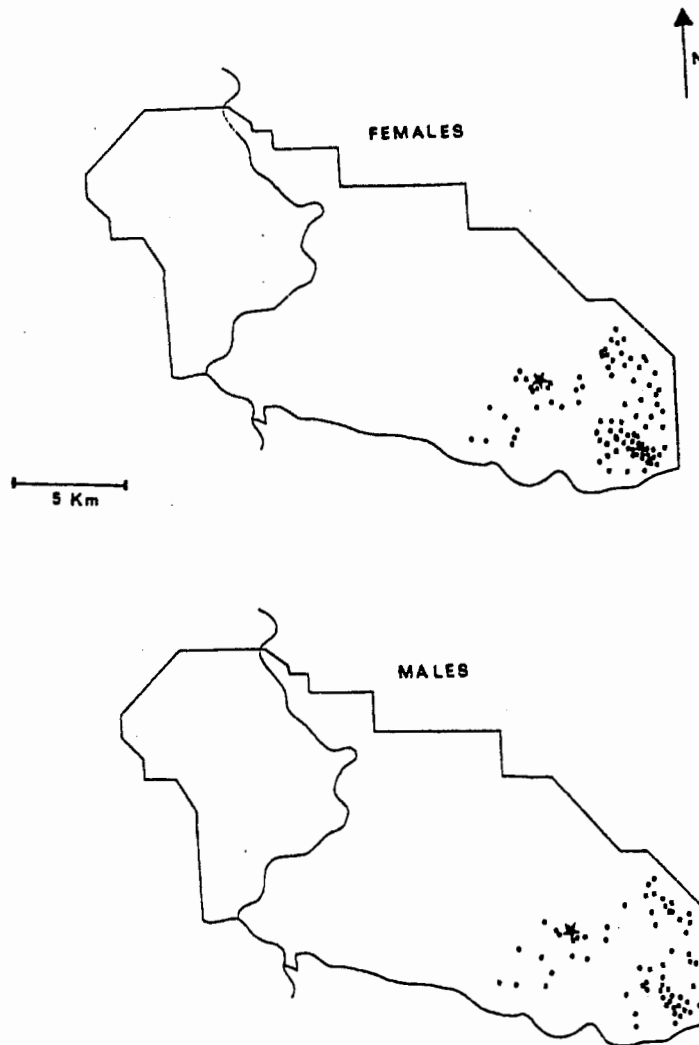


Figure 3. Locations of marked elk in TRNP, 1985.
★ = release site of elk

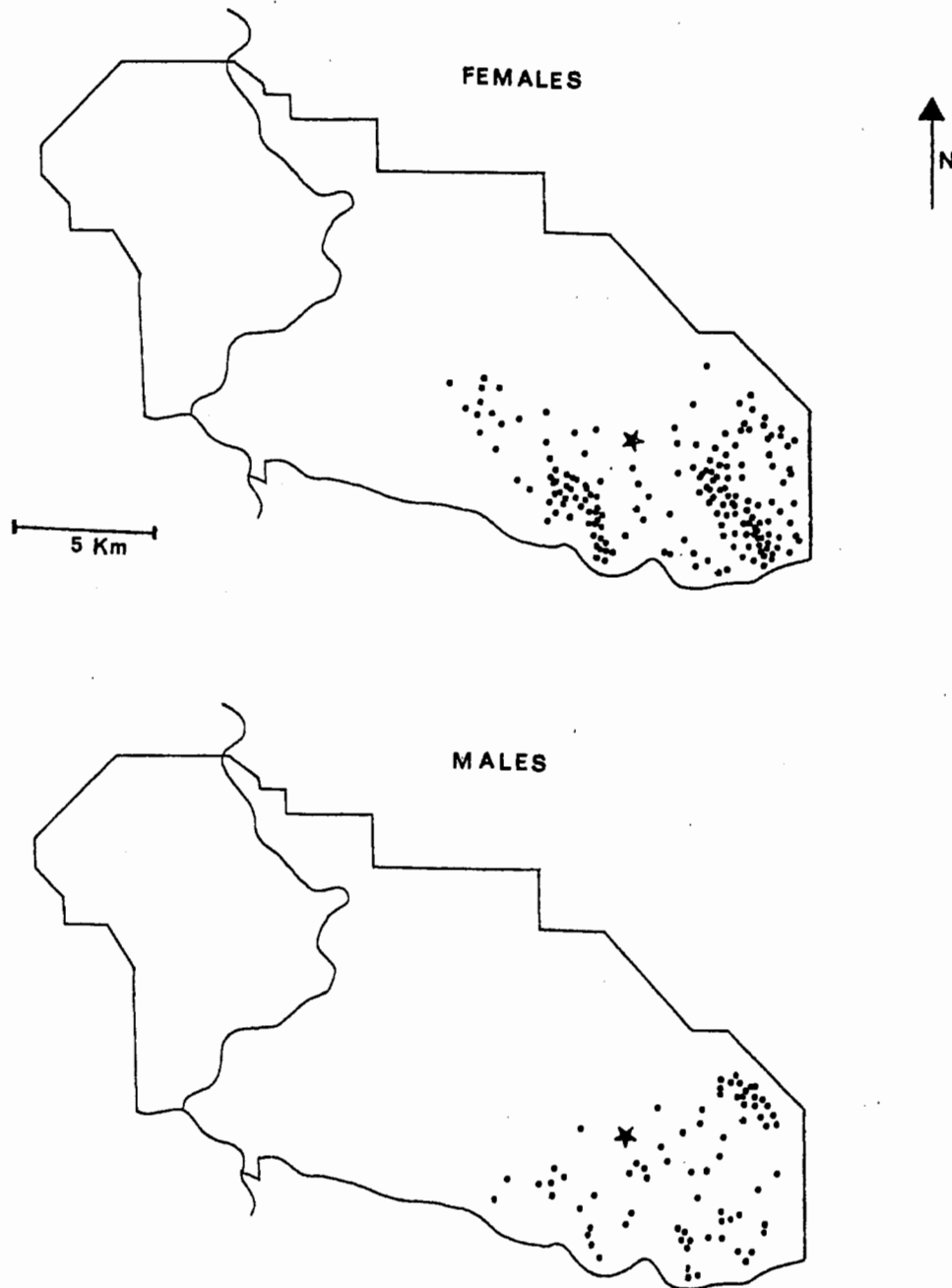


Figure 4. Locations of marked elk in TRNP, 1986.
★ = release site of elk

Home Ranges

Seasonal, annual, and total home range sizes for radio-collared elk are given in Table 3. Seasonal and annual home range sizes were calculated for one nonradio-collared elk, a yearling (spike) bull in 1985. Total home range size was calculated for each radio-collared elk by combining annual home ranges for 1985 and 1986.

The smallest seasonal home range for all animals occurred in summer 1985, when elk were concentrated along the eastern edge of the Park. Home range size increased in fall as movements and elk distribution in TRNP increased. Elk remained in one large herd in fall, resulting in similar home range sizes for all marked animals.

In spring 1986, home range size decreased slightly for 8001 and 8004, but remained the same for 8032. This may have been due to the failure of the radio-collars on 8004 and 8001 during the previous fall and winter, resulting in fewer relocations in spring of these elk (25 and 26 relocations respectively, compared with 34 for 8032). Both 8004 and 8001 were fitted with new radio-collars in late May.

Summer home range size was calculated for 8032, 8004, 8001 and 0001, a yearling bull which was radio-collared in May. The larger summer ranges for 8032 and 0001 were due to movements of these elk to the center of the Park where

Table 3. Seasonal, annual, and total home range sizes (km²) for marked animals in TRNP during the study. Number of relocations (N) are given in table.

Animal I.D.	Sex	Age ^a	Summer 1985		Fall 1985		Total 1985		Spring 1986		Summer 1986		Total 1986		Total 1985-87	
			Size	N	Size	N	Size	N	Size	N	Size	N	Size	N	Size	N
8032	F	A	17.0	28	31.6	37	34.6	69	34.5	35	53.4	36	63.1	75	95.4	152
8004	F	A	15.7	30	30.3	30	31.8	60	24.0	25	21.6	31	30.9	58	66.9	126
3976	M	Y	12.1	20	29.8	27	32.7	48							34.1	68
0001	M	Y									32.1	30	35.5	40	55.6	47
8001	M	A			32.2	38	32.2	42	27.3	24	26.8	23	35.2	51	42.2	100
0002	M	A			30.1	24	30.1	24								
Total ^b		All	17.0	28	32.8	156	34.9	243	51.2	102	64.8	126	75.0	244	98.1	517

^aA = Adults (>1 yr), Y = Yearlings (<1 yr)

^bCombined home range of all marked elk

they were observed with a small band of cows and calves. Elk 8004 was observed with a calf at this time which may have restricted her movements. Elk 8032 had a calf in 1985 but none in 1986.

Home range size for 8001, a 3-year-old bull, remained the same for spring and summer 1986 (27 km²). This bull had the smallest seasonal and annual home range of all radio-collared elk in TRNP. The small annual home range size of this bull and the limited distribution of bulls in the Park contrasts with the large home ranges for which bulls are generally noted with respect to cows. Knowles (1975) found that radio-collared bull elk in the Missouri River Breaks region of eastern Montana had annual home ranges up to twice as large as radio-collared cow elk.

Table 4. Percent overlap between combined overall home ranges of marked elk in TRNP 1985-87.

Animal I.D.	Animal I.D.		
	8032	8004	8001
8004	97		
8001	59	60	
0001	80	83	74

Annual home ranges of all marked elk overlapped extensively (Table 4). The least overlap occurred in the case of 8001, an adult bull, due to the separation between bulls and cows in 1986. Two adult cows, 8032 and 8004, had

the greatest overlap (97%). Elk 0001, a yearling bull, overlapped more with the adult cows than with 8001. Distribution of radio-collared elk closely matched total elk distribution in the Park for the duration of this study (Fig. 5).

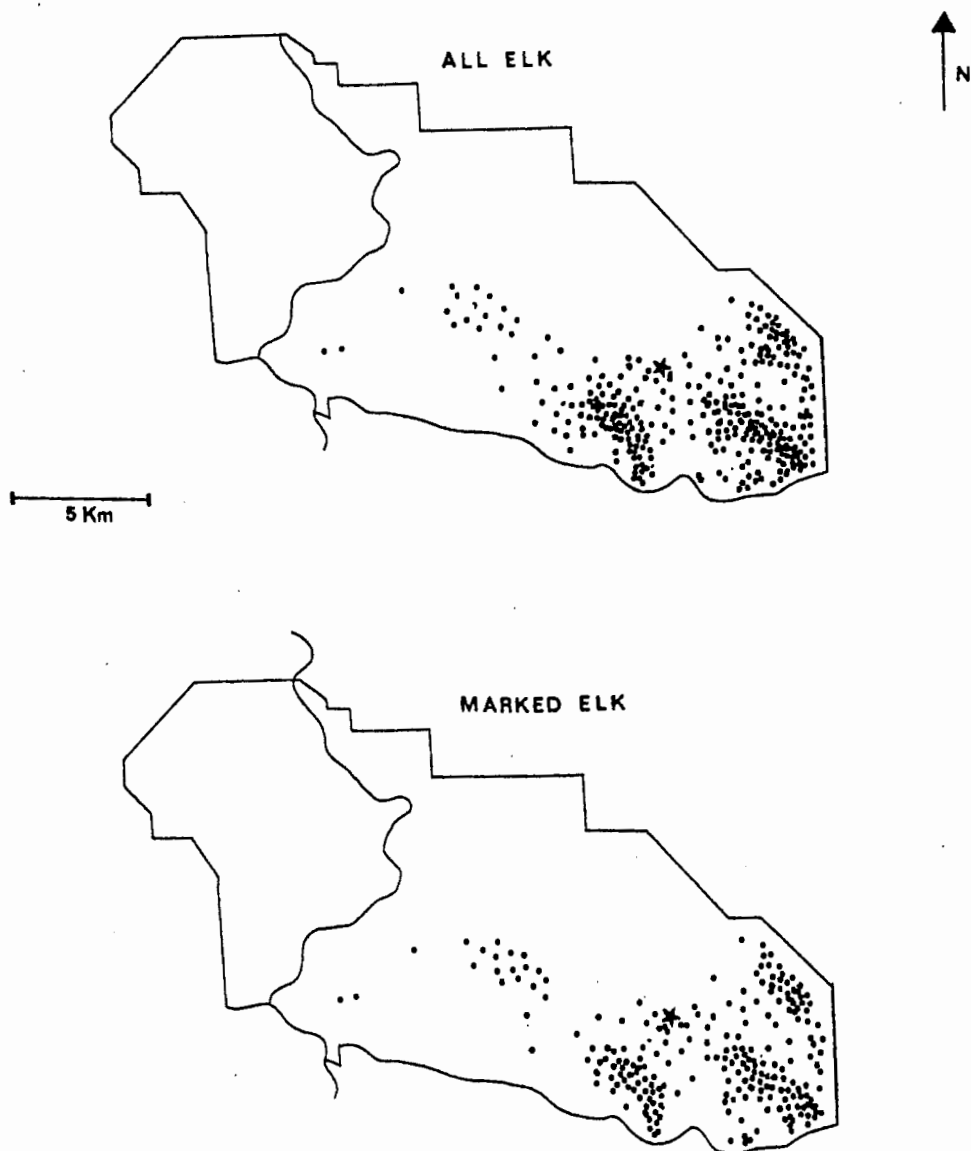


Figure 5. Sightings of all elk and marked elk in TRNP 1985-87.

★ = release site of elk

Pellet Group Survey

In August 1986, a survey of pellet groups on trails was conducted to determine if observations of elk associating with radio-collared animals sampled all major use areas in TRNP. Pellet group distribution closely matched estimates of distribution based on sightings (Fig. 6).

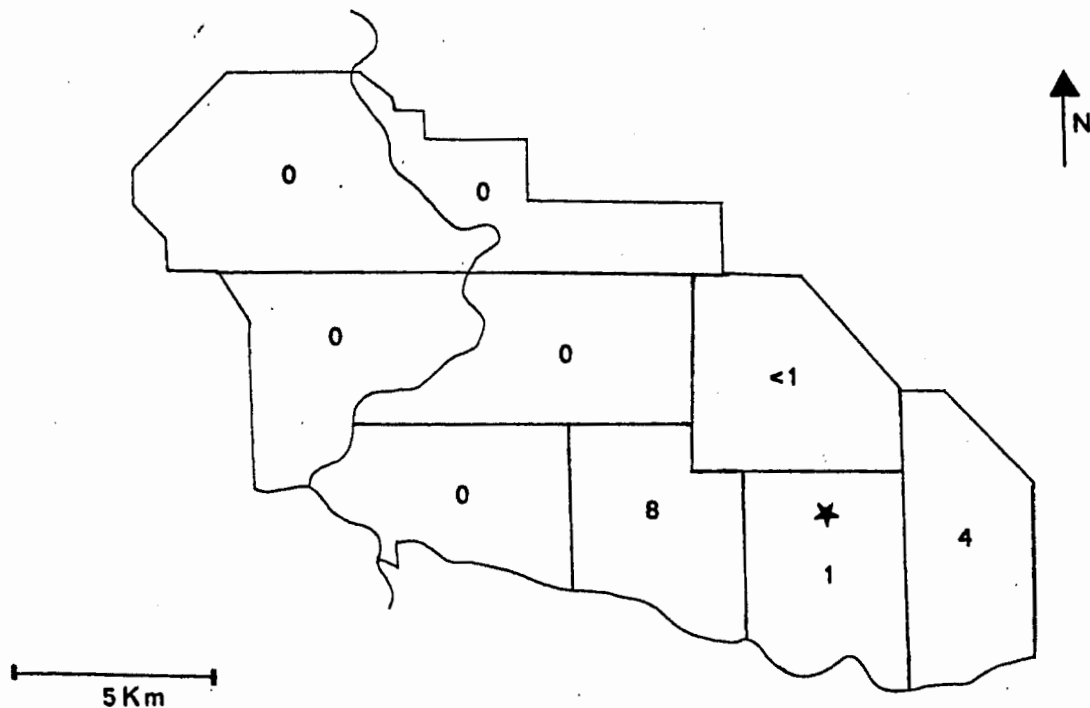


Figure 6. Trail survey of pellet groups in TRNP, 1986.
Numbers in sections = pellet group per km
★ = release site of elk

Population Dynamics

Elk have increased from 47 to 80 animals in TRNP during the two years following their introduction (Table 5). Calf production in 1985 and 1986 contributed at least 41 animals to the population, 16 calves in 1985 and 25 in 1986. A few elk have escaped from the Park. In 1985 four elk, two radio-collared bulls, a cow, and a calf, were reported outside the Park. At least one of these elk, a radio-collared bull reentered the Park in September. In spring 1986, two sightings, involving one to two elk outside the Park, were reported. One of these animals was observed to have a Park eartag (B. Jensen pers. comm. 1986). In fall 1986, five to six elk were reported outside the Park by hunters and local ranchers. Some of these elk may have been migrants from a resident elk population near the North Unit of TRNP.

The cow-calf ratio in September 1985 was 45:100. This is less than expected for an area devoid of large predators; however, conception occurred the previous fall in Wind Cave National Park and at least one abortion occurred during the holding and transportation of elk prior to their release into TRNP (J. Bradybaugh pers. comm. 1986). In September 1986, the cow-calf ratio was 60:100, indicative of a highly productive herd.

Table 5. Population structure of elk introduced into Theodore Roosevelt National Park.

Census period	Males (>1yr)	Females (>1yr)	Calves	Total
March 1985 (Transplant)	8	36	3	47
September 1985				
In TRNP	8	37	16	61
Outside TRNP	1	1	1	3
Total	<u>9</u>	<u>38</u>	<u>17</u>	<u>64</u>
March 1986				
In TRNP	8	37	16	61
Outside TRNP		1		1
Total	<u>8</u>	<u>38</u>	<u>16</u>	<u>62</u>
August 1986				
In TRNP	15	41	25	81
Outside TRNP ^a		1		1
Total	<u>15</u>	<u>42</u>	<u>25</u>	<u>82</u>
January 1987				
In TRNP	15	(65 Females and Calves)		80
Outside TRNP ^b				
Total	<u>15</u>	<u>(65 females and Calves)</u>		<u>80</u>

^a Five to six elk were reported outside TRNP during autumn and could have been outside the Park during August.

^b No elk were reported outside TRNP during Winter 1986-87.

Activity and Behavior Patterns

A total of 80977 minutes were used to describe activity patterns. Feeding and bedding were dominant diurnal activities. Standing, moving, and other made up a small fraction of total activity. Craighead et al. (1973) found that nonmigratory elk in Yellowstone National Park spent 44.3% and 45.8% of their time feeding and bedding, respectively, in a 24-hr period. In this study, 49% and 41% of elk minutes recorded were spent feeding and bedding, respectively, during daytime periods. Because elk tended to bed in wooded areas and feed in open grasslands, feeding is believed to be overestimated and bedding underestimated. Feeding was predominant during early morning and evening while most bedding occurred in late morning and early afternoon (Fig. 7).

Nocturnal activity monitoring, during 12-hr and 24-hr triangulation periods, indicated that elk spent approximately equal amounts of time active and inactive at night. An inactive signal probably indicated that elk were bedded. Active periods were presumably dominated by feeding.

In summer and fall, feeding reached a daily low at midmorning (Figs. 8 and 9). This was especially noticeable in fall when only 21-34% of all elk minutes were spent feeding from 0800-1155, and 51-73% of elk minutes were

spent bedding. In both these seasons, a small peak in activity, lasting 1-2 hrs, occurred in the early afternoon.

Feeding declined throughout the morning to an early afternoon low (1200-1255) during winter and spring (Figs. 10 and 11). In winter, feeding increased steadily throughout the afternoon to an evening peak. Afternoon feeding and bedding patterns in spring were highly variable but also showed an evening peak in feeding.

Moving, standing, and other activities peaked in the early morning and late evening (Figs. 7-11). Moving was closely related to feeding and coincided with movements of elk between bedding and feeding areas. Decreased movement during the fall and winter resulted from elk bedding in open areas on cool days.

The other activity category consisted primarily of social behavior and was low during all seasons. No peak in other, standing, or moving was observed in fall when social activities are usually highest as a consequence of the rut (Geist 1982). This may be the result of the low number and young age class of bulls in the Park during the first year of the study (seven 2-yr-old bulls). Although rutting activities (sparing, cow chasing, etc.) were frequently observed in early fall, these activities dropped off quickly following a peak in late September. By mid October, sparing was only occasionally observed in bulls.

