Distribution, habitat use, and food habits of reintroduced elk in Theodore Roosevelt National Park, North Dakota

by Mark Gerald Sullivan

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

Montana State University

Abstract:
This study was initiated to determine distribution, habitat use, food habits and, potential effects of elk (Cervus elaphus) on flora and fauna in the South Unit (SU) of Theodore Roosevelt National Park (TRNP). Elk were reintroduced into TRNP in March 1985. In 2 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 heminionus), white-tailed deer (0. virginianus), and feral horses (Equuis 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 most 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.

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ABSTRACT

This study was initiated to determine distribution, habitat use, food habits and potential effects of elk (Cervus elaphus) on flora and fauna in the South Unit (SU) of Theodore Roosevelt National Park (TRNP). Elk were reintroduced into TRNP in March 1985. In 2 years the population grew from 47 to 80 animals with no known mortality. The range of elk increased in the Park from 35 km^2 the first year to 75 km^2 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 heminionus), white-tailed deer (O. virginianus), and feral horses (Equuis 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 most 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.

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 Cervus 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 6 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 (NU) 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 improve 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.

The objectives of this study, conducted from June 1985 to January 1988, were to determine: distribution, home range, population dynamics, activity and behavior patterns, habitat use, food habits, and the potential impacts of elk on Park resources. This study represents the first phase of a 4 year study with the primary objective of determining the carrying capacity of elk in TRNP. 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 SU, located in southwest North Dakota near Medora, and a NU, located 80 kilometers (km) north of Medora. The SU covers 18,756 hectares (ha) 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. Small buttes and hills are often capped with scoria, a clinker formed from clay baked by burning coal veins.

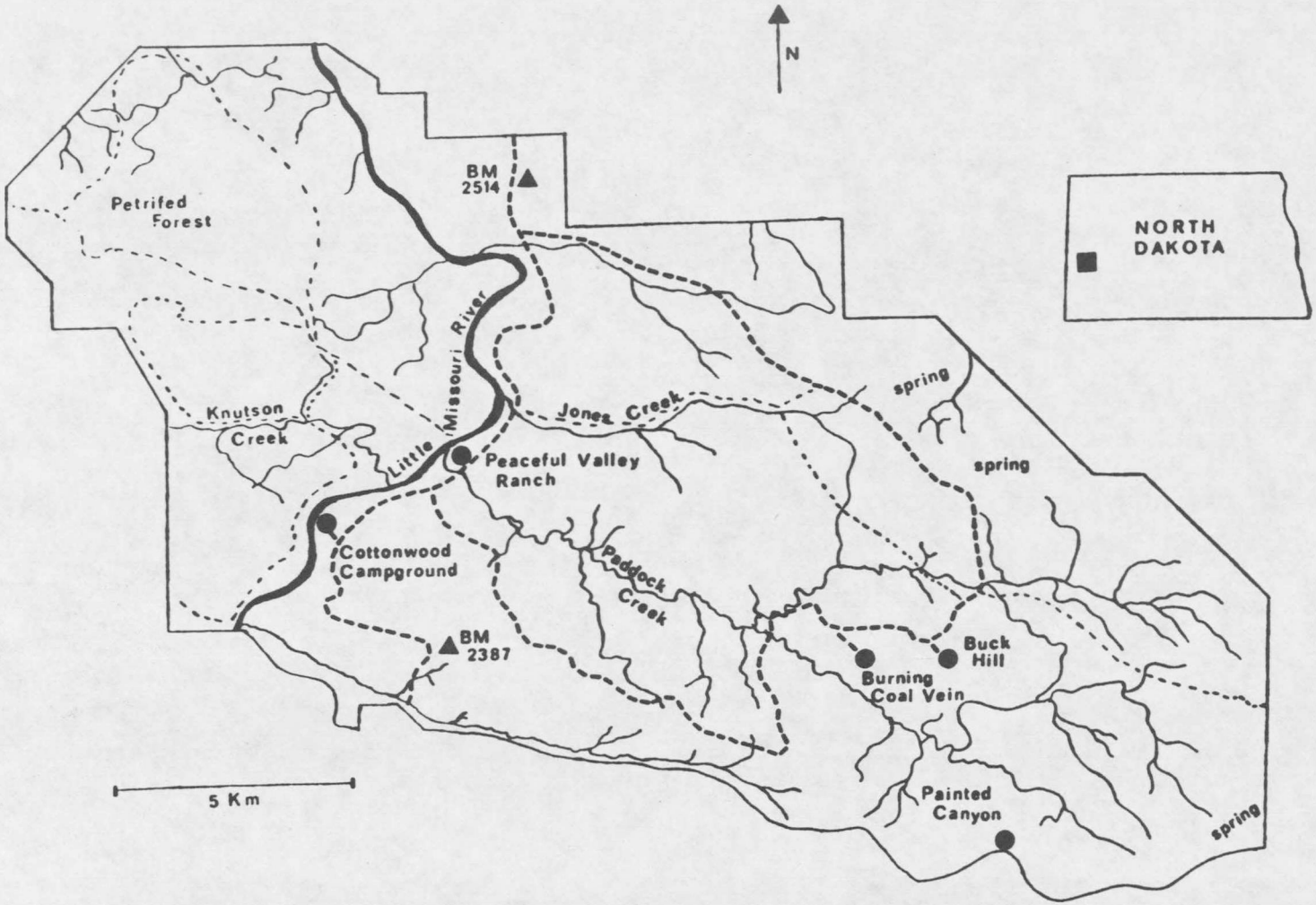

Figure 1. Map of South Unit, Theodore Roosevelt National Park.

Climate

Climate for Western North Dakota is Continental, characterized by short arid summers (mean July Temp.= 22 Celeus (C)) and long cold winters (mean Jan. Temp.= -11 C). Average annual rainfall is about 35.5 centimeters (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 2 schemes (physiographic/vegetational types and habitat types) to describe vegetation in TRNP.

A system of physiographic/vegetational types was developed based on terrain form and vegetational structural characteristics (Norland 1984). Eleven types are present in the SU: 1) Breaks consist of steep slopes which are often devoid of vegetation; 2) Cottonwood forests are found along the Little Missouri River and are dominated by

plains cottonwood (Populus deltoides); 3) Woody draws are deciduous tree stringers along slopes and are dominated by green ash (Fraxinus pennsylvanica) and chokecherry (Prunus virginiana); 4) Upland grasslands are level to rolling grasslands found on the plains above the river valley; 5) Old river terraces are level grasslands 61 to 152 m above the river situated on terraces; 6) Grassland flats are grassed alluvial deposits found 30 to 61 m above the river valley; 7) Bottom grasslands are grassed alluvial deposits found on higher floodplains of the Little Missouri River and its tributaries 8) Ridge and Ravine types are lands highly dissected by ephemeral water courses and covered by a wide variety of grasses, shrubs, and trees; 9) Scoria hills are rugged varied topography covered by grasses and shrubs; 10) Sagebrush bottoms are floodplains dominated by silver sagebrush (Artemisia cana) with a grass understory; 11) Prairie dog towns are lands influenced by black-tailed prairie dogs (Cynomys ludovicianus) where vegetation is absent or dominated by unpalatable plant species.

Norland (1984) also classified the vegetation types in TRNP 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.