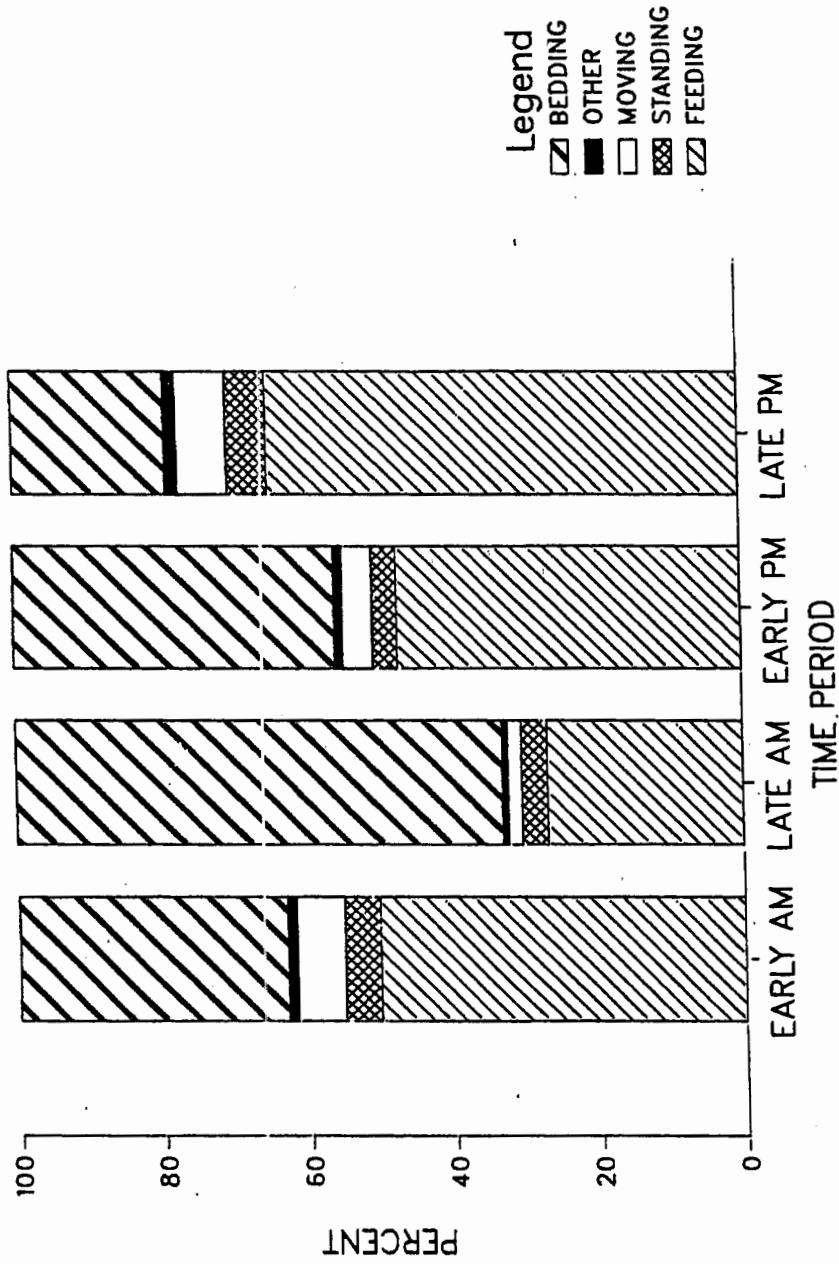


Figure 7. Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP during the study. Two summers are included in data.

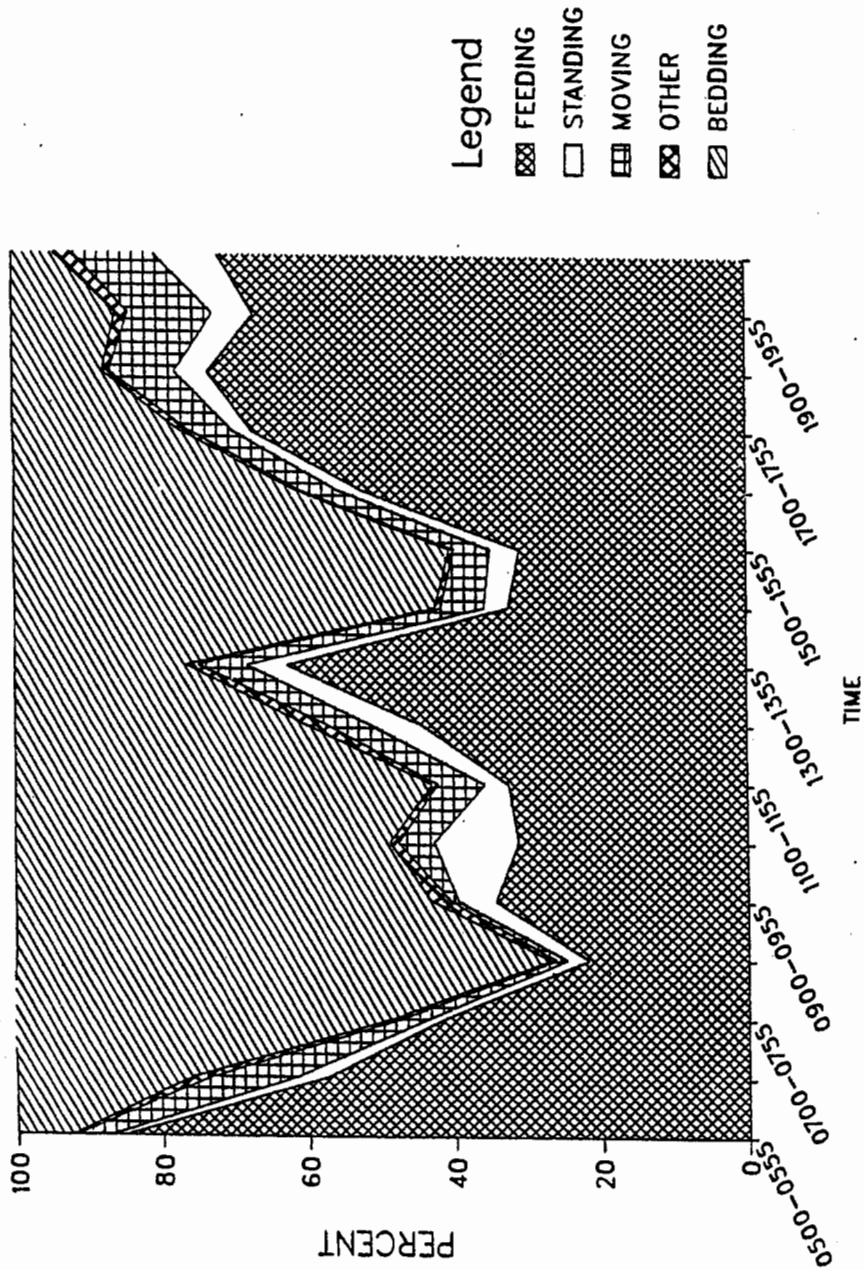


Figure 8. Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in summer, 1985-86.

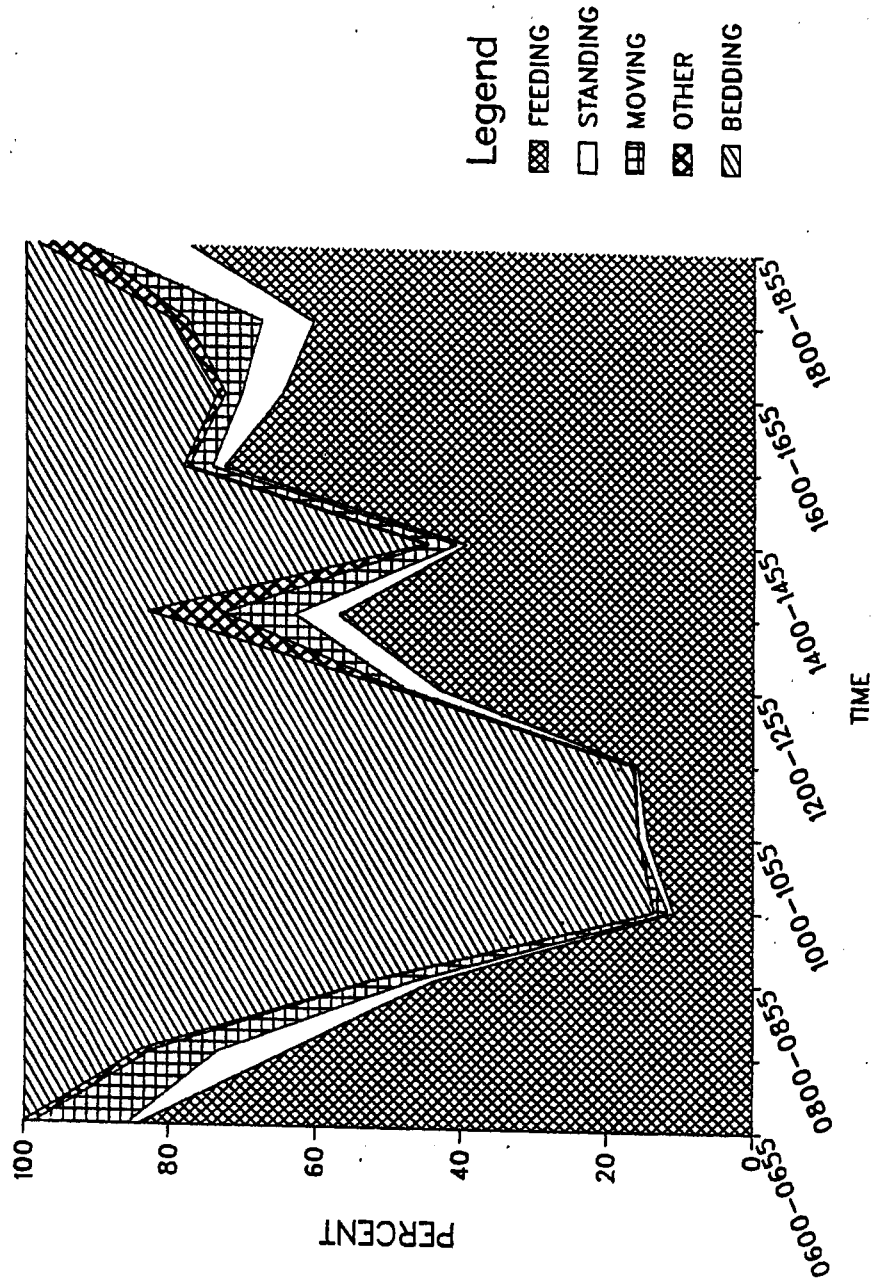


Figure 9. Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in fall, 1985.

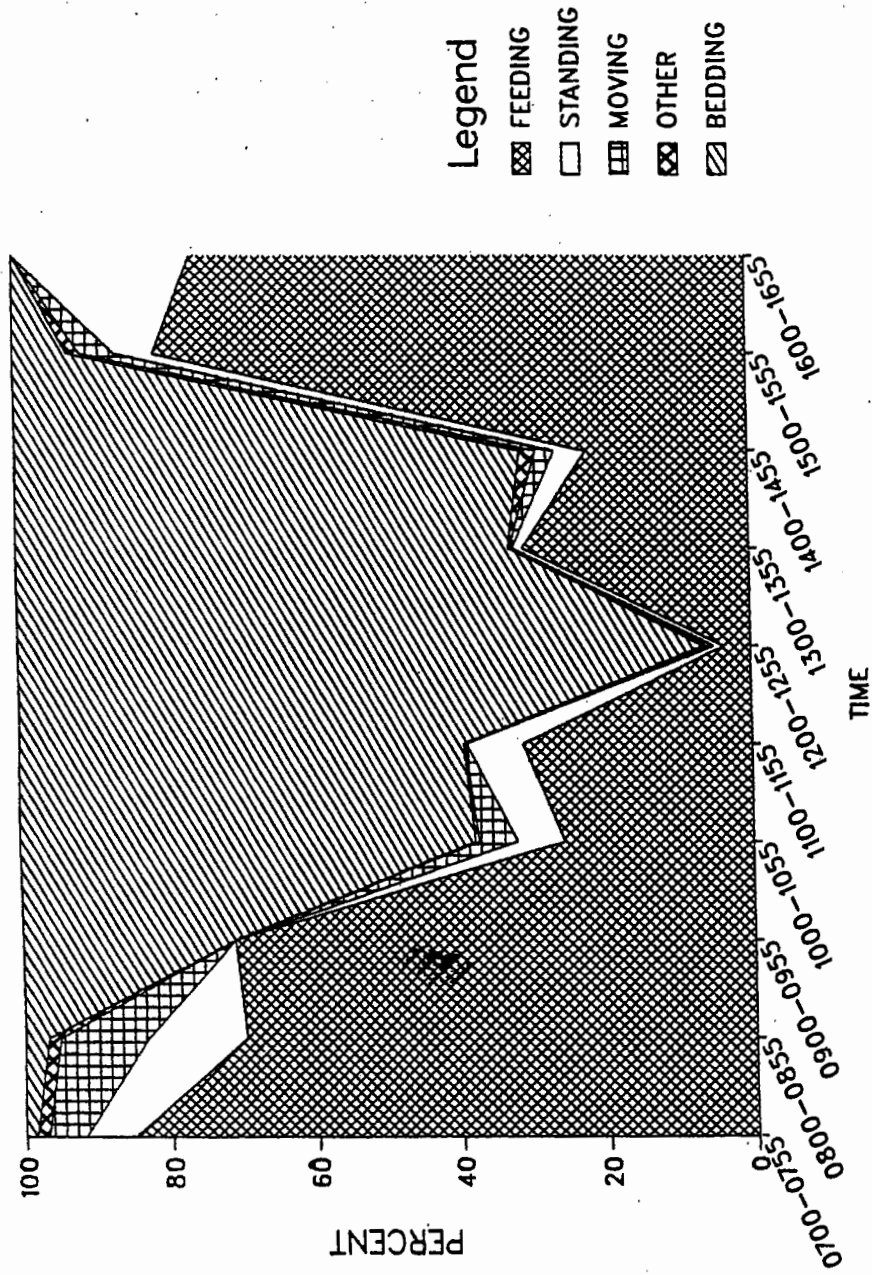


Figure 10. Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in winter, 1985-87.

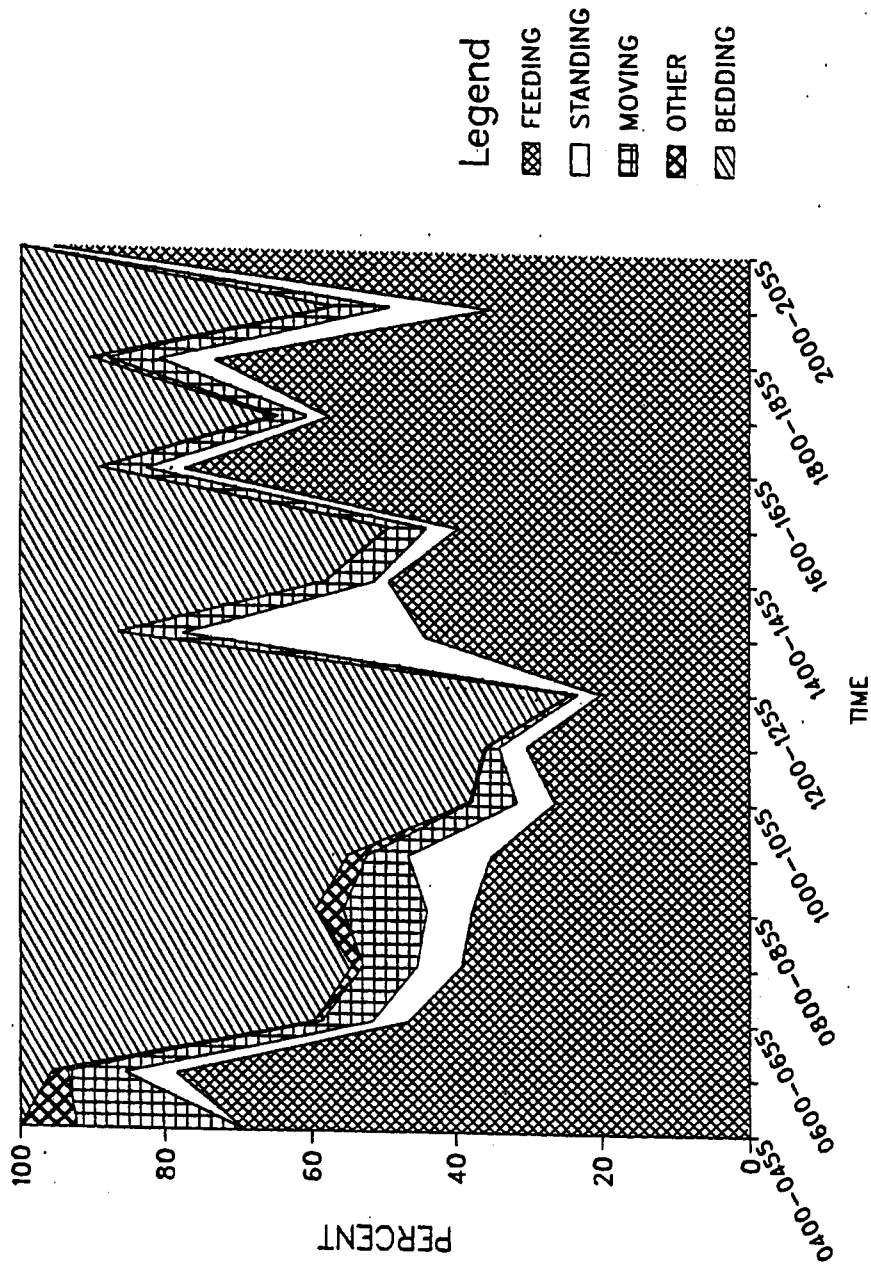


Figure 11. Percent of elk minutes spent feeding, bedding, standing, moving, and other in TRNP in spring, 1986,

Habitat Use

The percent of elk minutes spent in each physiographic class and habitat type for all seasons was calculated for cows, calves, and bulls (Tables 6 and 7). Differences between age and sex classes were not significant ($p > .05$) and data were pooled for further analysis. Diurnal habitat use was calculated from direct observations of elk. Information gathered during nocturnal and 24-hour radio relocation periods indicated that elk utilized the same habitats during the night that they were observed in during early morning and late evening.

Table 6. Percent diurnal habitat use of elk in TRNP 1985-87, for all seasons (including two summers). Number of elk minutes observed is in parentheses.

HT, MU, & Complexes	Cows (80238)	Calves (15685)	Bulls (7836)
<i>Agropyron smithii</i> - <i>Stipa viridula</i>	35	40	31
<i>Agropyron smithii</i> - <i>stipa comata</i>	3	3	3
<i>Stipa comata</i> - <i>Bouteloua gracilis</i>	2	2	3
<i>Artemisia cana</i>	1	2	1
<i>Schizachyrium scoparium</i> - <i>Juniperus horizontalis</i>	1	tr	1
<i>Artemisia tridentata</i> - <i>Atriplex confertifolia</i>	5	6	7
<i>Artemisia tridentata</i> - <i>Bouteloua gracilis</i>	1	tr	3
<i>Schizachyrium scoparium</i>	9	5	6
Hardwood draw	9	13	9
<i>Juniperus Scopulorum</i> - <i>Oryzopsis mircantha</i>	21	17	25
Brush	2	2	3
Introduced grass	1	1	2
Prairie dog towns	1	3	1
Steep scoria complex	6	2	2
Rolling scoria complex	4	4	5
Unvegetated areas	tr	tr	tr

Table 7. Percent diurnal habitat use of elk in TRNP 1985-87, for all seasons (including two summers). Number of elk minutes in parentheses.

Physiographic Class	Cows (80238)	Calves (15685)	Bulls (7836)
Grassland flats	30	30	27
Breaks	39	41	46
Ridge & ravine	6	4	5
Prairie dog town	1	3	1
Upland grassland	14	15	14
Scoria hills	9	6	6
Sagebrush bottoms	1	2	1

Diurnal and projected 24-hour habitat use for all seasons were compared with availability of habitat types and physiographic classes on the east side of the Little Missouri River (Tables 8 and 9). Differences between availability and use were significant ($p < .05$) for both diurnal and projected 24-hour data sets. Use of three habitat types and one physiographic class, prairie dog towns, was proportionate to availability. Most habitat types and physiographic classes were utilized disproportionately relative to availability; however, the broad array of differences may be a function of the limited distribution of elk during their first two years in the Park or the large sample sizes in the Chi-square test rather than actual preference or avoidance of habitats.

Table 8. Percent coverage, diurnal use (%D Use), and projected 24-hr use (%T Use) of habitat types, mapping units, and complexes available to elk in TRNP. Habitat use is for all seasons and includes two summers.

HT, MU, and Complexes	% Coverage	%D Use	%T Use
Agropyron smithii - Stipa viridula	17	35*	43*
Agropyron smithii - Stipa comata	2	3*	7*
Stipa comata - Bouteloua gracilis	2	2	2
Artemisia cana	5	1*	2*
Schizachyrium scoparium - Juniperus horizontalis	2	1*	1*
Artemisia tridentata - Atriplex confertifolia	2	5*	5*
Artemisia tridentata - Bouteloua gracilis	1	1	2*
Schizachyrium scoparium	5	8*	6*
Hardwood Draw	2	10*	7*
Juniperus Scopulorum - Oryzopsis mircantha	2	21*	14*
Introduced grasses	1	1	4*
Prairie dog town	1	1	1
Steep scoria complex	15	5*	4*
Rolling scoria complex	11	4*	5*
Unvegetated areas and river	31	tr*	tr*
Populus tremuloides	tr	tr*	tr*
Brush	tr	2*	2*

* Indicates a significant difference between use and availability at .05 level of confidence.

Table 9. Percent coverage, diurnal use (%D Use) and projected 24-hr use (%T Use) of physiographic classes available to elk in TRNP. Habitat use is for all seasons and includes two summers.

Physiographic Classes	% Coverage	%D Use	%T Use
Grassland flats	14	29*	31*
Breaks	24	40*	30*
Ridge & ravine	14	6*	4*
Prairie dog town	1	1	1
Upland grassland	7	14*	24*
Scoria hills	33	9*	8*
Sagebrush bottoms	5	1*	2*

* Indicates a difference between use and availability at the .05 level of significance.

A consistant yearlong pattern of habitat use was identified. Upland grasslands and grassland flats were heavily used at night and elk were frequently observed feeding in these areas during early morning and evening. Breaks received heavy use during midday hours, especially in late morning when bedding was the dominant activity. This habitat use strategy allowed elk to maximize foraging on productive grasslands during evening when temperatures were coolest. The susceptibility of elk to hot weather (Boyd 1978) and their inherent need for hiding and security cover (Skovlin 1982) favored a move into woodland habitats of the breaks during midday hours. Because this habitat use pattern is based on all observations of elk during the study, it is biased towards summer and winter is poorly represented.

Seasonal Habitat Use

Seasonal habitat use was determined for summer 1985, fall 1985, winter 1985-87, spring 1986 and summer 1986. Table 10 details the starting and ending dates for each season, the number of days elk were observed, and the number of elk minutes recorded. The percentages of elk minutes spent feeding, bedding, and other during each season are given in Appendix B for habitat types and physiographic classes. Appendix C gives the percent of elk

minutes recorded as feeding, bedding, standing, moving, and other during four time periods per season for each habitat type and physiographic class.

Table 10. Season lengths and the number of days and minutes elk were observed each season.

Season	Starting Date	Ending Date	Observations	
			days	Minutes
Winter	Dec. 15	March 15	10	10777
Spring	March 15	June 15	39	27493
Summer ^a	June 15	Sept. 15	32	17044
Summer ^b	June 15	Sept. 15	33	16241
Fall	Sept. 15	Dec. 15	33	32204

^aSummer 1985

^bSummer 1986

A relatively small number of habitat types and physiographic classes were utilized in summer 1985 when elk were concentrated along the east edge of the Park (Tables 11 and 12). Upland grassland and breaks physiographic classes were heavily used throughout the summer. Hardwood draws, included within the breaks physiographic class, were used primarily as hiding and security cover. Little use of adjacent juniper draws occurred.

The number of habitat types and physiographic classes used by elk increased in fall, corresponding to an increase in elk range. Grassland flats replaced upland grasslands as the most heavily used physiographic class.

Table 11. Percent of elk minutes observed in habitat types, mapping units, and complexes for Winter 1985-87, Spring 1986, Summer 1985, Summer 1986, and Fall 1985. The number of elk minutes recorded each season is in parentheses.

HT, MJ, & Complexes	Season				
	Win (10777)	Spr (27493)	Sum 85 (17044)	Sum 86 (16241)	Fall (32204)
Agropyron smithii - Stipa viridula	6	32	39	23	50
Agropyron smithii - stipa comata	9	2	4	4	2
Stipa comata - Bouteloua gracilis	4	2	0	0	3
Artemisia cana	0	1	0	1	3
Schizachyrium scoparium -					
Juniperus horizontalis	2	tr	tr	1	1
Artemisia tridentata -					
Atriplex confertifolia	2	4	1	6	10
Artemisia tridentata -					
Bouteloua gracilis	tr	3	0	2	tr
Schizachyrium scoparium	39	4	5	2	5
Hardwood draw	1	4	44	4	2
Juniperus Scopulorum -					
Oryzopsis mircantha	6	39	4	36	11
Brush	tr	1	tr	1	5
Introduced grass	0	2	1	1	2
Prairie dog towns	0	tr	1	3	1
Steep scoria complex	32	2	0	5	3
Rolling scoria complex	0	3	0	12	3

Table 12. Percent of elk minutes observed in physiographic classes for Winter 1985-87, Spring 1986, Summer 1985, Summer 1986, and Fall 1985. The number of elk minutes recorded each season is in parentheses.

Physiographic Class	Season				
	Win (10777)	Spr (27493)	Sum 85 (17044)	Sum 86 (16241)	Fall (32204)
Grassland flats	41	20	8	20	49
Breaks	19	49	53	50	28
Ridge & ravine	3	10	10	tr	4
Prairie dog town	0	tr	1	3	1
Upland grassland	10	16	29	10	9
Scoria hills	28	5	0	17	5
Sagebrush bottoms	0	tr	0	1	3

Cooler temperatures apparently reduced the need for thermal cover. Although overall use of the breaks physiographic class decreased, use remained high during late morning (Table 13). Rutting activities were observed in the grassland flats physiographic class in early fall. Unlike bison in TRNP, whose mating activities occur primarily in prairie dog towns (Norland 1984), elk did not seek out specific habitats at this time.

In winter, grassland flats and scoria hills received high use, while use of breaks dropped 10% between fall and winter (Table 12). Most feeding occurred in the scoria hills physiographic class. Grassland flats were primarily used for bedding, especially in the Schizachyrium scoparium habitat type. The small sample size of winter observations and mild conditions during these observations limit our confidence in identifying this pattern as typical habitat use.

Use of breaks increased in spring as warmer temperatures presumably caused elk to seek thermal cover (Murie 1951, Boyd 1978, and Skovlin 1982). Juniper draws (Juniperus scopulorum - Oryzopsis micrantha habitat type) provided thermal and security cover for elk; however, difficulty in observing elk resulted in an underestimation of bedding activity in these habitats. Calving evidently occurred in breaks and scoria hills physiographic classes, and 1-2-week old calves were observed in these classes

during early June. Upland grasslands and grassland flats were heavily used for feeding. On cool days, elk would bed in these habitats between feeding periods.

Habitat use changed between summer 1985 and summer 1986 (Tables 11 and 12). Differences were a result of the increased range of elk in 1986 and a switch from use of hardwood draws to juniper draws as bedding areas. Upland grasslands and grassland flats remained important feeding habitats in the evening and early morning, while breaks were heavily used during midday for bedding.

Table 13. Percent of elk minutes spent in grassland flats (GF), breaks (BR), ridge & ravine (RR), prairie dog town (PDT), upland grassland (UG), scoria hills (SH), and sagebrush bottoms (SB) classes each season for four time periods. Total elk minutes recorded per season is in parentheses.

Time Period	Physiographic Class						
	GF	BR	RR	PDT	UG	SH	SB
Winter 1985-87 (10777)							
Early morning	18	9	12	0	10	50	0
Late morning	28	28	0	0	5	39	0
Afternoon	51	25	0	0	4	20	0
Evening	54	14	0	0	23	10	0
Daily	41	19	3	0	10	28	0
Spring 1986 (27493)							
Early Morning	20	49	21	1	22	4	tr ^a
Late Morning	2	78	4	0	13	3	0
Afternoon	28	50	2	tr	10	10	1
Evening	48	15	11	tr	22	2	2
Daily	20	49	10	tr	16	5	1
Summer 1985 (17044)							
Early morning	7	46	15	1	31	0	0
late morning	6	88	6	0	0	0	0
Afternoon	5	63	10	0	22	0	0
Evening	15	25	4	2	54	0	0
Daily	8	53	10	1	29	0	0
Summer 1986 (16241)							
Early morning	15	50	0	0	16	17	1
Late morning	4	70	0	0	2	16	0
Afternoon	2	52	0	12	17	16	0
Evening	52	26	0	4	9	8	tr
Daily	20	50	0	3	10	17	1
Fall 1985 (32204)							
Early morning	36	26	8	0	13	11	7
Late morning	32	50	6	0	9	3	0
Afternoon	60	20	2	3	8	3	4
Evening	72	18	tr	0	4	5	1
Daily	49	28	4	1	9	5	3

^atr = <0.5%

Food Habits

Appendix F lists all forage items identified in fecal samples from elk, mule deer, white-tailed deer, and feral horses. Although discrepancies between fecal content and actual diet undoubtedly exist, we refer to our results as "diet" to avoid awkward phrasing. A summary of elk seasonal diets is given in Table 14. Patterns of forage utilization by elk in TRNP were similar to those found by researchers in areas east of the continental divide (Murie 1951, Mackie 1970, Kufeld 1973, Boyd 1978, Nelson and Leege 1982 and Peek 1982).

Greatest utilization of browse occurred in summer when elk spent most of the long daylight hours in wooded draws. Winterfat (Eurotia lanata) and chokecherry accounted for 19.3% and 10.8% of the total seasonal diet, respectively. Forbs and graminoids each comprised less than one fourth of the summer diet. Other researchers (Mackie 1970, Kufeld 1973, and Nelson and Leege 1982) found forbs to be the most important item in the summer diet. Elk in the Missouri River Breaks of northcentral Montana utilized yellow sweetclover (Melilotus officinalis) so heavily that it comprised greater than one half of the total summer diet (Mackie 1970). Yellow sweetclover abundance varies widely among years and was not common in TRNP during summer 1986 when fecal samples used for diet analysis were collected.

Table 14. Seasonal diet composition (%) for forage items comprising >3% of any seasonal diet for elk in TRNP, 1985-86.

Plant Species	Spring	Summer	Fall	Winter	Yearly Average
Graminoids					
<u>Agropyron cristatum</u>	10.4				2.6
<u>Agropyron smithii</u> <i>mead</i>	5.5	4.0	9.7	14.2	8.4
<u>Bouteloua gracilis</u> <i>grass</i>	1.5	1.3	4.8	4.5	3.0
<u>Bromus inermis</u> <i>grasses</i>	12.0				3.0
<u>Carex filifolia</u> <i>sedges</i>	12.8			14.4	6.8
<u>Carex sprengellii</u> <i>sedges</i>		0.5	4.2		1.2
<u>Elymus virginicus</u>		2.8	3.7	0.3	1.7
<u>Oryzopsis micrantha</u> <i>grasses</i>	4.0	0.3	6.5	4.7	3.9
<u>Poa spp.</u> <i>grasses</i>	5.5	2.5	15.1	2.5	6.4
<u>Schizachirium scoparium</u>	5.7	0.7	0.8	4.7	2.9
<u>Stipa comata</u> <i>needle grass</i>	5.4	2.7	1.4	14.8	6.1
<u>Stipa viridula</u>	2.8	1.1	9.0	6.5	4.9
Total Graminoids	67.6	17.2	56.0	76.5	55.4
Forbs					
<u>Sphaeralcea coccinea</u>	2.3	4.1	0.2		1.6
Total Forbs	9.2	22.3	1.8		8.9
Browse					
<u>Artemisia frigida</u> <i>brush</i>	1.3	3.3	3.6	5.2	3.3
<u>Betula occidentalis</u>		6.1			1.5
<u>Eurotia lanata</u>	12.4	19.3	20.5	9.8	15.5
<u>Prunus virginiana</u> <i>chokeberry</i>	5.7	10.8	7.5		6.0
<u>Ribes setosum</u> <i>gooseberry</i>	0.6	2.9	3.1		1.6
<u>Shepherdia argentea</u> <i>hott. berry</i>		8.5			2.1
<u>Symphoricarpos occidentalis</u>	0.4	5.4	4.9		2.7
<u>Yucca glauca</u>				7.6	1.9
Total Browse	23.3	59.7	42.2	23.6	37.2

Precipitation patterns can also cause variation in elk summer diets. Elk in western Montana used more mesic habitats earlier in the summer during dry years resulting in a change of food habits from that observed during average years (Marcum 1979). Our fecal samples were collected during a relatively wet summer when elk were not restricted by water availability.

In fall, elk began feeding more heavily on graminoids. This was especially apparent in late fall when graminoids accounted for 63.1% of the elk diet. Bluegrass received the greatest use. Heavy elk utilization of graminoids is common in fall (Mackie 1970, Boyd 1978, and Nelson and Leege 1982). Kufelt (1973) noted that graminoids made up an average of 73% of fall diets in nine elk studies conducted in Montana.

Use of browse decreased in fall to less than one half of the total seasonal diet. Winterfat persisted as the most heavily used plant species, accounting for 20.5% of the fall diet. Chokecherry was important in early fall but was only lightly utilized in late fall.

Forbs constituted only a minor portion of the fall diet. Mackie (1970) found forbs to be the second most important forage class in the Missouri River Breaks in fall but the majority of this use occurred on yellow sweetclover.

Use of graminoids was high in winter. Western wheatgrass (Agropyron smithii), needleandthread grass (Stipa comata), and thread-leaved sedge (Carex filifolia) each accounted for over 14% of the total seasonal diet. These graminoid species are important components of the high, wind-swept habitats elk used during the winter of 1985-86 when snow reduced the availability of graminoids in the lower grassland habitat types. Graminoids are also important forage items in Montana where the majority of elk winter ranges occur in grassland habitats (Nelson and Leege 1982). Constan (1972), working in the Gallatin Valley of southwest Montana, found that elk switched to browse in late winter only after most grass species had been depleted.

Browse accounted for 23.6% of the elk winter diet and winterfat and yucca (Yucca glauca) were the two most important browse species. No forbs were detected in fecal samples collected during winter. Louisiana sagewort (Artemisia ludoviciana), a forb highly preferred by elk in Wind Cave National Park during fall and winter (Wydeven and Dahlgren 1983), was not detected in any of our biseasonal fecal collections although it appeared to be as abundant as winterfat in TRNP.

Grass use peaked at 86.7% of the diet in early spring but decreased in late spring when forbs and browse species increased in importance. The two most heavily used grass

species were crested wheatgrass (Agropyron cristatum) and smooth brome (Bromus inermis). Both are major constituents of the introduced grass mapping unit. Nelson and Leege (1982) attribute heavy elk utilization of grass in spring to the early green up of many grasses as compared to forbs. Crested wheatgrass and smooth brome are two of the first grasses to green up, making them palatable at a time when other forage is still dry and brown.

Use of browse increased in late spring and comprised one quarter of the total spring diet. Winterfat and chokecherry were important browse species.

Forb use also increased in late spring but still accounted for less than 10% of the total seasonal diet. Other researchers have also found forbs to play a minor role in the spring diet of elk (Mackie 1970, Kufelt 1973).

Damage to Park Resources

Vegetation

Two sets (high and low elk use) of woodland vegetation transects measured in 1985 and 1986 indicated that changes between these two years were not attributable to elk (Tables 12 and 13 and Appendix D). Differences between plant growth in dry (1985) and wet (1986) years masked effects of herbivores on vegetation composition (Table 15);

however, utilization of shrubs, saplings, and trees did show some variation between transect location and year (Table 16).

Table 15. Mean canopy coverage (%) in ground stratum (includes vegetation <1 m in height) for hardwood and Rocky Mountain juniper draws within and outside the range of elk in TRNP (data from Appendix E).

Cover Type	Elk Use		No Elk Use	
	1985	1986	1985	1986
Hardwood Draws				
Grasses	3	3	6	5
Forbs	11	11	6	11
Ferns	tr ^a	tr	0	tr
Shrubs	13	15	10	15
Moss	tr	tr	tr	tr
Litter	96	94	96	97
Bare ground	1	2	1	tr
Juniper Draws				
Grasses	8	4	7	8
Forbs	3	6	3	5
Ferns	tr	tr	tr	tr
Shrubs	2	4	4	5
Moss	51	49	52	59
Litter	36	35	36	35
Bare ground	4	9	tr	tr

^atr = <0.5%

Hardwood draw utilization rates for all size classes of shrubs and saplings and trees combined were significantly higher in elk use areas in 1985 than in elk use areas in 1986 and nonelk use areas in 1985 and 1986 ($p < .05$). These measured utilization rates correspond to the decreased use of hardwood draws by elk in 1986, as noted in field observations.

Table 16. Mean density (D) and utilization (%U) of shrubs (N/M^2), saplings ($N/60 M^2$), and trees ($N/60 M^2$) within and outside the range of elk in TRNP (descriptions of vegetation classes and data for individual transects are given in Appendices D and E).

Cover Type	Elk Use				No Elk Use			
	1985		1986		1985		1986	
	D	%U	D	%U	D	%U	D	%U
Hardwood Draws								
Shrubs								
0-50 cm	14	15	22	5	12	5	25	3
50-100 cm	4	12	6	4	5	4	7	9
100-200 cm	4	20	3	3	2	1	3	1
Saplings	37	64	42	4	46	5	42	1
Trees	6	33	5	11	3	13	4	15
Juniper Draws								
Shrubs								
0-50 cm	6	7	11	6	9	14	9	tr ^a
50-100 cm	1	19	1	3	3	1	3	tr
100-200 cm	0		0		2	3	tr	0
Saplings	16	0	17	3	17	1	15	0
Trees	9	0	8	0	5	0	7	0

^atr = <0.5%

Heavy use of hardwood draws by elk occurred in summer 1985, when elk distribution was concentrated in a small area containing several large hardwood draws. Because of the drought conditions in 1985, readily available water in and near these draws from an undeveloped spring and a nearby dish tank may have been an important factor in the restricted elk distribution.

No differences in plant utilization were detected in juniper draws between elk use and nonelk use areas or between years. Although elk were observed browsing in Rocky Mountain juniper draws, our transects failed to detect any utilization. Most browsing occurred in small patches of hardwoods (chokecherry, snowberry, etc.) located inside and on the edges of these draws. Juniper draw transects were located in sites with a typical moss/little Indian ricegrass (Oryzopsis micrantha) understory and a Rocky Mountain juniper overstory.

Additional vegetation transects were established in cottonwood draws and open shrubby habitats in 1986. These transects will provide base line data in the advent of heavy utilization of these habitats by elk in the future.

Other Herbivores

Greatest similarity in the use of physiographic classes occurred between elk and mule deer ($p < .05$) (Table 17). Both of these ungulates utilized breaks, grassland flats and upland grassland physiographic classes in that order of preference. Use of physiographic classes was also significantly similar ($p < .05$) between feral horses and elk and feral horses and mule deer, but the correlation was weaker than between elk and mule deer. Elk, bison, and white-tailed deer did not show significant similarities in habitat use ($p > .05$). This may change once elk move into the western region of TRNP, an area in which upland

grasslands are heavily utilized by bison or on to river bottoms utilized by white-tailed deer.

Table 17. Percent diurnal use of physiographic classes by large herbivores in TRNP. The number of minutes collected for elk and bison and the number of sightings of horses, white-tailed deer (WTD), and mule deer (MD) are in parentheses. Bison data from Marlow et al. 1984.

Physiographic Class	Animal Species				
	Elk (104813) ^a	Bison (298,016) ^a	Horses (1811) ^b	WTD (74) ^b	MD (1700) ^b
Grasslands flats	30	8	29	0	23
Breaks	40	3	3	0	42
Sagebrush bottoms	1	9	1	7	1
Upland grassland	14	7	54	4	15
Prairie dog town	1	18	1	0	1
Cottonwood forest	0	3	0	89	tr ^a
Ridge & ravine	6	6	6	0	6
Scoria hills	9	10	5	0	9
Old River Terraces	tr	35	0	0	1

^a observation minutes

^b sightings

^c tr = <0.5%

Spearman rank correlations were used to determine if significant similarities existed in the seasonal diets of elk and other large herbivores in TRNP. Biseasonal diet compositions for elk, mule deer, white-tailed deer and feral horses are given in Table 18 and Appendix F. Information pertaining to bison seasonal diet is from Marlow et al. (1984).

Table 18. Percent composition of graminoids, browse, and forbs in the diets of large herbivores in the SU of TRNP, 1985-86.

Season	Animal Species				
	Elk	MD	WTD	Horses	Bison ^a
Summer 1986					
Graminoids	17.2	5.2	8.7	93.0	87.6
Browse	59.7	91.0	43.4	5.3	2.2
Forbs	22.3	3.8	48.0	1.2	10.2
Fall 1985					
Graminoids	56.0	10.7	23.1	94.3	89.4
Browse	42.2	80.7	65.6	5.3	5.1
Forbs	1.8	8.5	11.3	tr ^b	5.7
Winter 1985-86					
Graminoids	76.5	tr	23.4	87.3	84.7
Browse	23.6	97.0	73.6	11.2	11.3
Forbs		2.7	3.0	1.6	4.1
Spring 1986					
Graminoids	67.6	15.6	28.3	96.7	88.3
Browse	23.3	60.9	14.7	3.0	15.7
Forbs	9.2	23.6	57.0	tr	9.1
Yearly Average					
Graminoids	55.4	8.0	20.9	92.8	86.9
Browse	37.2	82.4	49.3	6.2	6.5
Forbs	8.9	9.6	29.8	1.0	6.6

^aBison diets are from 1983-84 (Marlow et al. 1984)

^btr = <0.5%

In summer, there was a significant ($p < .05$) overlap in the diets of elk, mule deer, and white-tailed deer. This overlap was evidently due to the high use of browse by all three species. Yearly use of physiographic classes was

similar between elk and mule deer but differed between elk and white-tailed deer and mule deer and white-tailed deer. Elk and mule deer in the Missouri River Breaks showed high similarities in diet and habitat use during the summer months (Mackie 1970).