The 7 grassland habitat types and mapping units in the SU are: Agropyron smithii - Stipa viridula, A. smithii -

S. comata, S. comata - Bouteloua gracilis, Schizachyrium scoparius, Andropogon gerardii, A. smithii - B. gracilis - Distichlis spicata, and Grassed floodplain (dominated by needle-and-thread grass (S. comata) and prairie sandreed (Calamovilfa longifolia)), habitat types. Two mapping units dominated by grasses are also present: Introduced grass (dominated by crested wheatgrass (A. cristatum) or smooth brome (Bromus inermis)) and Prairie dog towns (areas where vegetation has been modified by prairie dogs).

Shrubby habitat types and mapping units include: Artemisia cana, A. tridentata - Atriplex confertifolia, and A. tridentata - B. gracilis habitat types and the Brush (dominated by snowberry (Symphoricarpos occidentalis or chockcherry) and Willow mapping units. Wooded habitat types include: Juniperus scopulorum - Oryzopsis micrantha, Populus deltoides - J. scopulorum, P. tremuloides - Betula occidentalis and Hardwood draws (dominated by green ash and chokecherry).

Areas having very small intermixed habitat types or mapping units were classified as complexes (Norland 1984). The rolling scoria complex was comprised of Schizachyrium scoparium, Agropryon smithii - Stipa viridula, S. comata - Bouteloua gracilis, A. smithii - S. comata, S. scoparium - Juniperus horizontalis, and the A. smithii - B. gracilis - Distichlis stricta habitat types. The steep scoria complex was comprised of S. scoparium, S. comata - Bouteloua

gracilis, A. smithii - S. viridula, S. scoparium - Juniperus horizontalis, and the A. smithii - B. gracilis - Distichlis stricta habitat types. The proportion of each habitat type within theses two complexes is given in Norland (1984).

Large Herbivores

Bison were reintroduced into the SU in 1956. The Park Service currently manages the population at a level of approximately 200 animals. Feral horses in the SU are descendents of escaped local horses and 5 stallions donated by the BLM (TRNP Resource Management Plan and Environmental Assesment 1984). Horses are managed at a level of approximately 40 animals and are primarily restricted to the eastern portion of the SU. Mule deer are common throughout TRNP and the estimated population in the SU is 600 - 700 animals (TRNP Resource Management Plan and Environmental Assesment 1984). White-tailed deer are found primarily in the bottom lands of the Little Missouri River and the estimated population in the SU is 150 - 225 animals (TRNP Resource Management Plan and Environmental Assesment 1984).

California bighorn sheep (Ovis canadensis california), introduced into the SU in the 1950's, suffered a population crash in the mid 1970's (TRNP Resource Management Plan and Environmental Assesment 1984). Only 5

- 6 animals were present at the time of this study. These sheep were kept in an enclosed area within the southwest corner of TRNP as Park personnel attempted to rebuild the population. A small population of pronghorn antelope (Antilocapra americana) are found in the northeastern region of the SU. Seventy five antelope were released into the SU in 1956 and the herd size has fluctuated around this number as seasonally migratory herds move in and out of the Park (TRNP Resource Management Plan and Environmental Assesment 1984).

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, 2 males and 2 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 for individual recognition.

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 2 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 5 12-hr night radio relocation periods in summer

1985, 3 in fall 1985, and 5 24-hr radio relocation periods in summer 1986. Two to 3 5-m towers, each equipped with 2 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 the location for each radio-collared elk was 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 (Montana Department of Fish, Wildlife and Parks 1985). Telday determines home range size by forming a minimum convex polygon (Mohr 1947) using animal relocations on the perimeter of all relocations. 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-hr diurnal observation periods. Elk were observed with 7x35 mm binoculars or a 15-60X spotting scope 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-hr 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. Habitat use during the first and last hour of light was assumed to be similar to the 4 hrs prior to dawn and the first 4 hrs after dusk, respectively.

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).

Food Habits

Fecal samples were collected from elk, mule deer, white-tailed deer, and feral horses. Samples consisted of 1-gram (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.

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.

Transects placed in hardwood and juniper 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 decimeter (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%.

Canopy coverage for hardwood draws within and outside elk use areas (Appendix B) was calculated by averaging the mean canopy coverage for individual transects located within or outside the range of elk in the Park, respectively.

Shrub (woody vegetation <2 m in height) density was measured in 7 1-m^2 plots spaced 3 m apart along the transect. The number of individual shrubs by species in 3 height classes were counted within each 1-m^2 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. Total utilization for each species within and outside elk use areas (Appendix B) was calculated by averaging the mean utilization values for individual transects within and outside the range of elk in TRNP.

Sapling and tree densities were measured in a 60-m^2 plot parallel to the transect base line. Saplings were classified as woody species >2 m in height, but having a diameter at breast height (dbh) <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-m^2 plot were recorded. I 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. I 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.

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.

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 availablity 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

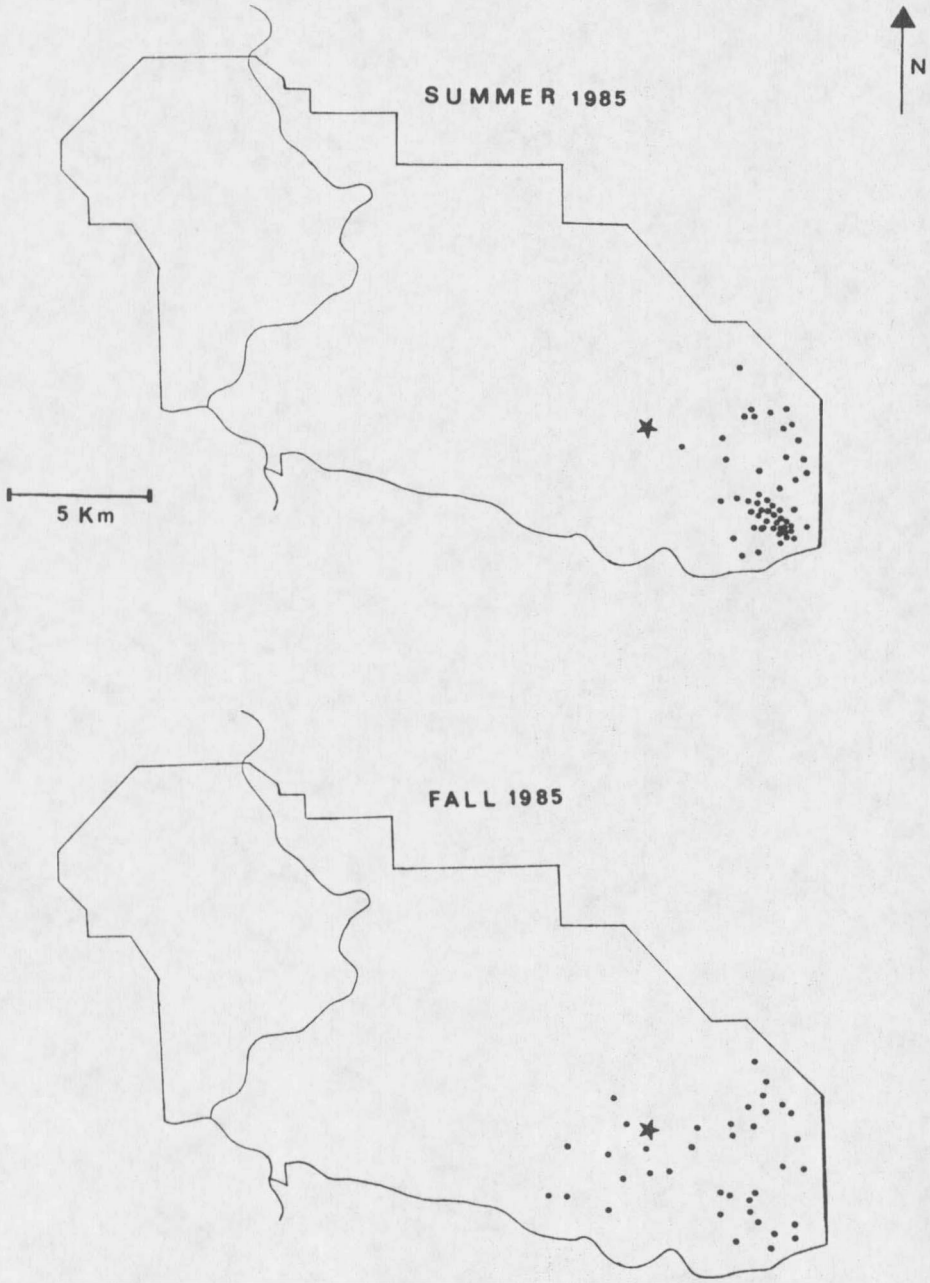

Figure 2. Seasonal distribution of elk in Theodore Roosevelt National Park, 1985-87.
★= release site of elk.

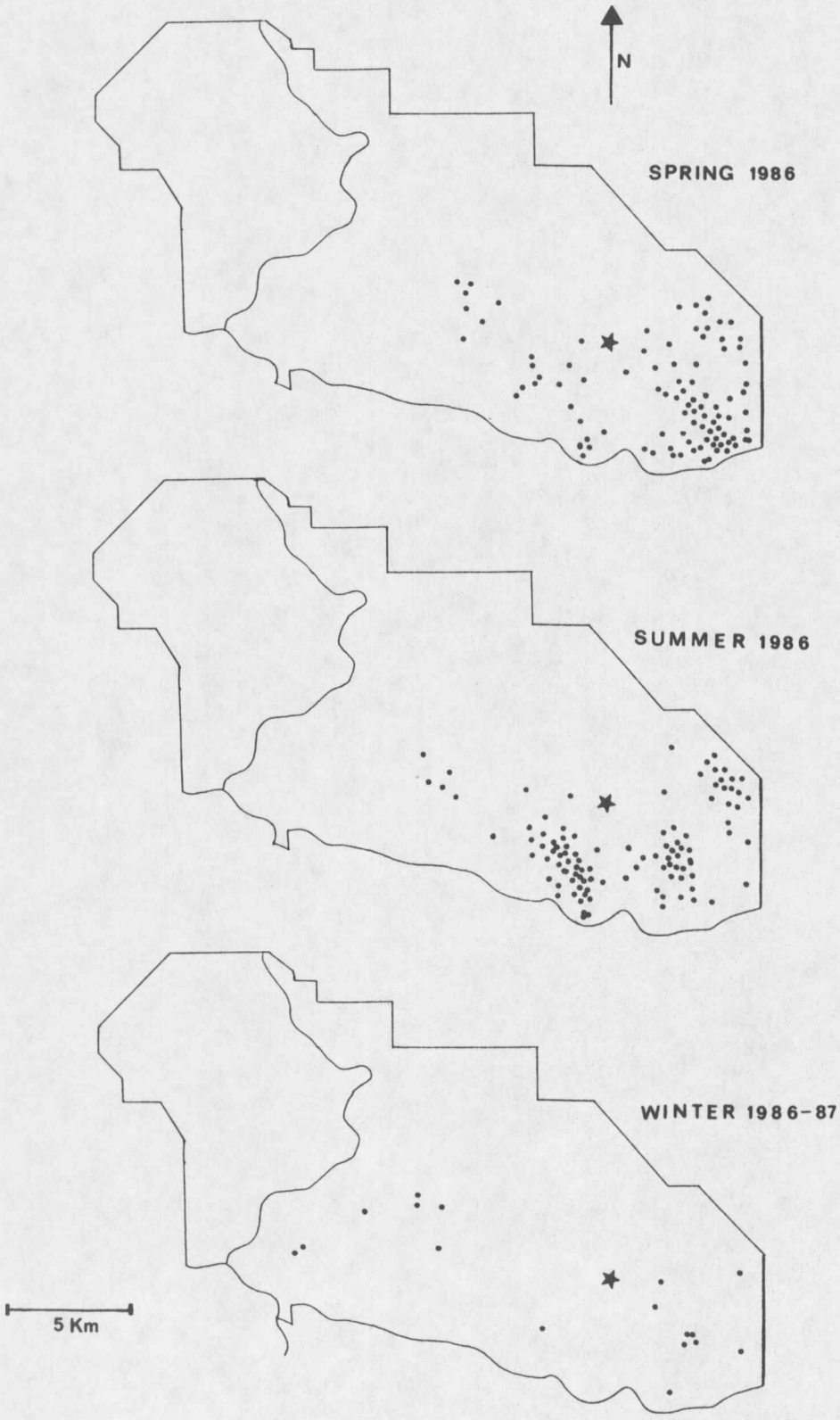

Figure 2. Continued.

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 common in elk (Geist 1982).

Cows and yearling bulls remained in 1 or 2 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 1 or 2 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 2 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.

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 9 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