In fall there were similarities in the diets of elk and feral horses ($p < .05$) although the correlation was weak. Graminoids were a major food item in the diets of both animals but were used much more intensively by horses than elk.

There were significant similarities ($p < .05$) in the diets of elk, bison, and feral horses in both spring and winter. This is contradictory to elk and bison food habits in Elk Island National Park, Alberta, where the greatest dietary overlap between elk and bison occurred in summer and the least overlap occurred in winter when elk utilized browse heavily (Telfer and Cairns 1979).

In TRNP, graminoids accounted for a high percentage of the spring and winter diets for elk, bison, and feral horses. The principle graminoids in the winter/spring diets of these herbivores were wheatgrass, bluegrass, sedge and needlegrass species.

There was a strong correlation between the spring diets of elk and feral horses. Both of these herbivores fed heavily on crested wheatgrass and smooth brome in the introduced grass mapping unit at this time.

Bison and feral horse diets overlapped significantly ($p < .05$) every season. Both species are primarily grazers and utilized graminoids heavily throughout the year. However, because of differences in habitat use (Table 17), and the control of both bison and horse populations by the Park Service, conflicts between bison and feral horses are probably minimal.

White-tailed deer and mule deer had significantly similar ($p < .05$) diets in summer, fall, and spring but the correlations were not as strong as those between elk and mule deer. Differences in habitat use by white-tailed deer and mule deer (Table 14) should minimize food competition between these two species.

The greatest potential for interspecific competition in TRNP appears to exist between elk and mule deer. The high amount of browse in the fecal samples of elk and mule deer from late spring to early fall is correlated with the high use of wooded draws in the breaks physiographic class by each of these species. Mule deer are typically heavy browsers, especially during winter (Lovaas 1958, Mackie 1970, Constan 1972, Wallmo and Regelin 1981 and Mackie et al. 1982) and are considered to be more restrictive in their selection of forage items than elk, whose diets are broader and more flexible (Mackie 1981, Nelson 1982). Because of their greater diet adaptability, elk are considered to be better competitors than mule deer.

Documentation of competition between mule deer and elk is rare. Situations where serious competition has occurred between these two species have been in areas where the elk population was rapidly increasing on commonly used winter range and utilized browse heavily (Nelson 1982).

Mackie (1970) found that elk and mule deer used similar habitats and forage items in the Missouri River Breaks between April and September and concluded that competition between these species must be occurring during this time period. In TRNP, browse comprised a much higher percentage of elk and mule deer diets from late spring through early fall than in the Missouri River Breaks. This could result in a depletion of browse available in winter when browse comprised close to 100% of the mule deer diet in TRNP. Mule deer populations would be more likely to decline than elk under these circumstances. Because of their greater adaptability and a switch from browse to graminoids in late fall, elk probably would not be seriously affected by a winter browse shortage.

Reproduction in both species could decline if browse becomes limiting in late spring and early summer due to the high energy costs associated with lactation. Klein (1968), studying black-tailed deer in Alaska, noted that spring and summer food deficiencies resulted in low fawn to doe ratios and decreased body size.

Overbrowsing could also result in a decrease of preferred woody species and the eventual decline of the hardwood draw habitat type. Other habitats having hardwood shrubs would also be affected.

In years when yellow sweetclover is abundant, forbs may comprise a greater portion of mule deer and elk summer diets reducing browsing pressure in the Park. However, Park personnel should not depend on high sweetclover years to relieve browsing problems. If browse species show a marked decline on permanent transects, controls on elk and mule deer numbers should be instituted.

The potential for conflict between elk and white-tailed deer is low at this time due to differences in diet and habitat use. This could change if elk move into the cottonwood bottoms along the Little Missouri River. In the Missouri River Breaks, elk used cottonwood bottoms during fall and winter when 16% and 45%, respectively, of all elk observations came from this habitat (Allen 1968). At Elk Island National Park, in central Alberta, white-tailed deer and elk range use overlapped 97% in the winter and 94% in the summer (Baker 1984).

Elk have the potential to increase uniformity of grazing in TRNP. This can benefit the vegetative component of the Park biotic community by reducing the rate of plant litter accumulation which in turn decreases the likelihood of plant community stagnation. However, the similarity in

diets and habitat use by several of the large herbivore species in TRNP limits the potential for impacting only underutilized plant communities. High population levels of large herbivores during several years of drought could lead to rapid changes in communities favored by 2 or more ungulate species.

Elk Carrying Capacity

Carrying capacity estimates for each forage category or item contributing >3% to a seasonal diet are given in Table 19 for primary and secondary ranges and Table 20 for marginal ranges. These estimates are conservative and are not considered to be equivalent to economical or ecological carrying capacities (Caughley 1979).

The 2 most limiting grass species in our model are smooth brome and little bluestem (Schizachirium scoparium). Smooth brome is an exotic grass introduced from Europe (Hitchcock and Chase 1971) and is a major component of the introduced grass mapping unit in TRNP. Although it made up 12% of the spring diet, it was not utilized at any other time of the year (Appendix F). Due to its exotic nature and its evident low palatability during most of the year, we believe it is inappropriate to base an elk carrying capacity on this grass.

Table 19. Total annual production (TAP), the proportion each species or plant type contributes to the spring and summer diet (PD), and elk carrying capacity estimates for primary and secondary ranges in the South Unit.

Species or Plant Type	TAP (kg x 1000)	PD	Elk/Year
Graminoids			
<u>Agropyron cristatum</u>	155.07	.052	200
<u>Agropyron smithii</u>	2251.51	.048	3,148
<u>Bouteloua gracilis</u>	923.93	.014	4,421
<u>Bromus inermis</u>	51.68	.060	58
<u>Carex</u> spp.	349.63	.033	711
<u>Poa</u> spp.	139.47	.040	235
<u>Schizachirium scoparium</u>	65.62	.032	140
<u>Stipa comata</u>	422.81	.040	709
<u>Stipa viridula</u>	192.34	.020	645
Perennial Grasses ^a	485.21	.019	1,714
Perennial Forbs ^b	739.03	.157	316
Browse			
<u>Prunus virginiana</u>	42.68	.082	35
<u>Symphoricarpos occidentalis</u>	100.71	.029	235
All Browse Species	565.10	.415	84

^aIncludes: Andropogon gerardii, Aristida spp., Calamovilfa longifolia, Echinochla crusgalli, Koeleria pyramidata, and Muhlenbergia spp..

^bDominant forbs include: Achillea millefolium, Phlox spp., Sphaeralcea coccinea, and Viola spp..

Table 20. Total annual production (TAP), the proportion each species or plant type contributes to the spring and summer diet (PD), and elk carrying capacity for marginal ranges for the South Unit.

Species or Plant Type	TAP (kg x 1000)	PD	Elk/Year
Graminoids			
<u>Agropyron cristatum</u>	^a		
<u>Agropyron smithii</u>	2032.33	.048	2,842
<u>Bouteloua gracilis</u>	848.96	.014	4,070
<u>Bromus inermis</u>	^a		
<u>Carex spp.</u>	707.03	.033	1,438
<u>Poa spp.</u>	137.75	.040	232
<u>Schizachirium scoparium</u>	372.84	.032	782
<u>Stipa comata</u>	632.81	.040	1,062
<u>Stipa viridula</u>	166.18	.020	558
Perennial Grasses ^b	1404.69	.019	4,962
Perennial Forbs ^c	642.95	.157	275
Browse			
<u>Prunus virginiana</u>	121.24	.082	99
<u>Symphoricarpos occidentalis</u>	286.06	.029	662
All Browse Species	2004.08	.415	324

^aNo TAP on marginal ranges.

^bIncludes: Andropogon gerardii, Aristida spp., Calamovilfa longifolia, Echinochla crusgalli, Elymus virginicus, Koeleria pyramidalata, and Muhlenbergia spp..

^cDominant forbs include: Achillea millefolium, Phlox spp., Sphaeralcea coccinea, and Viola spp..

Little bluestem is the second most limiting grass species. This grass is native to Western North Dakota (Hitchcock and Chase 1971) and is a major component of two habitat types (Schizachirium scoparium H. T. and Schizachirium scoparium - Juniperus horizontalis H. T.) in TRNP. Because these habitat types often occur as small isolated islands within other habitat types, the production of this grass species is believed to be underestimated. Because of this and the high production of little bluestem on marginal ranges (Table 4) little bluestem should not be in danger of overutilization.

Carrying capacities for individual forb species could not be calculated because production estimates were not available. However, only one forb species, scarlet globe-mallow (Sphaeralcea coccinea), made up >3% of any seasonal diet (2.3% and 4.1% of the spring and summer diet, respectively) for elk. Scarlet globe-mallow is a common forb in TRNP and is frequently found in the prairie dog town mapping unit, where vegetation has been modified by prairie dog activity. Scarlet globe-mallow does very well in recently disturbed areas due to its rhizomatous root structure (Barr 1983). Because of its general abundance and proliferation in prairie dog towns, scarlet globe-mallow is not considered to be in danger of overgrazing.

Browse species, especially chokecherry, have the highest probability of overutilization by elk in TRNP.

Information is not available on the production of individual browse species in grassland habitats, but sagebrush (Artemisia) species are the dominant shrubs in grassland habitats and would account for most of the shrub production. No production estimates were available for fringed sage (Artemisia frigida), water birch (Betula occidentalis), winterfat, golden currant (Ribes setosum), buffaloberry (Shepherdia argentea), or yucca although all of these species contributed >3% to at least one seasonal diet. Production estimates for chokecherry are from hardwood draws, where this species is most abundant. Chokecherry also occurs in the brush mapping unit (no production estimates available) and in Rocky Mountain juniper draws (no production estimates available). Because spring and summer diet compositions were calculated from fecal samples collected in 1986, much of the chokecherry occurring in the diet is believed to be from juniper draws, which were used heavily for bedding and cover in 1986. Observations of the interior of juniper draws revealed a high degree of browsing on several hardwood species, including chokecherry, skunkbrush (Rhus trilobata), and golden currant. These hardwood species were frequently found in moist areas where slumping has occurred.

Water birch, a relatively uncommon tree in TRNP, comprised 3.05% of the spring and summer diet for elk. No

production estimates are available for this tree species, but green ash has similar epidermal characteristics and may have been misidentified as water birch in the diet (B. Davitt pers. comm. 1988). Green ash could support 138 elk on primary and secondary ranges and 865 elk on marginal ranges using our carrying capacity formula and 3.05% as the percent contribution of green ash in the spring and summer diets.

The lack of production estimates for the brush mapping unit and the juniper draw habitat type (which made up 2% of the South Unit and were favored habitats by elk) indicates that a larger number of elk could be supported by browse in TRNP than is indicated in Tables 19 and 20. Because of this, we estimate that a carrying capacity of 150 elk should be adequate to maintain or increase the vigor of most plant communities in the Park. However, preferred browse species which are heavily utilized by both elk and mule deer should be closely monitored to ensure that overutilization is not occurring. Nelson (1960) and Butler (1983) found that the production of chokecherry decreased in draws receiving moderate to heavy utilization by cattle. Other less palatable species, such as woods rose increased under heavy grazing pressure.

Another browse species of concern is winterfat. Winterfat is a relatively uncommon shrub found in grassland

habitat types. This species constituted a greater percentage of the elk's diet during each season than any other browse species and was the most important browse in the diets of horses (Appendix F) and bison during late winter (Marlow et al. 1984). Vegetation measurements should be conducted at least every 3-4 years on primary elk ranges to ensure that winterfat is not overutilized.

Our carrying capacity estimates for plant species and types are conservatively based on a prolonged drought situation, but did not take diet overlap between elk and other large herbivores into account. Overutilization due to use by two or more species could affect the following shrub species: winterfat, chokecherry, snowberry, buffaloberry, yucca, golden currant, water birch, and green ash. Graminoid species which are most likely to be affected by multiple use are: big bluestem (Andropogon gerardii), little bluestem and bluegrass species. Only small amounts of big bluestem were detected in elk fecal samples in TRNP, but big bluestem is a relatively uncommon grass and was highly preferred by elk in Wind Cave National Park (Wydeven and Dahlgren 1983) and by bison in TRNP (Marlow et al. 1984). Overutilization of forb species is impossible to predict without information on forb production by species and habitat type. A forage allocation model considering all the major large

ungulates in TRNP will be developed in 1989 (Irby et al. Elk movements, habitat use, and population dynamics in Theodore Roosevelt National Park, phase II).

SUMMARY

Elk numbers in the South Unit of TRNP have increased from 47 to 80 animals in the 2 years following the reintroduction of elk in March 1985. Reproductive success has been high and there have been no reports of mortality.

As the population increased, the range of elk in the Park increased from 35 km² the first summer to 75 km² the second summer. The increased home range size of elk was associated with decreased traffic and tourist activity in the Park from late fall through early spring, cooler temperatures and greater water availability in summer 1986, and the increase in elk numbers the second year.

As elk increased their range, they utilized a wider variety of habitat types. During the first summer, habitat use was restricted to a small number of habitat types found in the southeast corner of the Park. Hardwood draws were heavily utilized at this time, possibly due to the presence of readily available water. Elk remained in hardwood draws during most of the daylight hours from spring through early fall. These woody draws provided elk with thermal cover and forage in the form of browse. In the late afternoon or evening, elk moved out of the draws onto grasslands where

they would intermittently graze and bed until early morning when they moved back into cover.

Elk use of wooded draws decreased in midfall. With the advent of cooler temperatures, elk were less inclined to move into cover during the day and were frequently observed bedded in open grasslands. This pattern of habitat use continued until midspring when warmer temperatures again caused elk to seek out thermal cover.

During the second summer, elk continued to use wooded habitat types during midday hours but use shifted from hardwood draws to Rocky Mountain juniper draws. This switch is believed to be a result of the greater abundance of juniper draws within the annual range of elk in TRNP. Water availability was probably not a critical factor during the second summer when increased precipitation produced pools in several of the larger intermittent streams in the Park.

Analysis of fecal samples, collected on a biseasonal basis from fall 1985 to summer 1986, indicated that browse was the most important item in the summer diets while graminoids were most important from late fall through late spring. A pronounced overlap in diet occurred between elk and mule deer during summer when browse comprised 60% of the diets for both of these ungulates. Both species also used similar habitats throughout the year. Mule deer are expected to be the most detrimentally affected by this diet

overlap due to their high dependency on browse throughout the year in TRNP. Elk have a more flexible diet and do not utilize browse heavily from late fall to midspring.

Reproductive success in both species could decline if browse becomes limiting in early summer when energy costs for females are high due to lactation.

Calculations based on food habits and forage production indicate that approximately 150 elk (without consideration of other species) could be maintained in the South Unit of TRNP without causing serious overbrowsing problems on most preferred shrub species. When the elk population reaches this level (in 1988 if the current rate of increase continues) forage utilization and vigor of browse species should be measured in habitat types favored by elk. Shrub species in danger of overutilization include: chokecherry, snowberry, golden currant, buffaloberry, winterfat, water birch, and yucca. Grass species in danger of overutilization include: big bluestem, little bluestem, and bluegrass species.

APPENDICES

APPENDIX A

Description of physiographic/vegetational classes, habitat
types, and mapping units

Table 21. Physiographic/vegetational classes in TRNP
(Norland 1984).

-
1. Breaks: consist of areas noticeably devoid of vegetation or if vegetation does exist, it is situated on steep slopes.
 2. Cottonwood Forests: gallery forests along perennial water courses dominated by plains cottonwood (Populus deltoides). Large expanses in the NU are devoid of a dense shrub understory and have instead a dense cover of grass and forbs.
 3. Wooded Draws: woody stringers dominated by either green ash (Fraxinus Pennsylvanicus) or aspen (Populus tremula tremuloides). The wooded draws are uniformly scattered over both units of the Park.
 4. Upland Grassland: level to rolling grasslands found on the plains above the river valley. These lands are typical of the northern Great Plains.
 5. Old River Terraces: level grasslands 61 to 152 m above the river which are situated on terraces formed before the rapid down-cutting of the river.
 6. Grassland Flats: large flat grassed alluvial deposits found 30 to 61 m above the river valley.
 7. Bottom Grasslands: large flat grassed alluvial deposits found on higher floodplains of the Little Missouri and its larger tributaries.
 8. Toe Slumps: gradually sloping lands formed by slumping and alluvial deposition. The land is covered with grass, shrubs, and trees.
 9. Rolling Grasslands: level to rolling grasslands found on the glaciated plains above the river valley.
 10. Achenbach Hills: hills found 200 m above the river which are covered by grass and shrubs. The large boulder fields on the slopes of the hills are the debris of a bedrock cap.
 11. Ridge and Ravine: lands highly dissected by watercourses and covered by various grasses, shrubs, and trees.

Table 21. Continued.

12. Scoria Hills: lands influenced by scoria (a clinker formed from the baking of clays adjacent to burning coal veins) which produces a differential weathering of the land. This weathering produces a very rugged and varied topography which is covered by various grasses and shrubs.

13. Sagebrush Bottoms: floodplains dominated by silver sagebrush (Artemisia cana) along with a substantial grass cover.

14. Prairie Dog Towns: lands which have been or are being influenced by prairie dogs. At the edges of towns plants are still characteristic of the former plant community. Nearer the center, vegetation is absent or dominated by unpalatable perennial plant species.

Table 22. Description of habitat types (HT) and mapping units (MU) in Theodore Roosevelt National Park (Norland 1984, Girard 1985, and Hirsch 1985).

Agropyron smithii - *Stipa viridula* HT

Distinguished by presence of *Stipa viridula* in habitats having heavy soil, protection from the wind, or extra moisture from runoff. *Agropyron smithii* is the primary grass component. Located on well drained, fine textured soils on terraces or gentle uplands with slopes of 0 - 4%.

Agropyron smithii - *Stipa comata* HT

Agropyron smithii is the major grass component. *Bouteloua gracilis* is the dominant short grass species. Shrubs are generally not found in this habitat type. Located on loamy to clay soils on uplands and flat terraces with slopes of 0 - 12%.

Stipa comata - *Bouteloua gracilis* HT

Canopy cover is dominated by *Stipa comata*; however, *Bouteloua gracilis* and *Carex* species contribute substantially to relative basal coverage. Located on gently rolling slopes dominated by sandy uplands with sandy loam or clay loam in the uppermost soil layer.

Artemisia cana HT

Dominated by *Artemisia cana*, but *Symphoricarpos occidentalis* frequently occurs here, also. Found on flood plains and low terraces. Frequently occupies large flats along streams and creeks. Soils vary due to periodic flooding and new depositions being laid down. Textures range from sandy loams to silt loams.

Schizachyrium scoparium - *Juniperus horizontalis*

Vegetation sparse with soil and exposed rock comprising up to 64% of total coverage. Shrubs common. Located on hilltops and buttes with very shallow loamy soils and slopes ranging from 20 - 24%.

Artemisia tridentata - *Atriplex confertifolia*

Vegetation sparse, comprised mostly of low shrubs. Located where barren outcroppings of bentonite clay and/or lignite deposits were obvious. Soils poorly developed and range from silty clay loam to clay loam.

Table 22. Continued.

Artemisia tridentata - *Bouteloua gracilis*

Artemisia tridentata abundant above a heavy grass cover comprised mostly of Bouteloua gracilis and Agropyron smithii. Located on upper slopes and stream terraces having shallow, fine textured soils and slopes ranging from 2 - 20%.

Schizachyrium scoparius HT

Schizachyrium scoparius occurs in bunches and is the primary grass component. Located on moderate steep to steep uplands on north, northeast, and western exposures with slopes from 18 - 20%. Soils are shallow, unleached clay loams to sandy loams.

Andropogon gerardii HT

Occurs in small patches. Easily recognized by heavy canopy coverage of Andropogon gerardii. Located in moist sites such as depressions and areas of snow accumulation. Soils range from sandy loams to clay loams.

Agropyron smithii - *Bouteloua gracilis* - *Distichlis spicata* HT

Characterized by presence of saline - sodic claypan with scattered bare spots devoid of vegetation. Located on level or hummocky terrain with slopes of 0 - 6%. Soils have a surface of loamy topsoil with a clay layer 0 - 25 cm below this.

Grassed Floodplains HT

Occurs on slopes of 0 - 2% on low terraces, fans, and flood plains. Dominated by Stipa comata and Calamovilfa longifolia.

Hardwood Draws HT

Fraxinus pennsylvanica is the dominant tree species in this HT, with Ulmus americana as a codominant in some stands. Prunus virginiana is the dominant understory tree species. Located in ravines in draws on moderate steep north facing slopes having silt loam to clay loam soils.

Table 22. Continued.

Juniperus scopulorum - Oryzopsis mircantha HT

Juniperus scopulorum is the dominant upperstory vegetation. The undergrowth is dominated by Oryzopsis mircantha and moss. Located on northwest to north facing hillsides having 35 - 70% slopes and sandy loam to clay loam soils.

Populus deltoides - Juniperus scopulorum HT

These are seral communities slowly being replaced by Fraxinus pennsylvanica. Located near the Little Missouri River along recent alluvium deposits in silt loam soils.

Populus tremuloides - Betula occidentalis HT

Characterized by Populus tremuloides as the dominant tree species. Frequently above stands of Fraxinus pennsylvanica - Prunus virginiana. Located on upper slopes facing northwest to east on sandy loam to clay loam soils.
Marsh MU

Marsh MU

Soils associated with this site have seepage, ponding, etc., which seasonally raise the water table to the surface. These sites are too dry most of the year for true aquatic plants.

Brush MU

Small patches of shrubs dominated by Symphoricarpos occidentalis, Prunus virginiana, or Prunus americana. Located on both slopes and grasslands.

Introduced Grass MU

Disturbed areas which have been planted with introduced grasses. The most common grasses occurring at these areas are Agropyron cristatum and Bromus inermis.

Prairie Dog Towns MU

Areas in or surrounding prairie dog towns where the vegetation has been modified by prairie dogs.

Table 22 Continued

River Bottoms MU

Areas seasonally flooded by the Little Missouri River.

Willows MU

Areas dominated by willows having few other plants growing.

Man-Managed MU

Areas where vegetation has been modified by human activities.

Table 23. List of vegetational complexes in the South Unit and the proportion of each HT or MU that comprised the complex (Marlow et al. 1984).

Petrified Forest Complex -

- .4 Agropyron smithii - Stipa comata
- .3 Agropyron smithii - Stipa viridula
- .1 Schizachyrium scoparium
- .05 Andropogon gerardii
- .15 Stipa comata - Bouteloua gracilis

Rolling Scoria Complex -

- .25 Schizachyrium scoparium
- .2 Agropyron smithii - Stipa viridula
- .2 Stipa comata - Bouteloua gracilis
- .15 Agropyron smithii - Stipa comata
- .1 Schizachyrium scoparium - Juniperus horizontalis
- .1 Agropyron smithii - Bouteloua gracilis -
Distichlis stricta

Steep Scoria Complex -

- .3 Schizachyrium scoparium
 - .25 Schizachyrium scoparium - Juniperus horizontalis
 - .15 Agropyron smithii - Stipa viridula
 - .15 Stipa comata - Bouteloua gracilis
 - .1 Artemisia tridentata - Atriplex confertifolia
 - .05 Agropyron smithii - Bouteloua gracilis -
Distichlis stricta
-

APPENDIX B

Percent of elk minutes spent feeding, bedding, and other in each habitat type and physiographic/vegetational class for each season.

Table 24. Percent of elk-minutes spent feeding in each physiographic class in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

Physiographic Class	Season				
	Win	Spr	Sum 85	Sum 86	Fall
Grassland flats	26	37	11	39	52
Breaks	21	15	21	26	21
Ridge & ravine	5	13	8	0	4
Prairie dog town	0	1	1	4	1
Upland grassland	14	26	59	15	11
Scoria hills	34	7	0	16	5
Sagebrush bottoms	0	1	0	1	6

Table 25. Percent of elk-minutes spent feeding in each habitat type in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

HT, MU, and Complexes	Season				
	Win	Spr	Sum 85	Sum 86	Fall
Agropyron smithii - Stipa viridula	6	57	64	47	55
Agropyron smithii - stipa comata	12	1	9	2	2
Stipa comata - Bouteloua gracilis	7	1	0	tr ^a	3
Artemisia cana	0	1	0	1	6
Schizachyrium scoparium - Juniperus horizontalis	2	8	tr	1	tr
Artemisia tridentata - Atriplex confertifolia	2	5	2	6	8
Artemisia tridentata - Bouteloua gracilis	1	6	0	3	4
Schizachyrium scoparium	24	8	5	2	1
Hardwood Draw	2	2	16	5	3
Juniperus Scopulorum - Oryzopsis mircantha	4	4	tr	11	8
Brush	1	2	tr	1	4
Introduced Grass	0	5	1	1	1
Prairie Dog Towns	0	1	1	4	2
Steep scoria complex	42	1	2	5	2
Rolling scoria complex	0	5	3	11	3

^atr = <0.5%

Table 26. Percent of elk-minutes spent in bedding activity for each physiographic class in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

Physiographic Class	Season				
	Win	Spr	Sum 85	Sum 86	Fall
Grassland flats	57	24	11	10	53
Breaks	18	19	36	39	17
Ridge & ravine	5	19	28	0	4
Prairie dog town	0	0	tr ^a	7	1
Upland grassland	14	28	25	12	7
Scoria hills	34	10	0	32	4
Sagebrush bottoms	0	0	0	0	1

^atr = <0.5%

Table 27. Percent of elk-minutes spent bedding in each habitat type in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

HT, MU, and Complexes	Season				
	Win	Spr	Sum 85	Sum 86	Fall
Agropyron smithii - Stipa viridula	7	50	52	9	52
Agropyron smithii - stipa comata	5	5	4	9	2
Stipa comata - Bouteloua gracilis	1	6	0	0	5
Artemisia cana	0	0	0	0	1
Schizachyrium scoparicus - Juniperus horizontalis	2	tr ^a	0	2	1
Artemisia tridentata - Atriplex confertifolia	1	7	tr	8	14
Artemisia tridentata - Bouteloua gracilis	0	4	0	3	tr
Schizachyrium scoparius	58	5	13	3	5
Hardwood Draw	1	3	26	5	2
Juniperus Scopulorum - Oryzopsis mircantha	7	8	4	21	9
Brush	0	tr	tr	0	3
Introduced Grass	0	1	0	tr	tr
Prairie Dog Towns	0	0	tr	7	2
Steep scoria complex	19	4	tr	7	2
Rolling scoria complex	0	6	0	25	3

^atr = <0.5%

Table 28. Percent of elk-minutes spent in 'other' activity for each physiographic class in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

Physiographic Class	Season				
	Win	Spr	Sum 85	Sum 86	Fall
Grassland flats	45	34	0	21	65
Breaks	19	25	17	27	17
Ridge & ravine	7	17	7	0	4
Prairie dog town	0	1	25	1	1
Upland grassland	7	23	51	19	3
Scoria hills	22	0	0	29	9
Sagebrush bottoms	0	0	0	2	2

Table 29. Percent of elk-minutes spent in 'other' activity in each habitat type in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

HT, MU, and Complexes	Season				
	Win	Spr	Sum 85	Sum 86	Fall
Agropyron smithii - Stipa viridula	7	41	21	36	62
Agropyron smithii - stipa comata	9	0	0	2	0
Stipa comata - Bouteloua gracilis	0	9	0	0	1
Artemisia cana	0	0	0	2	2
Schizachyrium scoparium - Juniperus horizontalis	2	0	0	2	1
Artemisia tridentata - Atriplex confertifolia	12	10	2	8	6
Artemisia tridentata - Bouteloua gracilis	5	4	0	1	5
Schizachyrium scoparium	27	2	3	0	4
Hardwood Draw	1	1	13	11	2
Juniperus Scopulorum - Oryzopsis mircantha	13	12	0	8	1
Brush	0	1	0	1	4
Introduced Grass	0	19	36	1	1
Prairie Dog Towns	0	1	25	1	1
Steep scoria complex	22	0	0	4	3
Rolling scoria complex	0	0	0	26	3

APPENDIX C

Percent of elk-minutes spent feeding, bedding, standing, moving, and other in physiographic/vegetational classes and habitat types for each season during four time periods.

Table 30. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the grassland flats physiographic class for each season during 4 time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (464)	91	0	8	0	1
Late morning (333)	15	82	1	0	2
Afternoon (2353)	17	78	5	0	tr ^a
Evening (1126)	32	62	4	0	3
Daily (4276)	66	29	4	tr	1
Spring 1986					
Early Morning (1495)	57	31	3	8	1
Late Morning (123)	54	7	18	15	6
Afternoon (2051)	61	36	2	2	tr
Evening (1726)	63	20	8	6	3
Daily (5395)	51	40	3	5	1
Summer 1985					
Early morning (393)	27	62	2	10	0
late morning (134)	47	41	6	6	0
Afternoon (276)	43	44	tr	13	0
Evening (491)	74	1	3	22	0
Daily (1294)	71	20	1	7	1
Summer 1986					
Early morning (556)	67	29	4	0	tr
Late morning (168)	60	31	10	0	1
Afternoon (66)	89	9	2	0	2
Evening (2189)	83	11	5	0	2
Daily (2976)	59	35	3	0	3
Fall 1985					
Early morning (3120)	38	56	2	3	1
Late morning (2556)	23	75	2	0	tr
Afternoon (6034)	54	40	2	3	3
Evening (4458)	63	26	6	4	2
Daily (16168)	59	37	3	1	tr

^atr = <0.5%

Table 31. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the breaks physiographic class for each season during 4 time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (225)	82	2	14	0	3
Late morning (362)	34	65	1	0	0
Afternoon (1137)	37	58	4	tr ^a	tr
Evening (294)	86	4	7	0	4
Daily (2018)	49	45	5	tr	1
Spring 1986					
Early morning (1491)	47	32	12	7	2
Late morning (739)	17	75	6	2	1
Afternoon (510)	47	24	15	13	1
Evening (281)	74	11	4	9	2
Daily (3021)	42	39	10	7	2
Summer 1985					
Early morning (1291)	26	64	6	3	tr
late morning (446)	61	36	1	1	1
Afternoon (531)	40	50	2	6	2
Evening (675)	57	19	6	18	tr
Daily (2943)	41	47	5	7	1
Summer 1986					
Early morning (1053)	31	60	6	0	3
Late morning (1282)	29	63	7	0	1
Afternoon (504)	44	44	11	0	2
Evening (939)	70	15	15	tr	tr
Daily (3778)	42	48	9	tr	2
Fall 1985					
Early morning (1384)	32	57	4	6	1
Late morning (3614)	21	78	1	0	tr
Afternoon (1385)	81	12	3	2	2
Evening (1015)	71	10	7	2	3
Daily (7398)	42	52	3	2	1

^atr = <0.5%

Table 32. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the ridge and ravine physiographic class for each season during 4 time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (288)	84	1	12	0	2
Late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (288)	84	1	12	0	2
Spring 1986					
Early morning (1811)	43	40	4	10	2
Late morning (273)	37	54	3	5	1
Afternoon (142)	37	59	5	0	0
Evening (412)	38	62	1	0	0
Daily (2638)	41	46	4	8	1
Summer 1985					
Early Morning (868)	17	76	2	4	1
late Morning (150)	61	38	0	0	0
Afternoon (510)	32	56	6	7	0
Evening (143)	54	46	1	0	0
Daily (1671)	29	64	3	4	tr ^a
Summer 1986					
Early morning (0)					
Late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (0)					
Fall 1985					
Early morning (681)	28	60	3	9	0
Late morning (469)	50	44	5	1	0
Afternoon (217)	38	0	18	38	7
Evening (14)	100	0	0	0	0
Daily (1381)	38	45	6	11	1

^atr = <0.5%

Table 33. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the scoria hills physiographic class for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (1179)	84	4	11	0	2
Late morning (480)	43	42	15	0	0
Afternoon (913)	21	76	3	0	tr ^a
Evening (240)	86	1	12	0	1
Daily (2812)	57	34	9	0	1
Spring 1986					
Early morning (373)	74	18	5	3	0
Late morning (278)	18	70	9	2	0
Afternoon (685)	31	59	5	5	0
Evening (54)	46	0	0	0	54
Daily (1390)	40	48	6	6	0
Summer 1985					
Early morning (0)					
late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (0)					
Summer 1986					
Early morning (715)	26	70	3	0	1
Late morning (1182)	27	62	7	0	4
Afternoon (389)	47	40	11	0	13
Evening (353)	70	21	8	tr	1
Daily (2639)	36	55	7	tr	2
Fall 1985					
Early morning (887)	40	36	13	9	1
Late morning (229)	36	30	25	7	3
Afternoon (338)	63	22	2	11	2
Evening (296)	52	33	5	6	4
Daily (1750)	46	32	11	9	2

^atr = <0.5%

Table 34. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the upland grassland physiographic class for each season during 4 daytime periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (255)	91	0	6	1	2
Late morning (70)	4	96	0	0	0
Afternoon (189)	38	62	0	0	0
Evening (504)	73	21	5	tr ^a	tr
Daily (1018)	66	29	4	tr	1
Spring 1986					
Early morning (1887)	41	44	5	7	2
Late morning (1073)	29	69	1	tr	0
Afternoon (699)	82	3	tr	15	0
Evening (811)	76	21	3	tr	0
Daily (4470)	51	40	3	5	1
Summer 1985					
Early morning (1789)	77	15	tr	8	tr
late morning (0)					
Afternoon (1116)	61	37	1	1	1
Evening (1946)	71	16	tr	10	2
Daily (4851)	71	20	1	7	1
Summer 1986					
Early morning (629)	86	8	1	0	5
Late morning (28)	11	79	7	0	4
Afternoon (483)	23	76	1	0	1
Evening (377)	64	25	10	0	1
Daily (1517)	59	35	3	0	3
Fall 1985					
Early morning (1163)	89	3	6	1	1
Late morning (700)	9	91	0	0	0
Afternoon (773)	55	43	1	1	tr
Evening (255)	71	25	0	4	tr
Daily (2891)	59	37	3	1	tr

^atr = <0.5%

Table 35. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in Agropyron smithii - Stipa viridula habitat type for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (38)	84	0	3	0	13
Late morning (121)	14	75	1	8	2
Afternoon (467)	46	49	4	tr ^a	0
Evening (0)					
Daily (626)	42	51	4	2	1
Spring 1986					
Early morning (2871)	46	41	3	8	1
Late morning (1200)	31	68	1	tr	tr
Afternoon (2541)	68	25	1	5	tr
Evening (2354)	64	24	6	5	2
Daily (8966)	55	36	3	5	1
Summer 1985					
Early morning (2568)	57	35	tr	8	tr
late morning (134)	47	41	6	6	0
Afternoon (1610)	54	41	1	4	tr
Evening (2116)	64	19	1	16	1
Daily (6428)	58	32	1	9	tr
Summer 1986					
Early morning (1219)	75	13	2	7	3
Late morning (186)	53	17	8	22	1
Afternoon (67)	87	9	2	2	2
Evening (2306)	78	10	6	5	2
Daily (3778)	76	11	5	6	2
Fall 1985					
Early morning (4123)	43	48	4	5	1
Late morning (2699)	25	74	1	0	tr
Afternoon (5193)	54	36	3	5	3
Evening (3985)	63	27	4	5	2
Daily (1600)	49	43	3	4	2

^atr = <0.5%

Table 36. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the Schizachyrium scoparium habitat type for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (389)	85	1	8	4	2
Late morning (363)	28	68	tr ^a	3	1
Afternoon (2371)	15	83	1	tr	tr
Evening (1022)	31	64	3	1	1
Daily (4145)	27	69	2	1	1
Spring 1986					
Early morning (903)	59	27	6	8	0
Late morning (68)	31	68	2	0	0
Afternoon (119)	57	36	4	1	2
Evening (82)	89	0	2	7	1
Daily (1172)	59	29	5	7	tr
Summer 1985					
Early morning (401)	14	73	7	6	tr
late morning (219)	80	19	0	1	1
Afternoon (279)	26	61	7	6	0
Evening (6)	16	0	0	83	0
Daily (905)	34	56	5	5	tr
Summer 1986					
Early morning (77)	7	92	1	0	0
Late morning (77)	65	26	5	4	0
Afternoon (52)	12	77	8	4	0
Evening (106)	68	6	10	16	0
Daily (312)	43	44	6	7	0
Fall 1985					
Early morning (371)	50	26	7	17	1
Late morning (692)	17	82	0	1	0
Afternoon (282)	80	17	4	0	0
Evening (133)	62	4	14	13	8
Daily (1478)	41	48	4	6	1

^atr = <0.5%

Table 37. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in hardwood draws for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (0)					
Late morning (0)					
Afternoon (73)	43	0	56	0	1
Evening (79)	53	47	0	0	0
Daily (152)	48	24	27	0	1
Spring 1986					
Early morning (264)	36	54	10	1	0
Late morning (0)					
Afternoon (156)	42	36	7	14	1
Evening (21)	91	0	5	5	0
Daily (441)	41	45	8	6	1
Summer 1985					
Early morning (820)	30	64	4	3	tr ^a
late morning (355)	49	50	0	1	0
Afternoon (514)	43	47	4	5	2
Evening (441)	70	15	5	10	0
Daily (2130)	44	47	3	4	1
Summer 1986					
Early morning (464)	38	49	7	1	5
Late morning (3)	100	0	0	0	0
Afternoon (62)	36	24	23	18	0
Evening (101)	85	3	12	0	0
Daily (630)	46	39	9	2	4
Fall 1985					
Early morning (0)					
Late morning (349)	26	67	4	0	3
Afternoon (0)					
Evening (0)					
Total Daily (349)	26	67	4	0	3

^atr = <0.5%

Table 38. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the Agropyron smithii - Stipa comata habitat type for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (248)	88	0	6	4	2
Late morning (70)	4	96	0	0	0
Afternoon (211)	34	56	10	0	0
Evening (389)	67	16	6	10	1
Daily (918)	61	27	6	5	1
Spring 1986					
Early morning (435)	18	71	5	6	0
Late morning (0)					
Afternoon (0)					
Evening (2)	100	0	0	0	0
Daily (437)	18	71	5	6	0
Summer 1985					
Early morning (223)	42	56	2	tr ^a	0
late morning (0)					
Afternoon (6)	100	0	0	0	0
Evening (465)	93	7	0	0	0
Daily (694)	77	23	tr	tr	0
Summer 1986					
Early morning (0)					
Late morning (29)	11	76	7	3	3
Afternoon (483)	23	76	1	0	1
Evening (56)	14	77	5	2	2
Daily (568)	22	76	1	tr	1
Fall 1985					
Early morning (0)					
Late morning (222)	10	90	0	0	0
Afternoon (260)	79	21	0	0	0
Evening (0)					
Daily (482)	47	53	0	0	0

^atr=<0.5%

Table 39. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the Stipa comata - Bouteloua gracilis habitat type for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (16)	81	0	6	12	0
Late morning (0)					
Afternoon (0)					
Evening (363)	81	15	4	tr ^a	0
Daily (379)	81	15	4	tr	0
Spring 1986					
Early morning (331)	23	67	2	3	5
Late morning (51)	43	55	0	0	2
Afternoon (0)					
Evening (155)	11	88	1	0	0
Daily (537)	22	72	1	2	3
Summer 1985					
Early morning (0)					
late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (0)					
Summer 1986					
Early morning (57)	5	89	2	4	2
Late morning (23)	9	87	4	0	0
Afternoon (0)					
Evening (233)	73	21	3	3	0
Daily (313)	56	38	3	3	tr
Fall 1985					
Early morning (112)	80	7	4	10	0
Late morning (478)	8	92	0	0	0
Afternoon (513)	43	54	1	2	tr
Evening (0)					
Daily (1103)	32	66	1	2	tr

^atr=<0.5%

Table 40. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in Artemisia tridentata - Atriplex confertifolia HT for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (18)	17	0	44	17	22
Late morning (0)					
Afternoon (132)	64	33	2	1	0
Evening (21)	38	0	24	0	38
Daily (171)	56	25	9	2	7
Spring 1986					
Early morning (277)	61	2	11	13	13
Late morning (0)					
Afternoon (0)					
Evening (270)	81	13	6	tr ^a	0
Daily (547)	71	8	8	7	7
Summer 1985					
Early morning (79)	71	0	24	5	0
late morning (29)	34	7	10	45	3
Afternoon (0)					
Evening (100)	51	5	11	32	1
Daily (208)	56	3	16	24	1
Summer 1986					
Early morning (170)	31	52	7	8	2
Late morning (378)	28	56	8	6	1
Afternoon (97)	25	12	24	34	5
Evening (300)	55	12	15	17	0
Daily (945)	37	37	12	13	2
Fall 1985					
Early morning (533)	16	79	5	1	0
Late morning (1736)	26	73	1	0	tr
Afternoon (605)	79	15	2	1	3
Evening (203)	48	3	14	34	2
Daily (3077)	36	58	3	3	1

^atr=<0.5%

Table 41. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the Juniperus scopulorum - Oryzopsis mircantha HT for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (71)	54	0	14	28	4
Late morning (120)	32	66	3	0	0
Afternoon (351)	15	71	11	1	1
Evening (67)	54	9	21	6	10
Daily (609)	27	55	11	5	2
Spring 1986					
Early morning (357)	56	19	8	12	5
Late morning (467)	8	85	4	2	1
Afternoon (203)	42	23	22	13	0
Evening (27)	33	41	19	0	7
Daily (1054)	32	50	9	8	2
Summer 1985					
Early morning (188)	1	85	10	4	0
late morning (0)					
Afternoon (22)	32	0	0	68	0
Evening (3)	0	100	0	0	0
Daily (213)	4	77	9	11	0
Summer 1986					
Early morning (279)	21	74	3	1	1
Late morning (792)	25	66	6	3	1
Afternoon (347)	48	45	4	3	1
Evening (438)	61	20	13	4	1
Daily (1856)	37	52	7	3	1
Fall 1985					
Early morning (415)	18	76	1	6	0
Late morning (964)	19	81	1	0	tr ^a
Afternoon (226)	63	16	5	15	1
Evening (111)	54	25	10	8	3
Daily (1716)	27	68	2	4	tr

^atr=<0.5%

Table 42. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in the introduced grass mapping unit for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (0)					
Late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (0)					
Spring 1986					
Early morning (277)	61	2	11	13	13
Late morning (0)					
Afternoon (0)					
Evening (270)	81	13	6	tr ^a	0
Daily (547)	71	8	8	7	7
Summer 1985					
Early morning (0)					
late morning (0)					
Afternoon (0)					
Evening (107)	63	0	2	4	32
Daily (107)	63	0	2	4	32
Summer 1986					
Early morning (0)					
Late morning (0)					
Afternoon (0)					
Evening (86)	67	6	6	17	4
Daily (86)	67	6	6	17	4
Fall 1985					
Early morning (0)					
Late morning (0)					
Afternoon (327)	32	63	2	2	1
Evening (0)					
Daily (327)	32	63	2	2	1

^atr=<0.5%

Table 43. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in rolling scoria complex for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (0)					
Late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (0)					
Spring 1986					
Early morning (272)	94	1	2	3	0
Late morning (161)	6	93	1	0	0
Afternoon (448)	37	53	3	7	0
Evening (54)	46	0	0	54	0
Daily (935)	49	42	3	7	0
Summer 1985					
Early morning (0)					
late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (0)					
Summer 1986					
Early morning (682)	26	71	1	2	1
Late morning (960)	29	57	7	2	5
Afternoon (67)	13	76	5	2	5
Evening (263)	72	19	6	3	tr ^a
Daily (1972)	33	57	5	2	3
Fall 1985					
Early morning (427)	56	7	13	21	3
Late morning (109)	47	24	21	6	2
Afternoon (125)	27	59	6	3	5
Evening (296)	52	33	5	6	4
Daily (957)	50	24	11	13	3

^atr = <.05%

Table 44. Percent of elk-minutes spent feeding (F), bedding (B), standing (S), moving (M), and other (O), in steep scoria complex for each season during four time periods. The number of elk minutes recorded during each time period is in parentheses.