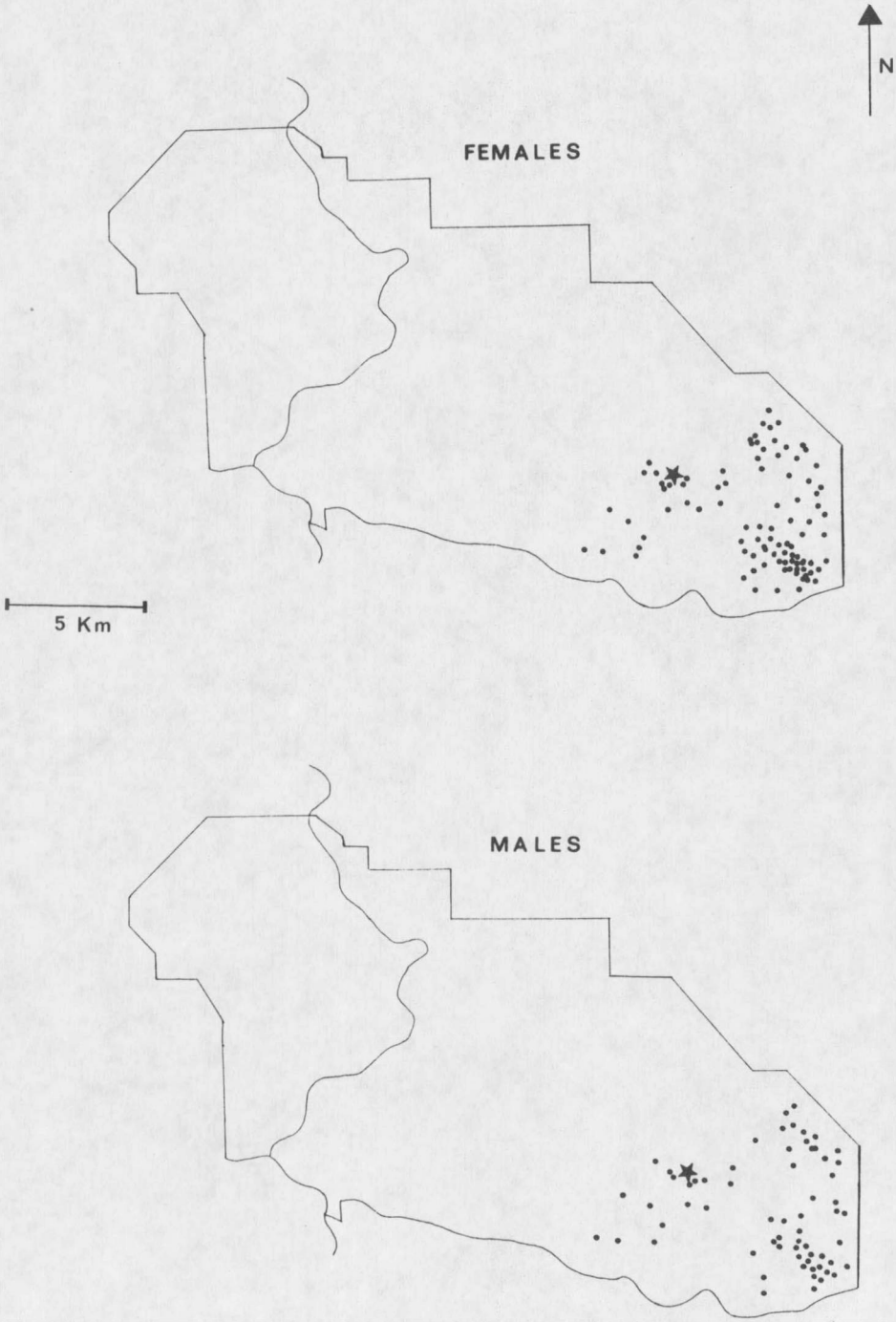

Figure 3. Locations of marked elk in Theodore Roosevelt National Park, 1985.
★ = release site of elk.

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. 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, were detected.

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.

Although distribution for both cows and bulls increased in 1986 (Fig. 4), 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 corner of the Park northeast of Buck Hill 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 6 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).

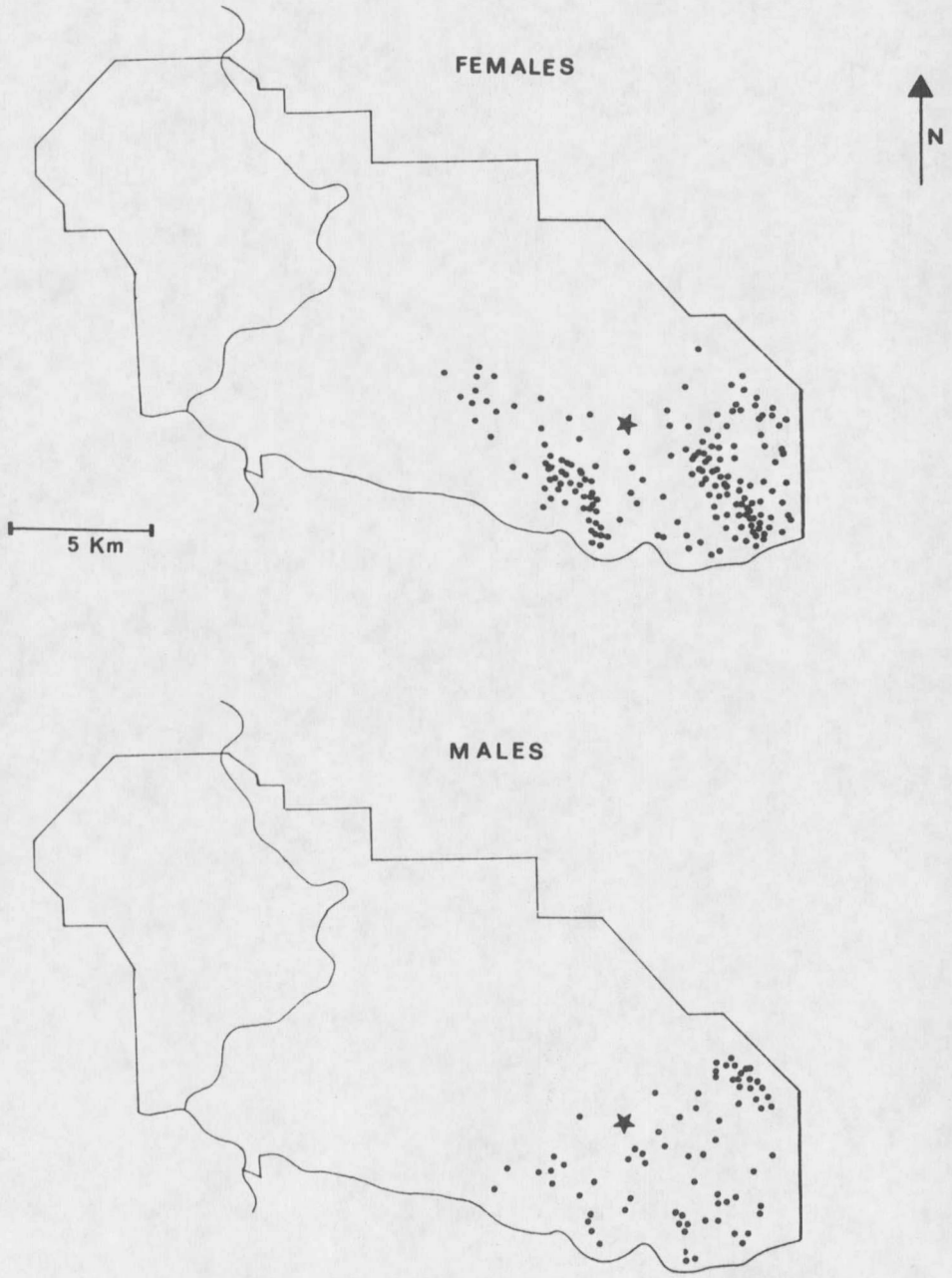

Figure 4. Locations of marked elk in Theodore Roosevelt National Park, 1986.
★= release site of elk.

Home Ranges

Seasonal, annual, and total home range sizes for radio-collared elk are given in Table 1. 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 1 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 1. Seasonal, annual, and total home range sizes (km^2) for marked elk in Theodore Roosevelt National Park during the study. Number of relocations (N) are given.

Animal			Summer 1985		Fall 1985		Total 1985		Spring 1986		Summer 1986		Total 1986		Total 1985-87	
I.D.	Sex	Age[a]	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

[a]A = Adults (>1 yr), Y = Yearlings (<1 yr)

[b]Combined 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 was observed with a calf in 1985 but not in 1986.

Home range size for 8001, a 3-year-old bull, remained the same for spring and summer 1986 (27 km^2). 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 is contradictory to the large home ranges bulls are generally noted for 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.

Annual home ranges of all marked elk overlapped extensively (Table 2). The least overlap occurred in the case of 8001, an adult bull, due to the separation of bulls from the cow herd 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). A pellet group survey, conducted in 1986, closely matched estimates of distribution based on sightings (Fig. 6).

Table 2. Percent overlap between combined overall home ranges of marked elk in Theodore Roosevelt National Park, 1985-87.

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

Population Dynamics

Elk have increased from 47 to 80 animals in TRNP during the 2 years following their introduction (Table 3). 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 4 elk (2 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, 2 sightings, involving 1 to 2 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, 5 to 6 elk were reported outside the Park by hunters and local ranchers. Some of these elk could have been migrants from a resident elk population near the North Unit of TRNP.

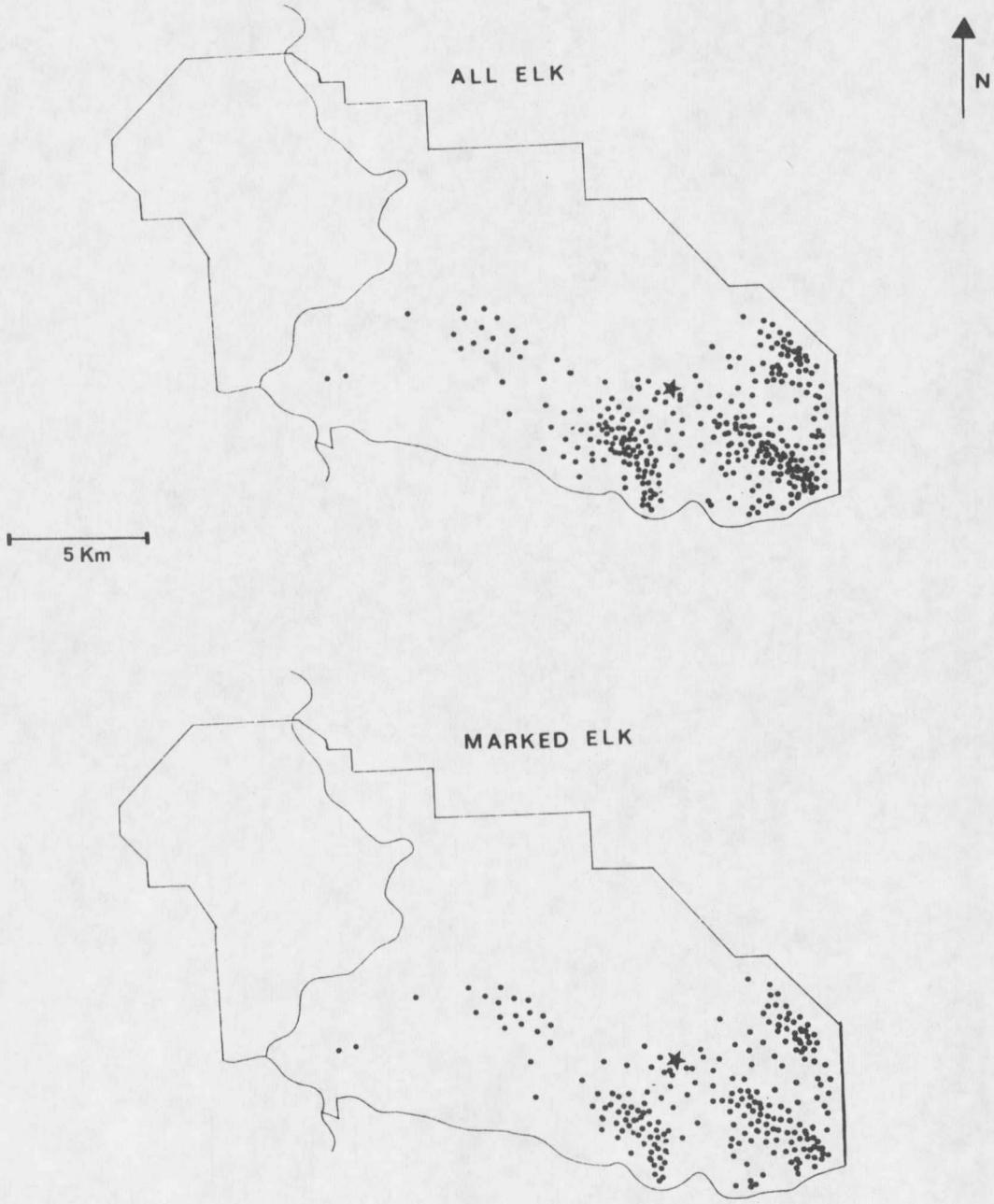

Figure 5. Sightings of all elk and marked elk in Theodore Roosevelt National Park, 1985-86.
★= release site of elk.

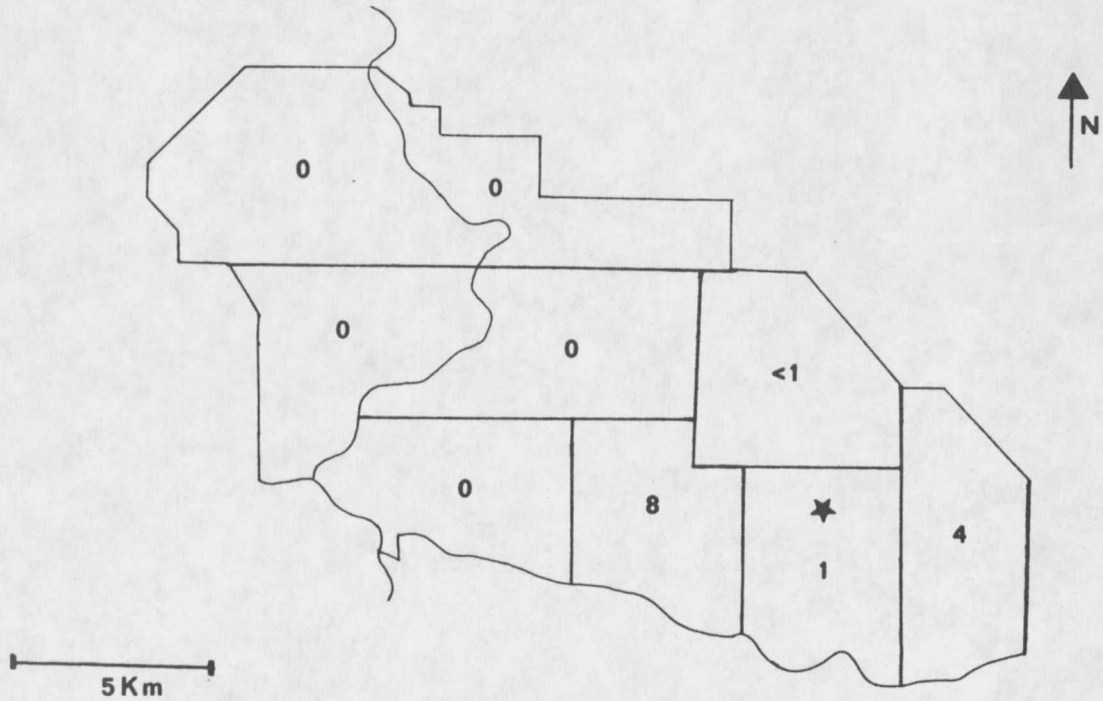

Figure 6. Trail survey of pellet groups in Theodore Roosevelt National Park, 1986.
Numbers in sections = pellet groups per km.
★ = release site of elk.

The cow-calf ratio in September 1985 was 45:100. This was less than expected for an area devoid of large predators; however, conception occurred the previous fall in Wind Cave National Park and at least 1 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 3. Population structure of elk introduced into Theodore Roosevelt National Park (TRNP).

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	9	38	17	64
March 1986				
In TRNP	8	37	16	61
Outside TRNP		1		1
Total	8	38	16	62
August 1986				
In TRNP	15	41	25	81
Outside TRNP[a]		1		1
Total	15	42	25	82
January 1987				
In TRNP	15	(65 Females and Calves)		80
Outside TRNP[b]				
Total	15	(65 females and Calves)		80

[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 80,977 minutes were used to describe activity patterns. Feeding and bedding were dominant diurnal activities during all seasons (Figs. 7-10).