Time Period	Activity				
	F	B	S	M	O
Winter 1985-87					
Early morning (1798)	78	3	10	9	1
Late morning (512)	41	39	14	6	0
Afternoon (920)	21	76	3	1	tr ^a
Evening (263)	78	1	11	9	1
Daily (3493)	57	27	9	6	1
Spring 1986					
Early morning (101)	19	65	14	2	0
Late morning (117)	35	39	21	5	0
Afternoon (237)	20	69	9	2	0
Evening (0)					
Daily (455)	23	60	13	3	0
Summer 1985					
Early morning (47)	98	2	0	0	0
late morning (0)					
Afternoon (0)					
Evening (0)					
Daily (47)	98	2	0	0	0
Summer 1986					
Early morning (50)	24	42	20	14	0
Late morning (245)	19	73	7	tr	1
Afternoon (392)	44	27	10	18	1
Evening (103)	55	25	14	5	1
Daily (790)	37	42	10	10	1
Fall 1985					
Early morning (511)	23	57	12	8	tr
Late morning (120)	27	35	28	8	3
Afternoon (213)	85	0	0	15	0
Evening (0)					
Total Daily (844)	39	39	11	10	1

APPENDIX D

Means of vegetation transects in hardwood draws and juniper
draws within and outside the range of elk in TRNP.

Table 45. Canopy coverage (%) in ground stratum (includes vegetation <1 m in height) for hardwood draws within and outside the range of elk in TRNP. Six transects were located in both elk use and nonelk use areas. Standard deviation is in parentheses.

Plant Species	Elk Use		No Elk Use	
	1985	1986	1985	1986
Grasses and Grasslike:				
<u>Agropyron trachycaulum</u>	tr	0	tr	tr
<u>Bromus inermis</u>	0	0	tr	tr
<u>Elymus virginicus</u>	tr	tr	tr	tr
<u>Carex spp.</u>	0	0	tr	tr
<u>Carex springelii</u>	1 (1)	1 (1)	3 (5)	2 (4)
<u>Oryzopsis micrantha</u>	1 (2)	1 (1)	1 (1)	1 (1)
<u>Poa pratensis</u>	tr	tr	tr	tr
<u>Stipa viridula</u>	tr	0	0	0
Unknown grasses	0	tr	tr	tr
Total Grasses	3	3	6	5
Forbs:				
<u>Achillea millefolium</u>	tr	tr	tr	tr
<u>Apocynum androsaemifolium</u>	0	0	0	tr
<u>Arctium minus</u>	0	0	tr	tr
<u>Chenopodium hybridum</u>	0	tr	tr	1 (2)
<u>Clematis ligusticifolia</u>	0	tr	tr	tr
<u>Disporum trachycarpum</u>	0	tr	0	0
<u>Fragaria glauca</u>	2 (2)	1 (3)	tr	1 (2)
<u>Galium asparine</u>	tr	tr	0	tr
<u>Galium boreale</u>	1 (1)	1 (1)	1 (1)	2 (1)
<u>Hachelia deflexa</u>	0	tr	0	tr
<u>Hedysarum boreal</u>	0	0	0	tr
<u>Heuchera richardsoni</u>	0	tr	0	tr
<u>Lysimachia ciliata</u>	1 (1)	2 (1)	tr	tr
<u>Monarda fistulosa</u>	tr	0	tr	tr
<u>Osmorhiza longistylis</u>	tr	0	0	tr
<u>Oxalis stricta</u>	0	0	tr	0
<u>Polygonatum commutatum</u>	tr	tr	0	0
<u>Sanicula marilandica</u>	0	tr	0	tr
<u>Smilacina stellata</u>	tr	2 (5)	tr	tr
<u>Smilax herbaceae</u>	0	0	0	tr
<u>Solidago spp.</u>	0	tr	tr	tr
<u>Thalictrum venulosum</u>	0	tr	0	tr
<u>Taraxacum officinale</u>	tr	1 (tr)	tr	tr
<u>Toxicodendron rydbergii</u>	tr	tr	tr	tr

Table 46 Continued.

Plant Species	Elk Use		No Elk Use	
	1985	1986	1985	1986
<u>Viola</u> spp.	tr	tr	tr	tr
Unknown forbs	4 (6)	tr	1 (tr)	2 (5)
Total forbs	10	9	6	10
Ferns				
<u>Cystopteris fragilis</u>	tr	tr	0	tr
Shrubs and Trees				
<u>Artemisia ludoviciana</u>	tr	0	0	0
<u>Amelanchier alnifolia</u>	1 (2)	tr	2 (1)	tr
<u>Elaeagnus argentea</u>	0	tr	0	0
<u>Fraxinus pennsylvanica</u>	tr	tr	2 (1)	2 (1)
<u>Juniperus communis</u>	0	0	tr	0
<u>Prunus virginiana</u>	7 (4)	8 (6)	2 (2)	7 (4)
<u>Rhus trilobata</u>	0	0	tr	1 (2)
<u>Ribes odoratum</u>	tr	0	tr	tr
<u>Ribes setosum</u>	tr	tr	tr	tr
<u>Rosa woodsii</u>	tr	tr	tr	tr
<u>Shepherdia argentea</u>	0	0	0	tr
<u>Symphoricarpos occidentalis</u>	4 (6)	6 (2)	3 (5)	4 (6)
Total shrubs	13	15	10	15
Moss	tr	tr	tr	tr
Litter	96 (1)	94 (2)	96 (1)	97 (1)
Bare ground	1 (1)	2 (2)	1 (1)	tr
Deer feces	tr	tr	0	0
Elk feces	tr	0	0	0

a tr = <.05

Table 47. Canopy coverage (%) in ground stratum (includes vegetation <1 m in height) for Rocky Mountain juniper draws within and outside the range of elk in TRNP. Three transects were located both in elk use areas and nonelk use areas in 1985; however, in 1986 four transects were located in elk use areas and two in nonelk use areas. Standard deviation is in parentheses.

Plant Species	Elk Use		No Elk Use	
	1985	1986	1985	1986
Grasses and Grasslike:				
<u>Agropyron trachycaulum</u>	tr ^a	tr	tr	tr
<u>Carex</u> spp.	0	tr	2 (3)	2 (3)
<u>Carex springelii</u>	0	tr	4 (6)	3 (5)
<u>Elymus virginicus</u>	0	0	tr	0
<u>Oryzopsis micrantha</u>	8 (10)	3(3)	1(1)	5 (7)
<u>Poa pratensis</u>	0	tr	0	tr
Unknown grasses	0	tr	0	0
Total Grasses	8	4	7	8
Forbs:				
<u>Achillea millefolium</u>	tr	tr	tr	tr
<u>Campanula rotundifolia</u>	0	tr	0	0
<u>Chenopodium hybridum</u>	tr	tr	0	1 (2)
<u>Cirsium canadensis</u>	1 (1)	1 (2)	0	0
<u>Clematis ligusticifolia</u>	0	0	0	tr
<u>Compositae</u> spp.	tr	0	tr	0
<u>Descurainia sophia</u>	tr	0	0	0
<u>Euphorbia podporae</u>	0	tr	0	0
<u>Galium asparine</u>	tr	0	0	0
<u>Galium boreale</u>	tr	1 (1)	tr	1 (tr)
<u>Geum triflorum</u>	0	tr	0	0
<u>Hachelia deflexa</u>	0	tr	0	1 (1)
<u>Hedysarum boreal</u>	0	tr	0	0
<u>Heuchera richardsonii</u>	0	tr	tr	tr
<u>Lysimachia ciliata</u>	0	tr	0	1 (2)
<u>Melilotus officinalis</u>	0	0	0	tr
<u>Smilacina stellata</u>	0	tr	0	tr
<u>Solidago</u> spp.	0	tr	0	tr
<u>Taraxacum officinale</u>	tr	tr	1 (1)	tr
<u>Viola</u> spp.	tr	tr	tr	0
Unknown forbs	tr	tr	tr	tr
Total Forbs	3	6	3	5

Table 47. Continued.

Plant Species	Elk Use		No Elk Use	
	1985	1986	1985	1986
Ferns				
<u>Cystopteris fragilis</u>	tr	tr	tr	tr
Shrubs and Trees				
<u>Chrysothamnus nauseosus</u>	0	tr	0	0
<u>Fraxinus pennsylvanica</u>	tr	tr	0	0
<u>Juniperus communis</u>	tr	1 (1)	2 (2)	1 (1)
<u>Juniperus scopulorum</u>	tr	tr	0	tr
<u>Prunus virginiana</u>	tr	1 (1)	1 (1)	3 (3)
<u>Rhus trilobata</u>	tr	tr	tr	0
<u>Ribes odoratum</u>	0	tr	0	0
<u>Rosa woodsii</u>	0	tr	0	0
<u>Sarcobatus vermiculatus</u>	0	0	tr	0
<u>Symphoricarpos occidentalis</u>	tr	tr	tr	1 (tr)
Total shrubs	2	4	4	5
Moss	51 (29)	49 (21)	52 (14)	59 (25)
Litter	36 (23)	35 (22)	36 (17)	35 (28)
Bare ground	4 (1)	9 (6)	tr	tr
Deer feces	tr	tr	tr	0
Elk feces	0	tr	0	0

^atr = <0.5%

Table 48. Mean density (N/M^2) and percent utilization of shrubs in hardwood draws located within and outside the range of elk in TRNP. Six transects were located in both elk use areas and in none elk use areas.

Plant Species	Elk Use				No Elk Use			
	1985		1986		1985		1986	
	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
0-50 cm								
<u>Amelanchier alnifolia</u>	1 (1)	4	2 (3)	tr ^a	tr	3	4 (2)	4
<u>Crataegus rotundifolia</u>	tr	0	tr					
<u>Elaeagnus argentea</u>	tr	25	tr	1	4 (3)	0	2 (3)	0
<u>Fraxinus pennsylvanica</u>	0						tr	0
<u>Juniperus scopulorum</u>	5 (2)	6	9 (6)	tr	3 (3)	tr	12 (14)	tr
<u>Prunus virginiana</u>	0				tr	tr	tr	tr
<u>Rhus trilobata</u>	tr	0	tr	15			tr	0
<u>Ribes odoratum</u>	tr	0	tr	0	tr	0	1 (4)	0
<u>Ribes setosum</u>	tr	0	tr	0	tr	0	tr	0
<u>Rosa woodsii</u>	7 (7)	22	10 (9)	10	4 (4)	10	5 (4)	9
<u>Symphoricarpos occidentalis</u>	0		tr	0			tr	0
<u>Ulmus americana</u>								
Total	14	15	22	5	12	5	25	3
50-100 cm								
<u>Amelanchier alnifolia</u>	tr	24	2 (3)	0	tr	15	1 (tr)	0
<u>Fraxinus pennsylvanica</u>	tr	0	tr	10	1 (2)	2	2 (3)	8
<u>Prunus virginiana</u>	3 (2)	7	3 (1)	1	2 (2)	4	2 (1)	tr
<u>Rhus trilobata</u>					tr	2	tr	2
<u>Ribes odoratum</u>	tr	55	tr					
<u>Ribes setosum</u>	tr	75	0					

Table 48. Continued.

Plant Species	Elk Use			No Elk Use		
	1985		1986		1986	
	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
50-100 cm						
<i>Rosa woodsii</i>	tr	5	tr	1	tr	0
<i>Symphoricarpos occidentalis</i>	tr	32	1 (1)	14	1 (1)	20
Total	4	12	6	4	5	9
100-200 cm						
<i>Amelanchier alnifolia</i>	1 (1)	32	1 (1)	6	tr	2
<i>Fraxinus pennsylvanica</i>	tr	35	tr	1	tr	2
<i>Prunus virginiana</i>	2 (1)	15	2 (1)	2	1 (1)	tr
<i>Rhus trilobata</i>	tr	24	tr	15	tr	5
<i>Ribes odoratum</i>	tr	30	0		tr	
<i>Ribes setosum</i>						
Total	4	20	3	3	2	1

^atr = <0.5

Table 49. Mean density (N/M^2) and percent utilization of shrubs in Juniper draws within and outside the range of elk in TRNP. Six transects were located in both elk use areas and none elk use areas.

Plant Species	Elk Use			No Elk Use		
	1985		% Use	1985		% Use
	X (S.D.)	X (S.D.)		X (S.D.)	X (S.D.)	
0-50 cm						
<u>Chrysothamnus nauseosus</u>						
<u>Fraxinus pennsylvanica</u>	tr	30		tr ^a	5	
<u>Juniperus communis</u>	tr	0	4 (4)	1 (1)	0	1 (1)
<u>Juniperus scopulorum</u>	1 (1)	0	2 (3)	2 (1)	0	2 (2)
<u>Prunus virginiana</u>	tr	12	1 (2)	2 (1)	tr	4 (2)
<u>Rhus trilobata</u>	1 (1)	9	1 (1)	tr	13	0
<u>Ribes setosum</u>	tr	0	tr	tr	0	0
<u>Rosa woodsii</u>	tr	0	tr	tr	0	0
<u>Symphoricarpos occidentalis</u>	3 (2)	7	4 (2)	3 (3)	25	2 (1)
Total	6	7	11	9	14	9
50-100 cm						
<u>Chrysothamnus nauseosus</u>						
<u>Fraxinus pennsylvanica</u>	tr	30	tr	tr	0	tr
<u>Potentilla fruticosa</u>	tr		0			2 (0)
<u>Prunus virginiana</u>	tr	25	1 (1)	3 (2)	1	tr
<u>Rhus trilobata</u>	tr	15	tr	tr	0	tr
<u>Rosa woodsii</u>	tr	1				tr
<u>Symphoricarpos occidentalis</u>						tr
Total	1	19	1	3	1	3
100-200						
<u>Prunus virginiana</u>				2 (3)	0	tr

a tr = $\leq 0.5\%$

Table 50. Mean Density ($N/60 \text{ m}^2$) and percent of saplings and trees browsed in hardwood draws within and outside of elk range in TRNP. Six transects were located in both elk use and nonelk use areas.

Plant Species	Elk use				No Elk Use			
	1985		1986		1985		1986	
	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
Saplings								
<u>Amelanchier alnifolia</u>	8 (9)	70	9 (9)	10	3 (3)	25	2 (2)	0
<u>Crateagus rotundifolia</u>	tr ^a	0	tr	0				
<u>Fraxinus pennsylvanica</u>	7 (4)	71	7 (3)	10	13 (9)	3	12 (7)	2
<u>Prunus virginiana</u>	21 (20)	58	23 (21)	1	28 (20)	4	26 (17)	1
<u>Prunus americana</u>					1 (2)	0	1 (2)	tr
<u>Rhus trilobata</u>					1 (2)	33	tr	0
<u>Ribes odoratum</u>	tr	0	1 (3)	0	tr	0	1 (1)	0
<u>Shepherdia spp.</u>					tr	0		
<u>Ulmus americana</u>	1 (2)	100	2 (3)	0				
Total	37	64	42	4	46	5	42	1
Trees								
<u>Fraxinus pennsylvanica</u>	6 (3)	33	5 (3)	11	3 (2)	13	4 (3)	15
<u>Juniperus scopulorum</u>	tr	0	tr	0	tr	0	tr	0
<u>Ulmus americana</u>								
Total	6	33	5	11	3	13	4	15

^atr = <.05%

Table 51. Mean density ($N/60 \text{ m}^2$) and percent of saplings and trees browsed in juniper draws within and outside the range of elk in TRNP. Three transects were located in both elk use and nonelk use areas in 1985. In 1986, two transects were located in nonelk areas and four transects were located in elk use areas.

Plant Species	Elk Use				No Elk Use			
	1985		1986		1985		1986	
	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
Saplings								
<u>Fraxinus pennsylvanica</u>	1 (2)	0	2 (2)	0	4 (4)	0	4 (6)	0
<u>Juniperus scopulorum</u>	15 (12)	0	15 (6)	3	10 (6)	0	7 (8)	0
<u>Prunus virginiana</u>					3 (5)	1	4 (6)	0
Total	16	0	17	3	17	1	15	0
Trees								
<u>Fraxinus pennsylvanica</u>					tr ^a	0	2 (2)	0
<u>Juniperus scopulorum</u>	9 (4)	0	8 (3)	0	5 (2)	0	5 (3)	0
Total	9	0	8	0	5	0	7	0

^atr = 0.5%

APPENDIX E

Means of individual vegetation transects in hardwood and juniper draws within and outside the range of elk in TRNP.

Table 52. Percent canopy coverage of herbaceous vegetation (<1 m) in hardwood draws within (+) and outside (-) the range of elk in TRNP, 1985. Standard deviation is in parentheses.

Plant Species	Transect Number										
	1(+)	2(+)	3(+)	4(-)	5(-)	6(-)	7(+)	8(+)	9(+)	13(-)	14(-)
Grasses and Grasslike:											
<i>Agropyron trachycarum</i>					tr						tr
<i>Bromus inermis</i>					tr						
<i>Elymus virginicus</i>		1 (1)	tr					1 (2)		1 (3)	1 (2)
<i>Carex</i> spp.										1 (1)	
<i>Carex sorinellii</i>	3 (9)	tr	1 (2)	tr	3 (9)					13 (13)	
<i>Oryzopsis microantha</i>	tr	3 (5)	1 (1)	1 (1)	tr		1 (1)	2 (8)			
<i>Poa pratensis</i>	tr	tr	tr	tr	1 (3)			tr			3 (4)
Unknown grasses						tr					tr
Forbs:											
<i>Achillea millefolium</i>	tr			tr		tr			1 (1)		
<i>Apocynum androsaemifolium</i>				tr							
<i>Arctium minus</i>											
<i>Chenopodium hybridum</i>				1 (3)				tr		4 (6)	2 (8)
<i>Clematis ligusticifolia</i>											
<i>Disporum trachycarum</i>				3 (5)			tr	7 (9)	6 (9)		
<i>Fraxinus glauca</i>				tr			2 (3)				
<i>Galium ascarine</i>			tr	tr							
<i>Galium boreale</i>	2 (3)	2 (1)	1 (1)	2 (1)	1 (2)	2 (2)	tr	2 (2)	1 (2)	1 (2)	4 (4)
<i>Hachelia deflexa</i>				tr						3 (4)	tr
<i>Hedysarum boreale</i>				tr							
<i>Heuchera richardsoni</i>				tr				1 (1)			
<i>Lysimachia ciliata</i>	2 (1)	3 (5)	1 (1)	tr			tr	4 (6)	2 (2)		
<i>Mnarda fistulosa</i>				tr							
<i>Osmorhiza longistylis</i>			1 (3)	tr				1 (3)	1 (3)	1 (3)	tr
<i>Polygonatum commutatum</i>											
<i>Sandwichia maritima</i>	1 (3)		1 (3)	tr							
<i>Sedum stellata</i>	1 (1)	1 (3)	12 (2)	tr	tr		tr				
<i>Sedum herbaceum</i>											
<i>Solidago</i> spp.		1 (2)		tr							
<i>Taraxacum officinale</i>	1 (1)	1 (1)	tr								
<i>Thalictrum venulosum</i>											
<i>Toxicodendron radicans</i>	1 (1)	2 (8)		1 (3)							
<i>Viola</i> spp.											
Unknown forbs	tr	tr	tr	1 (3)	tr	1 (2)	tr	tr	tr		1 (2)

Table 52. Continued.