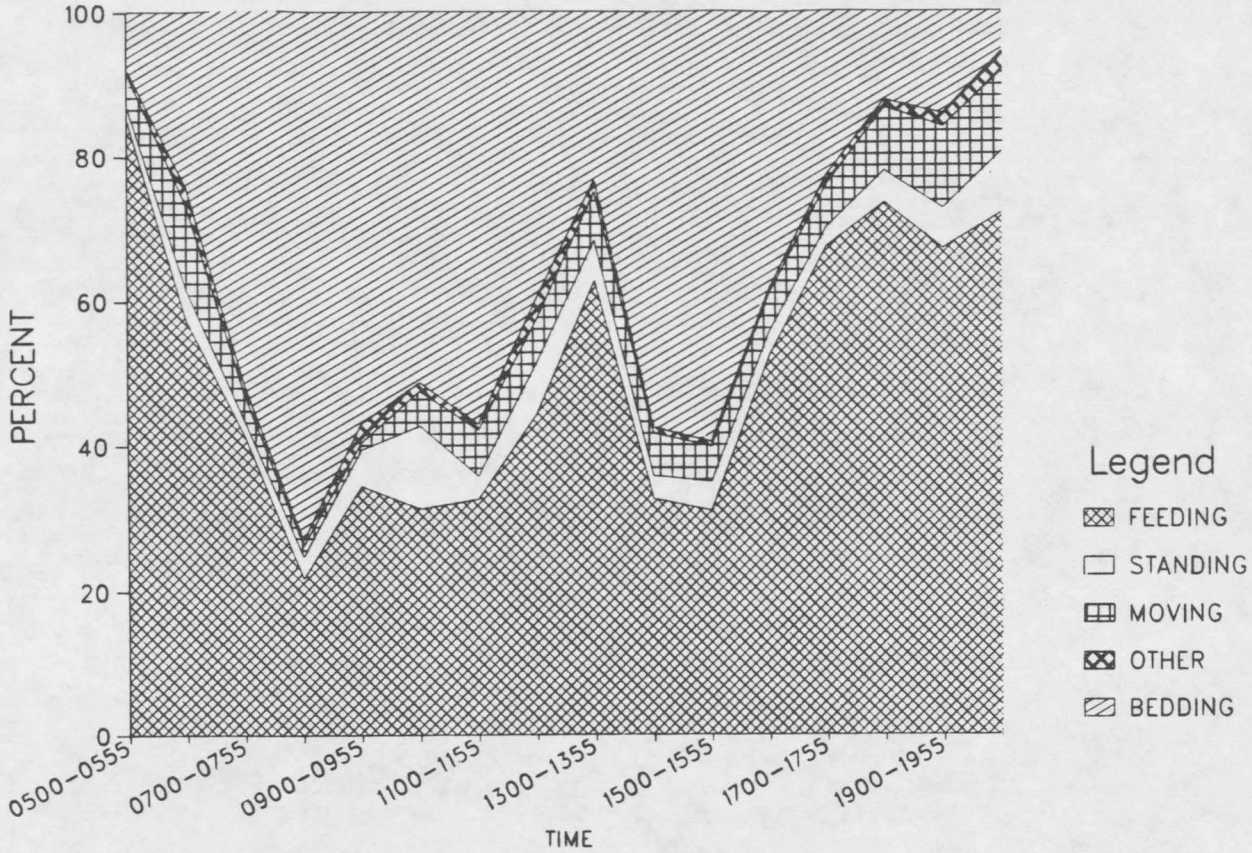

Figure 7. Percent of elk minutes spent feeding, bedding, standing, moving, and other in Theodore Roosevelt National Park in summer, 1985-86.

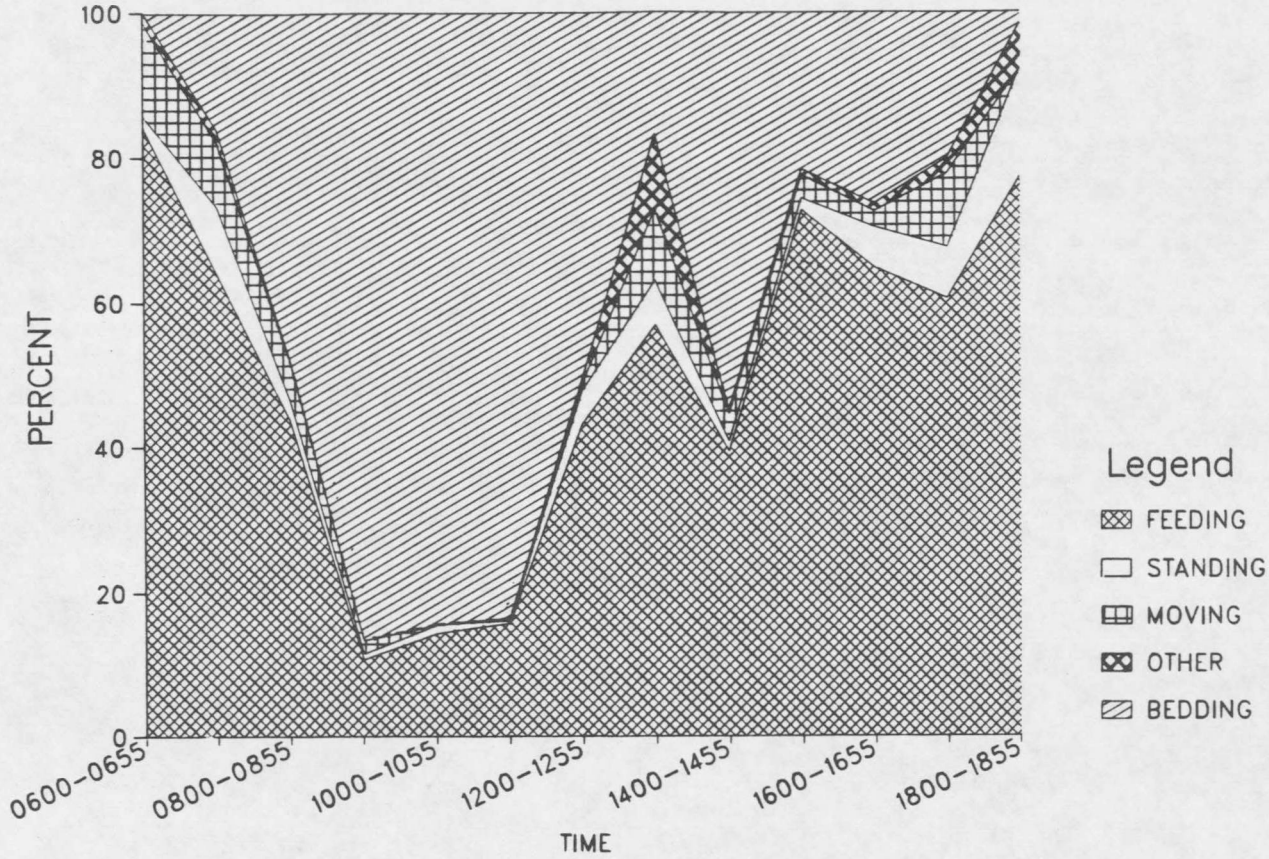

Figure 8. Percent of elk minutes spent feeding, bedding, standing, moving, and other in Theodore Roosevelt National Park in fall, 1985.

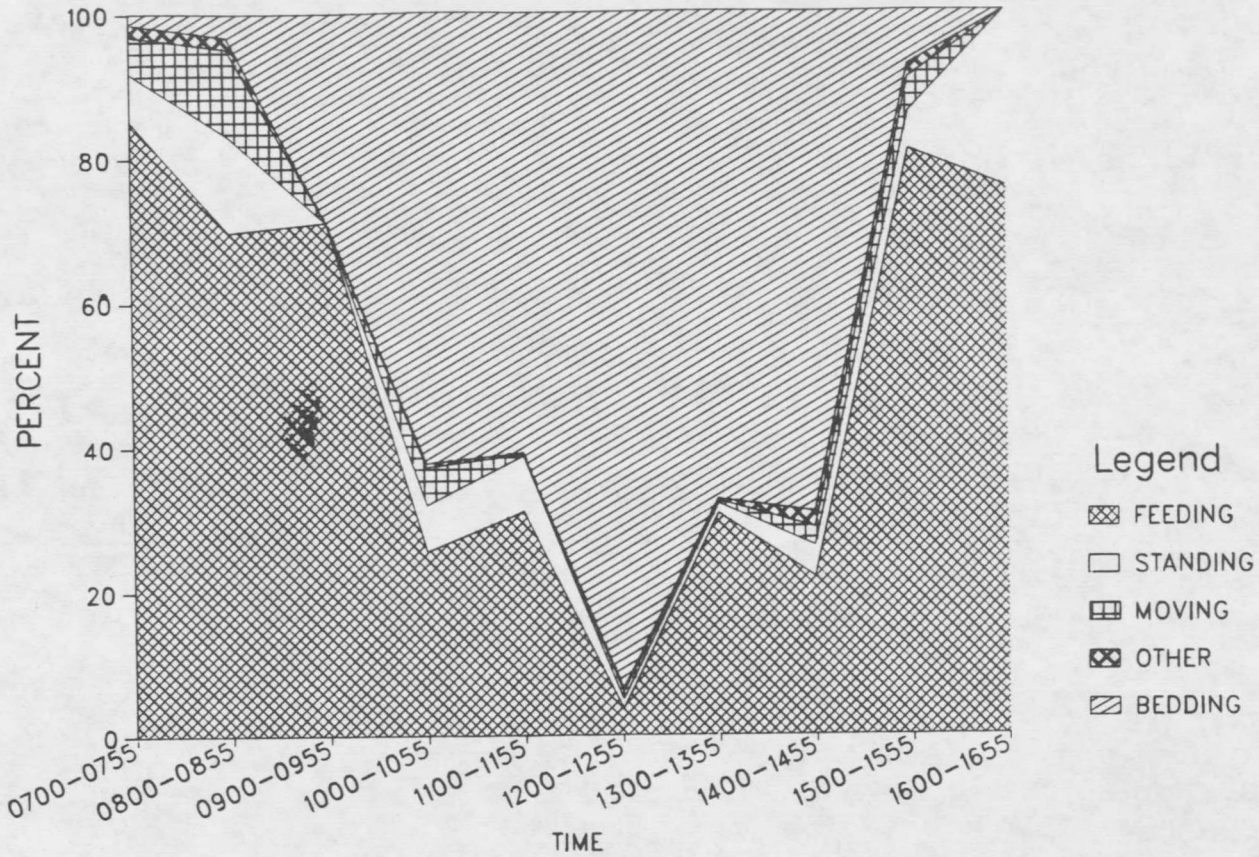

Figure 9. Percent of elk minutes spent feeding, bedding, standing, moving, and other in Theodore Roosevelt National Park in winter, 1985-87.

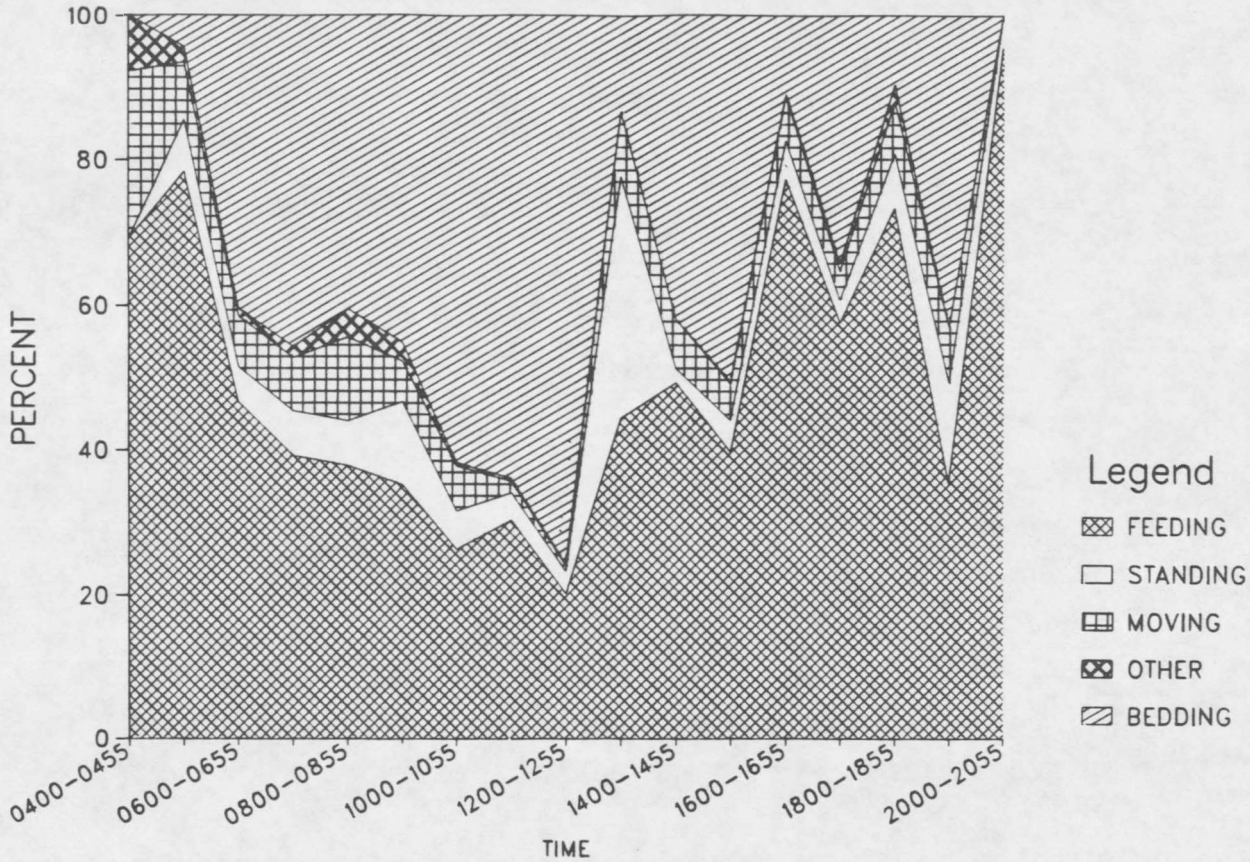

Figure 10. Percent of elk minutes spent feeding, bedding, standing, moving, and other in Theodore Roosevelt National Park in spring, 1986,

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 dominant during early morning and evening while most bedding occurred in late morning and early afternoon (Figs. 7-10).

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. 7 and 8). 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. 9 and 10). 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. 7-10). 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 close to where they had been feeding.

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 (7 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.

Habitat Use

The percent of elk minutes spent in each physiographic and habitat type for all seasons was calculated for cows, calves, and bulls (Tables 4 and 5). Habitat use was similar for all sexes and age classes 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 4. Percent diurnal habitat use of elk in Theodore Roosevelt National Park, 1985-87, for all seasons (including two summers). Elk minutes are in parentheses.