Plant Species	Transect Number											
	1(+)	2(+)	3(+)	4(-)	5(-)	6(-)	7(+)	8(+)	9(+)	13(-)	14(-)	15(-)
Shrubs and Trees												
<u>Amelanchier alnifolia</u>	tr	4 (6)	tr	tr		tr				tr		
<u>Fraxinus pennsylvanica</u>	tr		tr	3 (9)	3 (9)	1 (3)		1 (3)		3 (9)	1 (4)	tr
<u>Juniperus communis</u>						tr						
<u>Prunus virginiana</u>	12 (10)	11 (11)	7 (12)	6 (10)	5 (6)	1 (3)	5 (10)	7 (12)	1 (1)	3 (8)	1 (3)	tr
<u>Rhus trilobata</u>	tr											tr
<u>Ribes odoratum</u>						tr					tr	
<u>Ribes setosum</u>		tr			tr					tr		
<u>Rosa woodsii</u>		tr			1 (3)	1 (3)		2 (6)		tr		
<u>Shepherdia argentea</u>					tr					tr		
<u>Symphoricarpos occidentalis</u>	11 (9)	12 (11)		tr		14 (24)			2 (4)	1 (3)	tr	2 (8)
Moss						tr			tr	tr		tr
Litter	95 (8)	96 (5)	95 (8)	95 (8)	96 (5)	94 (6)	96 (5)	92 (12)	93 (7)	96 (3)	98 (1)	96 (3)
Bare ground	2 (8)		4 (9)	2 (4)	tr	1 (3)	1 (3)	tr	2 (3)			
Deer feces									tr			
Elk feces			1 (1)				tr		tr			

Table 53. Percent canopy coverage of herbaceous vegetation (<1 m) in hardwood draws within (+) and outside (-) the range of elk in TRNP, 1986. Standard deviation is in parentheses.

Plant Species	Transect Number											
	1(+)	2(+)	3(+)	4(-)	5(-)	6(-)	7(+)	8(+)	9(+)	13(-)	14(-)	15(-)
Grasses and Graminoids:												
<i>Agropyron trachypogon</i>	tr				tr	tr		tr		1 (3)		
<i>Bromus inermis</i>	tr	tr	tr						tr		tr	tr
<i>Elymus virginicus</i>											tr	
<i>Carex</i> spp.	2 (8)	1 (3)	1 (1)		5 (12)		2 (6)	1 (1)		8 (9)		
<i>Carex tortuifolii</i>	1 (3)	1 (3)	tr	2 (3)	tr	3 (8)			5 (5)	2 (3)		1 (1)
<i>Oryzopsis microantha</i>	1 (3)	tr	tr	tr	tr	tr		tr				
<i>Poa pratensis</i>	tr											
<i>Stipa viridula</i>												
Forbs:												
<i>Achillea millefolium</i>	tr					tr			tr			
<i>Arctium minus</i>											2 (5)	
<i>Chenopodium hybridum</i>											tr	
<i>Clematis ligusticifolia</i>												
<i>Fragaria glauca</i>	1 (1)	tr		tr			3 (6)	5 (5)	3 (4)			
<i>Galium anserine</i>	tr											
<i>Galium boreale</i>	2 (1)	3 (5)	1 (1)	1 (3)	2 (3)	2 (1)		1 (1)	tr	tr	1 (1)	1 (1)
<i>Lysimachia ciliata</i>	tr	2 (5)						1 (4)		tr		
<i>Helianthus foeniculifolius</i>												
<i>Monarda fistulosa</i>	tr	tr				tr						tr
<i>Oenothera longistylis</i>	tr											tr
<i>Ononis stricta</i>												
<i>Polygonatum commutatum</i>			tr								tr	
<i>Potentilla</i> spp.	tr	tr	tr		tr	tr						
<i>Salicaria stellata</i>												
<i>Salix herbacea</i>												
<i>Solidago</i> spp.	tr		tr			1 (3)	tr	tr				tr
<i>Taraxacum officinale</i>	tr			tr								
<i>Toxicodendron radicans</i>	tr			tr			tr	tr	1 (3)			
<i>Viola</i> spp.				tr		tr	tr	tr	tr		tr	tr
Unknown forbs	tr		tr	tr	tr	tr	tr	tr				
Ferns												
<i>Cystopteris fragilis</i>							tr					

Table 54. Percent canopy coverage of herbaceous vegetation (<1-m) in juniper draws within (+) and outside (-) the range of elk in TRNP, Standard deviation is in parentheses.

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(-)
Grasses and Grasslike:						
<u>Agropyron trachycaulum</u>	tr ^a		tr		1 (3)	tr
<u>Elymus virginicus</u>		tr				
<u>Carex spp.</u>				6 (9)		1 (1)
<u>Carex springellii</u>		11 (22)				tr
<u>Oryzopsis micrantha</u>	20 (20)	3 (4)	2 (3)	1 (1)	2 (4)	tr
Forbs:						
<u>Achillea millefolium</u>		tr			tr	tr
<u>Chenopodium hybridum</u>	tr					
<u>Cirsium canadensis</u>	2 (5)					
<u>Compositae spp.</u>			1 (1)		tr	
<u>Descurainia sophia</u>	tr					
<u>Galium asparine</u>	tr		1 (1)			
<u>Galium boreale</u>	tr	tr	tr	tr	tr	tr
<u>Heuchera richardsoni</u>					tr	
<u>Taraxacum officinale</u>	1 (1)	2 (3)			tr	tr
<u>Viola spp.</u>	1 (1)	tr	tr		tr	tr
Unknown forbs	tr	tr	tr	tr	tr	
Ferns						
<u>Cystopteris fragilis</u>	tr	tr				

Table 54. Continued.

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(-)
Shrubs and Trees						
<u>Fraxinus pennsylvanica</u>	tr		1 (2)	4 (9)		2 (5)
<u>Juniperus communis</u>			1 (2)			1 (3)
<u>Juniperus scopulorum</u>				tr		1 (3)
<u>Prunus virginiana</u>	1 (1)	1 (3)	tr		tr	tr
<u>Rhus trilobata</u>		tr				1 (3)
<u>Sarcobatus vermiculatus</u>			1 (1)	tr		
<u>Symphoricarpos occidentalis</u>	tr					
Moss	18 (30)	37 (28)	63 (39)	65 (19)	73 (20)	53 (36)
Litter	60 (32)	46 (24)	33 (34)	21 (14)	15 (17)	42 (35)
Bare ground	6 (19)	1 (3)	3 (14)		4 (17)	tr
Deer feces		tr			tr	

^atr = <0.5%

Table 55. Percent canopy coverage of herbaceous vegetation (<1 m) in juniper draws within (+) and outside (-) the range of elk in TRNP, 1986. Standard deviation is in parentheses.

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(+)
Grasses and Grasslike:						
<u>Agropyron trachycaulum</u>		tr ^a		5 (9)		tr
<u>Carex spp.</u>						2 (3)
<u>Carex springellii</u>		7 (13)				tr
<u>Oryzopsis micrantha</u>	16 (20)	5 (6)	1 (1)	tr	4 (5)	1 (3)
<u>Poa pratensis</u>		tr	tr			1 (3)
<u>Unknown grass</u>						tr
Forbs:						
<u>Achillea millefolium</u>		tr				tr
<u>Campanula rotundifolia</u>			tr			
<u>Chenopodium hybridum</u>	2 (3)					
<u>Cirsium canadensis</u>	4 (11)					
<u>Clematis ligusticifolia</u>		1 (2)				
<u>Euphorbia esula</u>			tr			
<u>Galium boreale</u>	tr	1 (1)	1 (2)	2 (3)	1 (2)	1 (3)
<u>Hachelia deflexa</u>	3 (5)	tr	tr		1 (3)	
<u>Heuchera boreale</u>					tr	
<u>Heuchera richardsonii</u>		tr			2 (3)	
<u>Lysimachia ciliata</u>	4 (6)	1 (2)				
<u>Melilotus officinalis</u>		tr				
<u>Smilacina stellata</u>	tr	tr	tr	tr	tr	tr
<u>Solidago spp.</u>		tr				
<u>Taraxacum officinale</u>	tr	tr		tr		tr
<u>Viola spp</u>			tr			tr
<u>Unknown forb</u>	tr	tr	1 (1)		tr	tr

Table 55 Continued.

125

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(+)
Ferns						
<u>Cystopteris fragilis</u>	tr	1 (2)			tr	1 (3)
Shrubs and Trees						
<u>Chrysothamnus nauseosus</u>						1 (1)
<u>Fraxinus pennsylvanica</u>						1 (1)
<u>Juniperus communis</u>				2 (8)		3 (8)
<u>Juniperus scopulorum</u>	tr	tr	tr		tr	tr
<u>Prunus virginiana</u>	1 (3)	2 (3)	tr		1 (3)	
<u>Rhus trilobata</u>	1 (3)					1 (4)
<u>Ribes odoratum</u>	tr					
<u>Rosa Woodsii</u>			tr			
<u>Symphoricarpos occidentalis</u>	2 (5)		1 (3)	tr	1 (2)	1 (3)
Moss	20 (34)	41 (38)	61 (40)	77 (21)	67 (30)	50 (32)
Litter	61 (40)	55 (31)	21 (26)	15 (11)	14 (19)	45 (34)
Bare ground	12 (30)	1 (4)	8 (23)		15 (26)	1 (3)
Deer feces	tr					
Elk feces	tr		tr			

Table 58. Mean density (N/m^2) and percent utilization of shrubs in juniper draws within (+) and outside (-) the range of elk in TRNP, 1985.

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(-)
0-50 cm						
<u>Chrysothamnus nauseosus</u>						tr ^a /5
<u>Fraxinus pennsylvanica</u>	tr/30	tr/0	1/0	1/0		2/0
<u>Juniperus communis</u>			1/0			
<u>Juniperus scopulorum</u>	1/36	1/0	1/12	3/0		2/tr
<u>Prunus virginiana</u>	tr/0		tr/0			1/13
<u>Rhus trilobata</u>			1/0		tr/0	tr/0
<u>Ribes setosum</u>			5/4		tr/0	
<u>Rosa woodsii</u>	2/41			2/17	2/25	6/25
<u>Symphoricarpos occidentalis</u>						
50-100 cm						
<u>Fraxinus pennsylvanica</u>	tr/30					
<u>Potentilla fruticosa</u>				tr/0		
<u>Prunus virginiana</u>	tr/75	1/2		5/0		4/0
<u>Rhus trilobata</u>			tr/30	tr/0		tr/1
<u>Rosa woodsii</u>				tr/0		
100-200 cm						
<u>Prunus virginiana</u>				6/0		

^atr = <0.5%

Table 59. Mean density (N/m^2) and percent utilization of shrubs in juniper draws within (+) and outside (-) the range of elk in TRNP, 1986.

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(+)
0-50 cm						
<u>Fraxinus pennsylvanica</u>				tr ^a /0		tr/5
<u>Juniperus communis</u>			6/0	2/0		5/0
<u>Juniperus scopulorum</u>		3/0	3/0			tr/0
<u>Prunus virginiana</u>	1/0	2/0	tr/0	5/0		4/tr
<u>Rhus trilobata</u>	tr/0		tr/0			1/0
<u>Ribes setosum</u>						tr/0
<u>Rosa Woodsii</u>			tr/0			
<u>Symphoricarpos occidentalis</u>	3/13	1/0	3/9	3/tr	5/5	6/8
50-100						
<u>Chrysothamnus nauseosus</u>						tr/0
<u>Potentilla fruticosa</u>				tr/0		
<u>Prunus virginiana</u>	1/8	2/0		2/0		1/0
<u>Rhus trilobata</u>			tr/5	tr/5		tr/3
<u>Symphoricarpos occidentalis</u>				tr/0		
100-200 cm						
<u>Prunus virginiana</u>		tr/0		tr/0		

^atr = <0.5%

Table 60. Density (N/60 m²) and percent utilization of saplings and trees browsed in hardwood draws within (+) and outside (-) the range of elk in TRNP, 1985.

Plant Species	Transect Number														
	1(+)	2(+)	3(+)	4(-)	5(-)	6(-)	7(+)	8(+)	9(+)	13(-)	14(-)	15(-)			
Saplings															
<i>Amelanchier alnifolia</i>	23/50	7/100	3/100	5/0		8/0	1/100	16/94		4/100			3/23		
<i>Cornus rotundifolia</i>	1/0														
<i>Fraxinus pennsylvanica</i>	6/60	7/60		25/10	21/11	15/0	9/78	9/38	11/100	6/0	9/0		3/0		
<i>Prunus americana</i>				3/100	3/100										
<i>Prunus virginiana</i>	12/42	16/94	56/35	22/10		20/8	29/69	12/92	1/100	31/6	35/0		62/0		
<i>Rhus trilobata</i>						1/0							5/40		
<i>Ribes odoratum</i>		2/0			1/1	2/0									
<i>Sambucus</i> spp.							5/100								
<i>Ulmus americana</i>															
Trees															
<i>Fraxinus pennsylvanica</i>															
<i>Juglans scopulorum</i>	4/33	3/0	5/0	2/0	2/0	1/0	7/50	11/10	6/67	5/0	1/33		3/0		
<i>Ulmus americana</i>			1/0			1/0	1/0								

1000

Plant Species	Transect Number											
	1(+)	2(+)	3(+)	4(-)	5(-)	6(-)	7(+)	8(+)	9(+)	13(-)	14(-)	15(-)
Saplings												
<u>Amelanchier alnifolia</u>	2/11	10/10	3/0	3/0		3/0	1/0	20/10		3/0		1/0
<u>Crataegus rotundifolia</u>	1/0											
<u>Fraxinus pennsylvanica</u>	1/3	1/26	2/0	21/0	19/0	12/0	5/0	6/0	12/8	7/0	1/20	6/0
<u>Pinus americana</u>				1/0	6/33						1/100	
<u>Pinus virginiana</u>	10/0	28/0	58/2	15/0	3/0	29/5	33/0	9/0	1/0	21/0	39/0	51/0
<u>Rhus trilobata</u>						1/0						1/0
<u>Ribes odoratum</u>		7/0				3/0		8/0				
<u>Ulmus americana</u>			1/0									
Trees												
<u>Fraxinus pennsylvanica</u>	tr/38		tr/0	1/0	1/25	tr/0		tr/0	tr/0	tr/0	tr/0	
<u>Juniperus scopulorum</u>						1/0						
<u>Ulmus americana</u>							2/0					

Table 62. Density (N/60 m²) and percent of saplings and trees browsed in juniper draws within (+) and outside (-) the range of elk in TRNP, 1985.

	Transect Number					
Plant Species	10(+)	11(-)	12(+)	16(-)	17(+)	18(-)
Saplings						
<u>Fraxinus pennsylvanica</u>	4/100	8/0				4/0
<u>Juniperus scopulorum</u>	5/0	3/0	29/0	12/0 9/11	12/0	15/0
<u>Prunus virginiana</u>						
Trees						
<u>Fraxinus pennsylvanica</u>		1/0				
<u>Juniperus scopulorum</u>	9/0	3/0	5/0	7/0	12/0	5/0

Table 63. Density (N/60 m²) and percent of saplings and trees browsed in juniper draws within (+) and outside (-) the range of elk in TRNP, 1986.

Plant Species	Transect Number					
	10(+)	11(-)	12(+)	16(-)	17(+)	18(+)
Saplings						
<u>Fraxinus pennsylvanica</u>	2/0	8/0				4/0
<u>Juniperus scopulorum</u>	7/0	1/0	21/7	12/0	16/0	16/0
<u>Prunus virginiana</u>				8/0		
Trees						
<u>Fraxinus pennsylvanica</u>		3/0				
<u>Juniperus scopulorum</u>	7/0	3/0	11/0	7/0	9/0	5/0

APPENDIX F

Percent diet composition of food items identified in
bimonthly fecal samples of elk, mule deer, white-tailed
deer, and feral horses in TRNP, 1985-86.

Table 64. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of elk in TRNP, 1985-86.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Graminoids								
<i>Agropyron cristatum</i>					10.7	10.1		
<i>Agropyron smithii</i>	7.5	11.9	16.9	11.5	5.8	5.2	6.4	1.6
<i>Andropogon gerardii</i>			.5	2.8		0.3		
<i>Aristida</i> spp.				1.5				
<i>Bouteloua gracilis</i>	0.6	9.0	3.2	5.8	2.5	0.5	0.7	1.8
<i>Bromus inermis</i>					16.3	7.6		
<i>Bromus tectorum</i>			0.7					
<i>Bromus</i> spp.				3.0				
<i>Calamovilfa longifolia</i>	0.5	0.6	1.1	3.4	1.6	1.2		0.6
<i>Carex filifolia</i>			14.1	14.6	20.8	4.8		
<i>Carex sorensonii</i>	0.4	8.0					1.0	
<i>Echinochloa crusgalli</i>				1.3				
<i>Eleus virginicus</i>	3.2	4.2	0.5					5.5
<i>Koeleria pyramidata</i>			1.5					
<i>Muhlenbergia</i> spp.	0.2	0.4	1.1	3.1	0.8	0.5	1.5	1.2
<i>Oryzopsis micrantha</i>	6.3	6.6	5.7	3.7	5.1	2.9		0.5
<i>Poa</i> spp.	15.8	14.4	4.0	1.0	4.1	6.8	1.9	3.1
<i>Schizachyrium scoparium</i>	0.8	0.8	3.0	6.3	8.6	2.7	1.3	
<i>Stipa comata</i>		2.8	12.3	17.3	5.5	5.2	2.5	2.8
<i>Stipa viridula</i>	13.6	4.4	10.6	2.4	4.9	0.7		2.2
Total Graminoids	48.9	63.1	75.1	77.7	86.7	48.5	15.2	19.2
Forbs								
<i>Achillea millefolium</i>					0.8	0.3	1.4	1.8
<i>Allium</i> spp.					0.4		2.1	
<i>Arabis holboellii</i>		0.5				1.2		1.1
<i>Aster</i> spp.								
<i>Calochortus nuttallii</i>						0.5		
<i>Cystopteris fragilis</i>						0.3		
<i>Echinacea angustifolia</i>						0.8	0.3	
<i>Erysimum asperum</i>							0.2	
<i>Gaura coccinea</i>							1.0	1.2
<i>Lactuca oblongifolia</i>						0.7		0.4
Lichen								
	0.2							

Table 64. Continued.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Forbs (Continued)								
<i>Lithospermum incisum</i>						0.7		
<i>Lyaschea ciliata</i>						0.6	2.5	0.7
<i>Melilotus</i> spp.						0.7		
Moss		2.4				0.6		
<i>Penstemon albidus</i>							2.8	0.7
<i>Phlox</i> spp.							0.4	
<i>Psoralea</i> spp.							1.9	
<i>Ranunculus glaberrimus</i>						0.2	0.3	2.0
<i>Ratibida columnifera</i>							1.2	0.5
<i>Salicaria stellata</i>						4.4	3.5	4.7
<i>Sphaeralcea coccinea</i>		0.4			0.2		2.5	
<i>Taraxacum officinale</i>								0.9
<i>Thermopsis rhombifolia</i>					1.9	1.6	7.2	
Unknown Forb						2.4	1.0	0.9
<i>Vicia americana</i>							1.4	
<i>Viola</i> spp.					3.3	15.0	29.6	14.9
Total Forbs	0.2	3.3						
Browse								
<i>Amelanchier alnifolia</i>							2.3	
<i>Artemisia</i> spp.	0.6	2.5	2.0	0.2	1.1	0.2		6.6
<i>Artemisia frigida</i>	1.3	5.8	5.4	5.0	2.6			12.2
<i>Betula occidentalis</i> ^a							24.4	14.1
<i>Betula lanata</i>	20.5	20.5	10.7	8.8	6.4	18.3		17.1
<i>Eurotia</i> spp.	0.5	0.3				11.3	4.5	
<i>Juniperus</i> spp.	14.6	0.7					1.3	
<i>Prunus virginiana</i>	1.4	0.6				1.2	3.4	2.4
<i>Rhus trilobata</i>	5.5					4.8	1.5	1.9
<i>Ribes</i> spp.							15.2	1.8
<i>Rosa</i> spp.						0.7	1.4	9.4
<i>Shepherdia argentea</i>								
<i>Symphoricarpos occidentalis</i>	6.5	3.3	6.8	8.3				
<i>Yucca glauca</i>								
Total Browse	50.9	33.5	24.9	22.2	10.1	36.5	54.0	65.4
Seed/Nut							1.2	0.6

^a includes primarily *A. cana* and *A. tridentata*
^b *Fraxinus pennsylvanica* has similar plant fragments as *B. occidentalis* and may represent a portion of this percentage (B. Davitt pers. comm. 1988)

Table 65. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of mule deer in TRNP, 1985-86.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Graminoids								
<i>Agropyron smithii</i>	1.7	1.4		2.6			0.6	2.2
<i>Carex sprengei</i>		0.5		1.2				
<i>Carex</i> spp.	4.2	2.4		1.9		2.5		1.1
<i>Elmus virginicus</i>						0.5		
<i>Muhlenbergia</i> spp.	2.2	1.0		0.8	2.9	0.3		1.4
<i>Oryzopsis microantha</i>	1.2	0.6			12.8	3.0		2.2
<i>Poa</i> spp.	0.6							
<i>Schizachirium scoparium</i>	2.3				1.5	1.2		2.9
<i>Stipa comata</i>	2.6	0.7				0.5		
<i>Stipa viridula</i>								
Total Graminoids	14.9	6.5		0.8	23.0	8.1	0.6	9.7
Forbs								
<i>Achillea millefolium</i>	0.3							
<i>Arabis holboellii</i>				0.2		1.4		
<i>Arctium minus</i>	0.7	0.3						
<i>Aster</i> spp.	2.3	0.4				2.9	0.2	1.6
<i>Astragalus</i> spp.						12.2		
<i>Campanula rotundifolia</i>				1.1				
<i>Erigeron</i> spp.		0.4						
<i>Erysimum asperum</i>						3.5		0.3
<i>Galium boreale</i>		4.7				1.2		1.5
<i>Gaura coccinea</i>						8.3	0.5	
<i>Glycyrrhiza lepidota</i>		0.9						
<i>Lactuca oblongifolia</i>	1.1	0.4	0.9			2.0		
<i>Lesquerella</i> spp.		2.2				0.5		
<i>Lithospermum incisum</i>						1.0		
<i>Linum</i> spp.						3.8	0.4	1.4
<i>Melilotus</i> spp.					0.3			
<i>Monarda fistulosa</i>								
<i>Opuntia</i> spp.				1.9				

Table 65. Continued.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Forbs (Continued)								
<i>Penstemon albidus</i>					0.8	3.5		1.7
<i>Ratibida columnifera</i>		0.2		1.4		0.3		
<i>Sphaeralcea coccinea</i>						2.4		
<i>Taraxacum officinale</i>					0.3	0.7		
<i>Thermopsis rhombifolia</i>	2.7	0.3						
<i>Viola</i> spp.					1.6			
Total Forbs	7.1	9.9	0.9	4.4	1.6	45.5	1.1	6.4
Browse								
<i>Amelanchier alnifolia</i>	2.9	1.8					0.3	0.1
<i>Artemisia</i> spp. ^a	7.7	31.4	36.4	61.5	58.6	5.2		
<i>Artemisia frigida</i>	0.5	3.1	0.2		3.0	3.8		
<i>Artemisia ludoviciana</i>		1.9				0.6		
<i>Atriplex confertifolia</i>		0.3			1.2			
<i>Chrysothamnus nauseosus</i>		4.0	0.6					
<i>Clemtis ligusticifolia</i>				0.3			0.3	
<i>Eurotia lanata</i>		0.4		0.5		0.5	0.2	
<i>Gutierrezia sarothrae</i>	4.2							
<i>Juniperus</i> spp.	6.7	5.2	0.6	27.7				
<i>Prunus virginiana</i>	5.9	2.2	51.6		7.5		3.2	13.1
<i>Rhus trilobata</i>	8.1	5.5	3.9		1.3		3.6	2.1
<i>Ribes setosum</i>	3.6	5.0	0.5			10.2	2.4	3.1
<i>Rosa</i> spp.	5.8	2.7	2.4	1.1			0.4	1.7
<i>Rubus idaeus</i>								0.5
<i>Shepherdia argentea</i>	4.5	0.9				23.2	69.6	49.7
<i>Symphoricarpos occidentalis</i>	28.0	18.9	2.7	0.9	3.6	2.8	18.1	13.5
<i>Yucca glauca</i>				2.8				
Total Browse	77.9	83.5	99.1	94.8	75.3	46.4	98.2	83.8

^aIncludes primarily *A. cana* and *A. tridentata*.

Table 66. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of white-tailed deer in TRNP, 1985-86.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Graminoids								
<u>Agropyron smithii</u>	1.7	1.4		2.6			0.6	2.2
<u>Carex sprengei</u>		0.5		1.2				
<u>Carex spp.</u>	4.2	2.4		1.9		2.5		1.1
<u>Elmus virginicus</u>						0.5		
<u>Muhlenbergia spp.</u>	2.2	1.0		0.8	2.9	0.3		1.4
<u>Oryzopsis microantha</u>	1.2	0.6		12.8		3.0		2.2
<u>Poa spp.</u>	0.6							
<u>Schizachyrium scoparium</u>	2.3					1.2		2.9
<u>Stipa comata</u>	2.6	0.7		1.5		0.5		0.5
<u>Stipa viridula</u>								
Total Graminoids	14.9	6.5		0.8	23.0	8.1	0.6	9.7
Forbs								
<u>Achillea millefolium</u>	0.3							
<u>Arabis holboellii</u>				0.2		1.4		
<u>Arctium minus</u>	0.7	0.3						
<u>Aster spp.</u>	2.3	0.4				2.9	0.2	1.6
<u>Astragalus spp.</u>						12.2		
<u>Campanula rotundifolia</u>				1.1				
<u>Erigeron spp.</u>		0.4						
<u>Erysimum asnerum</u>						3.5		0.3
<u>Galium boreale</u>		4.7				1.2		1.5
<u>Gaura coccinea</u>						8.3	0.5	
<u>Glycyrrhiza lepidota</u>		0.9						
<u>Lactuca oblongifolia</u>	1.1	0.4	0.9			2.0		
<u>Lesquerella spp.</u>		2.2						
<u>Lithospermum incisum</u>						0.5		
<u>Linum spp.</u>					0.3	1.0		
<u>Melilotus spp.</u>						3.8	0.4	1.4
<u>Monarda fistulosa</u>				1.9				
<u>Ononitis spp.</u>								

Table 66. Continued.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Forbs (Continued)								
<i>Penstemon albidus</i>							1.4	1.5
<i>Potentilla</i> sp.						0.5	0.3	
<i>Psoralea</i> sp.					1.0			
<i>Ranunculus glaberrimus</i>						4.8	3.8	
<i>Ratibida columbifera</i>				2.5	0.5	0.2	0.4	
<i>Sanicula marilandica</i>							0.6	0.8
<i>Solidago stellata</i>							0.6	
<i>Sphaeralcea coccinea</i>		1.5			1.5	5.0	2.4	2.2
<i>Taraxacum officinale</i>						9.0	5.7	3.3
<i>Thalictrum venulosum</i>	3.4						4.5	0.9
<i>Thlaspi dubius</i>	0.9				0.1		1.4	4.2
<i>Trigonostemon dubius</i>						2.1	1.9	
<i>Trifolium pratense</i>						7.8	5.7	3.0
Unknown Forb							2.2	1.0
<i>Urtica dioica</i>					2.5	10.5		
<i>Vicia americana</i>								
<i>Viola</i> sp.								
Total Forbs	10.8	11.8	3.4	2.5	33.7	80.3	58.0	38.0
Browse								
<i>Acer negundo</i>	0.3		3.6				0.9	
<i>Aemilanchier alnifolia</i>	5.7	1.5	1.0					
<i>Artemisia</i> sp.	0.3	0.9	0.3	3.4	2.8	0.1	0.1	
<i>Artemisia frigida</i>		8.1	2.6	15.4	2.1	0.5		
<i>Artemisia ludoviciana</i>								0.3
<i>Atriplex confertifolia</i>								
<i>Fraxinus pennsylvanica</i>	1.4		1.1	19.3				
<i>Juniperus</i> sp.		0.6	17.0	0.7				
<i>Populus deltoides</i>		2.5	3.5	3.6	0.6			3.9
<i>Prunus virginiana</i>	27.1	5.4	18.1	5.0	2.3	2.9	0.4	1.5
<i>Rhus trilobata</i>	4.2	1.7	7.3	1.1	1.0	1.5	0.5	3.5
<i>Ribes acetosum</i>	20.2	18.7	22.1	4.6				
<i>Rosa</i> sp.	6.6	6.1	8.8	1.6				
<i>Shepherdia argentea</i>	0.5	0.5	6.2	2.1	4.2	5.0	26.9	37.3
<i>Symphoricarpos occidentalis</i>	9.9	6.4				0.8		1.8
<i>Toxicodendron rydbergii</i>		2.4			2.7	1.7	2.8	6.8
Total Browse	76.3	54.9	91.4	35.8	16.8	12.6	31.6	55.1

*Includes primarily *A. cana* and *A. tridentata*

Table 67. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of feral horses in TRNP, 1985-86.

Plant Species	Early Fall 1985	Late Fall 1985	Early Winter 1985-86	Late Winter 1985-86	Early Spring 1986	Late Spring 1986	Early Summer 1986	Late Summer 1986
Graminoids								
<u>Agropyron cristatum</u>		1.2		5.2	3.1	9.3	5.2	4.3
<u>Agropyron smithii</u>	24.1	16.5	13.8	10.4	5.9	8.6	20.2	19.4
<u>Andropogon gerardii</u>		3.0	2.2	0.6	0.8		2.6	3.8
<u>Bouteloua gracilis</u>	4.6	2.7	2.9	4.5	5.4	0.1	2.2	3.7
<u>Bromus inermis</u>	1.8				1.9	0.3		2.3
<u>Bromus tectorum</u>	4.3	0.5	1.3	2.8	2.7	3.3	1.9	
<u>Bromus</u> sp.	2.5	1.8	5.8	1.8				
<u>Calamovilfa longifolia</u>								
<u>Carex</u> sp.				9.7	19.0	14.9	1.9	3.7
<u>Distichlis stricta</u>						0.6	7.1	0.9
<u>Eleus virginicus</u>							1.4	
<u>Muhlenbergia</u> sp.	1.6	3.5	0.4	0.4		2.1	5.6	2.3
<u>Oryzopsis microantha</u>	1.7	2.3	3.1	6.3	4.8	1.0	2.2	2.1
<u>Poa</u> sp.	26.7	21.3	25.0	18.5	8.3	36.2	7.3	9.2
<u>Schizachyrium scoparium</u>	0.4	2.4	2.6	3.8	10.6	5.4	4.5	3.7
<u>Stipa comata</u>	14.3	13.4	16.3	14.4	23.9	7.4	22.4	21.5
<u>Stipa viridula</u>	12.3	25.7	13.2	9.3	8.0	9.9	9.8	12.4
Total Graminoids	94.3	94.3	86.9	87.7	94.3	99.1	96.7	89.3
Forbs								
<u>Achillea millefolium</u>			0.3	0.7			0.5	0.5
<u>Lichen</u>							0.2	
<u>Opuntia</u> sp.			0.7			0.4	1.5	
<u>Rumex</u> sp.						0.2		
<u>Sphaeralcea coccinea</u>	0.8		1.5				0.8	
Unknown Forb								
Total Forbs	0.8		2.5	0.7		0.6	3.0	0.5
Browse								
<u>Artemisia frigida</u>			3.6	7.0	1.4			
<u>Eurotia lanata</u>	4.8	5.7	6.2	4.7	4.3	0.2	0.3	10.2
<u>Shepherdia argentea</u>			0.9					
Total Browse	4.8	5.7	10.7	11.7	5.7	0.2	0.3	10.2

REFERENCES CITED

REFERENCES CITED

- Allen, E. D. 1968. Range use, foods, conditions, and productivity of white-tailed deer in Montana. J. Wildl. Manage. 32:130-141
- Baker, R. H. 1984. Classification and distribution. Pages 1-18 in L. K. Halls, ed. White-tailed deer: ecology and management. Stackpole Books. Harrisburg, Pa.
- Barr, C. A. 1983. Jewels of the plains: wildflowers of the Great Plains and hills. Univ. of Minn. Press. Minneapolis. 223 pp.
- Bell, H. M. 1973. Rangeland management for livestock production. Univ. of Oklahoma Press. Norman. 303 pp.
- Boyd, R. J. 1978. American elk. Pages 11-29 in J. L. Schmidt and D. L. Gilbert, eds. Big game of North America. Stackpole Books. Harrisburg, Pa.
- Burkhalter, D. E., and T. E. Lonner. 1983. User manual for the computer program TELDAY. 14 pp.
- Butler, J. L. 1983. Grazing and topographic influences on selected green ash (Fraxinus pennsylvanica) communities in the North Dakota badlands. M. S. Thesis. University of North Dakota, Fargo. 87pp.
- Byers, R. C., R. K. Steinhorst, and P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48: 1050-1053.
- Byrant, D. L., and C. Maser. 1982. Classification and distribution. Pages 1-59 in J. W. Thomas and D. E. Towell, eds. Elk of North America. Stackpole Books. Harrisburg, Pa.
- Canfield, R. H. 1941. Application of the line intercept method in sampling range vegetation. J. Forestry 39: 388-394.

- Caughley, G. 1979. What is this thing called carrying capacity? Pages 2-8 in M. S. Boyce and L. D. Hayden-Wing, eds. North American elk: ecology, behavior and management. The University of Wyoming. Laramie.
- Constan, K. J. 1972. Winter foods and range use of three species of ungulates. J. Wildl. Manage. 48:1068-1076.
- Craighead, J. J., F. C. Craighead, Jr., R. L. Ruff, and B. W. O'Gara. 1973. Home ranges and activity patterns of non-migratory elk of the Madison drainage herd as determined by biotelemetry. Wildl. Monogr. No. 33 50 pp.
- Daubenmire, R. F. 1959. A canopy coverage method of vegetational analysis. North West Sci. 33:43-64.
- Geist, V. 1982. Adaptive behavioral strategies. Pages 219-277 in J. W. Thomas and D. E. Toweill, eds. Elk of North America. Stackpole Books. Harrisburg, Pa.
- Girard, M. M. 1985. Native woodland ecology and habitat type classification of southwestern North Dakota. Ph.D. Thesis. North Dakota State Univ., Fargo. 314 pp.
- Hanson, P. L. 1980. An ecological study of the vegetation of Theodore Roosevelt National Park. M.S. Thesis. University of South Dakota. 182 pp.
- _____, R. B. Hopkins, and G. R. Hoffman. 1980. An ecological study of the habitat types and their animal components at Theodore Roosevelt National Park, North Dakota. University of South Dakota. 182 pp.
- _____, G. R. Hoffman, and A. J. Bjugstad. 1984. The vegetation of Theodore Roosevelt National Park, North Dakota: A habitat type classification. USDA, Forest Service Gen. Tech. Rep. RM-113. 35 pp.
- Hirsch, K. J. 1985. Habitat type classification of grasslands and shrublands of southwestern North Dakota. Ph.D. Thesis. Univ. of North Dakota, Fargo. 291 pp.
- Hitchcock, A. S. and A. Chase. 1971. Manual of the grasses of the United States. Dover Publications, New York, N. Y. 1051 pp.
- Klein, D. R. 1965. Ecology of deer range in Alaska. Ecol. Monog. 35(3):259-284.

- Knowles, C. J. 1975. Range relationships of mule deer, elk and cattle in a rest rotation grazing system during summer and fall. M.S. Thesis. Montana State University, Bozeman. 111 pp.
- Kruckenbergl, L. 1973. Game management of North Dakota - a summation and review. North Dakota Outdoors, Vol 35 (Feb. 1973). 57 pp.
- Kufeld, R. C. 1973. Foods eaten by Rocky Mountain elk. J. Range. Manage. 26:106-113.
- Laird, W. M. 1950. The geology of the South Unit of Theodore Roosevelt National Memorial Park. Theodore Roosevelt Nature and History Association. 17:225-240.
- Lovaas, A. L. 1958. Mule deer food habits and range use, Little Belt Mountains, Montana. J. Wildl. Manage. 22:275-283.
- Mackie, R. J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildl. Monogr. No. 20. Washington, D. C.: The Wildlife Society. 79 pp.
- _____. 1981. Interspecific relationships. Pages 487-507 in O. C. Wallmo, ed. Mule and black-tailed deer of North America. Univ. of Nebraska Press, Lincoln.
- _____, K. L. Hamlin, and D. F. Pac. 1982. Mule deer. Pages 862-877 in J. A. Chapman and G. A. Feldhamer eds. Wild mammals of North America: biology, management, economics. The John Hopkins University Press. Baltimore.
- Marcum, C. L. 1979. Summer-fall food habits and forage preferences of a western Montana elk herd. Pages 54-62 in M. S. Boyce and L. D. Hayden-Wing eds. North American elk: ecology, behavior and management. The University of Wyoming. Laramie.
- Marlow, C. B., L. R. Irby, and J. E. Norland. 1984. Optimum carrying capacity for bison in Theodore Roosevelt National Park. Montana State University, Bozeman. 83 pp.
- Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

- Morgantini, L. E. and R. J. Hudson. 1979. Human disturbance and habitat selection in elk. Pages 132-139 in M. S. Boyce and L. D. Hayden-Wing eds. North American elk: ecology, behavior and management. The University of Wyoming. Laramie.
- Murie, O. J. 1951. The elk of North America. Teton Bookshop, Jackson, Wy. 376pp.
- Nelson, J. R. 1960. Composition and structure of the woody vegetation types in the North Dakota badlands. M. S. Thesis. North Dakota State Univ., Grand Forks 195 pp.
- Nelson, J. R. 1982. Relationships of elk and other large herbivores. Pages 415-442 in J. W. Thomas and D. E. Toweill, eds. Elk of North America. Stackpole books. Harrisburg, Pa.
- _____, and J. L. Leege. 1982. Nutritional requirements and food habits. Pages 323-369 in J. W. Thomas and D. E. Toweill, eds. Elk of North America. Stackpole Books. Harrisburg, Pa.
- Norland, J. E. 1984. Habitat use and distribution of bison in Theodore Roosevelt National Park. M.S. Thesis. Montana State Univ., Bozeman. 131 pp.
- Peek, J. M. 1982. Elk. Pages 851-861 in J. A. Chapman and G. A. Feldhamer eds. Wild mammals of North America: biology, management, economics. The John Hopkins University Press, Baltimore.
- Sampson, A. W. 1952. Range management: principles and practices. John Wiley and Sons Inc., New York. 570 pp.
- Schultz, R. D. and J. A. Bailey. 1978. Responses of elk to human activity. J. Wildl. Manage. 42:91-100.
- Seigel, S. 1956. Nonparametric Statistics for behavioral sciences. McGraw-Hill, New York. 312 pp.
- Skovlin, J. M. 1982. Habitat requirements and evaluations. Pages 369-413 in J. W. Thomas and D. E. Toweill, eds. Elk of North America. Stackpole Books. Harrisburg, Pa.
- Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods, 7th ed. Iowa State Univ. Press, Ames. 507 pp.

USDA 1982. National list of plant scientific names. SCS-TP-159.

Telfer, E. S. and A. Cairns. 1979. Bison-wapiti interrelationships in Elk Island National Park, Alberta. Pages 114-121 in M. S. Boyce and L. D. Hayden-Wing eds. North American elk: ecology, behavior and management. The University of Wyoming. Laramie.

Varland K. L. 1978. Herd organization and movements of elk in Wind Cave National Park, South Dakota. Natural Resources Report Number 13. 28 pp.

Ward, A. L., J. L. Cupal, A. L. Lea, C. A. Oakley and R. W. Weeks. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. Trans. N. A. Wildl. Conf. 38:327-337.

Whitman, W. C. 1978. Analysis of grassland vegetation on selected key areas in southwestern North Dakota. North Dakota Regional Environmental Program. 72 pp.

Wallmo O. C. and W. L. Reglin. 1981. Food habits and nutrition Pages 387-398 in O. C. Wallmo ed. Mule and black-tailed deer of North America.

Wydeven, A. P. and R. B. Dahlgren. 1983. Food habits of elk in the northern great plains. J. Wildl. Manage. 47:916-923.

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall Inc. New Jersey. 718 pp.