Physiographic type	Cows (80,238)	Calves (15,685)	Bulls (7,836)
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 and physiographic types on the east side of the Little Missouri River (Tables 6 and 7). Differences between availability

Table 5. Percent diurnal use of habitat types (HT), mapping units (MU) and complexes in Theodore Roosevelt National Park, 1985-87, for all seasons (including two summers). Elk minutes are in parentheses.

HT, MU, and complexes	Cows (80,238)	Calves (15,685)	Bulls (7,836)
Agropyron smithii -Stipa viridula	35	40	31
Agropyron smithii - Stipa comata	3	3	3
Stipa comata - Bouteloua gracilis	2	2	3
Artemisia cana	1	2	1
Schizachyrium scoparious - Juniperus horizontalis	1	tr	1
Artemisia tridentata - Atriplex confertifolia	5	6	7
Artemisia tridentata - Bouteloua gracilis	1	tr	3
Schizachyrium scoparius	9	5	6
Hardwood draw	9	13	9
Juniperus Scopulorum - Oryzopsis mircantha	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

tr = <0.5%

and use were significant ($p < .05$) for both diurnal and projected 24-hour data sets. Use of 3 habitat types and 1 physiographic type, prairie dog towns, was proportionate to availability. Most habitat types and physiographic classes were utilized disproportionately relative to availability. This broad array of differences may be a function of the limited distribution of elk during their first 2 years in the Park or the large sample sizes in the Chi-square test rather than actual preference or avoidance of habitats.

The dominant pattern of habitat use observed in TRNP involved use of upland grasslands and grassland flats at

Table 6. Percent coverage, diurnal use (%D Use) and projected 24-hr use (%T Use) of physiographic types available to elk in Theodore Roosevelt National Park. Habitat use is for all seasons and includes two summers.

Physiographic types	% 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.

Table 7. Percent coverage, diurnal use (%D Use), and projected 24-hr use (%T Use) of habitat types (HT), mapping units (MU), and complexes available to elk in Theodore Roosevelt National Park. 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 scoparious - *Juniperus horizontalis*	2	1*	1*
Artemisia tridentata - *Atriplex confertifolia*	2	5*	5*
Artemisia tridentata - *Bouteloua gracilis*	1	1	2*
Schizachyrium scoparius	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*[a]
Populus tremuloides	tr	tr*	tr*
Brush	tr	2*	2*

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

[a]tr = <0.5%

night and during the early morning and evening and use of breaks during midday hours. Elk usually fed in grasslands and bedded in wooded breaks areas. This habitat use strategy was most pronounced during the summer months and allowed elk to forage 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.

Seasonal Habitat Use

Seasonal habitat use was determined for summer 1985, fall 1985, winter 1985-87, spring 1986 and summer 1986. Table 8 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 A for habitat types and physiographic types.

A relatively small number of habitat and physiographic types were utilized in summer 1985 when elk were concentrated along the east edge of the Park (Tables 9 and 10). Upland grassland and breaks physiographic types were heavily used throughout the summer. Hardwood draws were the most heavily use habitat type within the breaks

physiographic types. Little use of adjacent juniper draws occurred.

Table 8. The number of minutes elk were observed each season.

Season	Starting date	Ending date	Observations	
			Days	Minutes
Winter	Dec. 15	March 15	10	10,777
Spring	March 15	June 15	39	27,493
Summer[a]	June 15	Sept. 15	32	17,044
Summer[b]	June 15	Sept. 15	33	16,241
Fall	Sept. 15	Dec. 15	33	32,204

[a]Summer 1985

[b]Summer 1986

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

Cooler temperatures in fall apparently reduced the need for thermal cover. Although overall use of the breaks physiographic type decreased, use remained high during late morning (Table 11). Rutting activities were observed in the grassland flats physiographic type 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.

Table 9. Percent of elk minutes observed in physiographic types for Winter 1985-87, Spring 1986, Summer 1985, Summer 1986, and Fall 1985. The number of elk minutes recorded each season is in parentheses.

	Season				
Physiographic type	Win (10,777)	Spr (27,493)	Sum 85 (17,044)	Sum 86 (16,241)	Fall (32,204)
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

Table 10. Percent of elk minutes observed in habitat types (HT), mapping units (MU), 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.

	Season				
HT, MU, & complexes	Win (10,777)	Spr (27,493)	Sum 85 (17,044)	Sum 86 (16,241)	Fall (32,204)
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 scoparious - *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 scoparius	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 11. 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) types each season for four time periods. Total elk minutes recorded per season is in parentheses.

	Physiographic types						
Time period	GF	BR	RR	PDT	UG	SH	SB
Winter 1985-87 (10,777)							
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 (27,493)							
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 (17,044)							
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 (16,241)							
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 (32,204)							
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

[a]tr = <0.5%

In winter, grassland flats and scoria hills received high use, while use of breaks dropped 10% between fall and winter. Most feeding occurred in the scoria hills physiographic type (Appendix A). Grassland flats, especially the Schizachyrium scoparious habitat type, were primarily used for bedding. The small sample size of winter observations and mild conditions during these observations limit my 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. 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 (Appendix A). On cool days, elk would bed in these habitats between feeding periods.

Habitat use changed between summer 1985 and summer 1986 (Tables 9 and 10). 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 (Appendix A).

Food Habits

Appendix C 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, I refer to the results as "diet" to avoid awkward phrasing. A summary of elk seasonal diets is given in Table 12. 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 summer 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, when available, that it comprised greater than one half of the total summer diet (Mackie 1970). Yellow sweetclover

Table 12. Seasonal diet composition (%) of forage items comprising >3% of any seasonal diet for elk in Theodore Roosevelt National Park 1985-86.

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

abundance varies widely among years and was not common in TRNP during summer 1986 when fecal samples used for diet analysis were collected.

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 (Poa species) 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 9 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. Much of this use may have been on leaves rather than stems as use dropped off sharply 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 with yellow sweetclover the dominant forb.

Use of graminoids was high in winter. Western wheatgrass (Agropyron smithii), needle-and-thread grass 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 accessibility 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 Canyon of southwest Montana, found that elk switched to browse in late winter only after most grass species had been depleted by earlier heavy use.

Browse accounted for 23.6% of the elk winter diet, and winterfat and yucca (Yucca glauca) were the 2 most important browse species. No forbs were detected in fecal samples collected during winter. Louisiana sagewort (Artemisia ludoviciana), a forb apparently 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 2 most heavily used grass species were crested wheatgrass and smooth brome. 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 growth initiation of many grasses as compared to forbs. Crested wheatgrass and smooth brome are 2 of the first grasses to begin growth, 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 then 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).

Potential Impacts on Park Resources

Vegetation

Two sets (high and low elk use) of woodland vegetation transects measured in 1985 and 1986 indicated that changes between these 2 years were not attributable to elk

(Tables 13 and 14 and Appendix B). Differences between plant growth in dry (1985) and wet (1986) years masked effects of herbivores on canopy coverage in the ground stratum (Table 13).

Table 13. 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 Theodore Roosevelt National Park (data from Appendix B).

	Elk use		No elk use	
Cover type	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

[a]tr = <0.5%

In hardwood draws, utilization for all size classes of shrubs and saplings and trees combined (Table 14) was 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 data were consistent with the decreased

use of hardwood draws by elk in 1986 noted in field observations.

Table 14. 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 Theodore Roosevelt National Park (descriptions of vegetation classes are given in Appendix B).

	Elk use				No elk use			
	1985		1986		1985		1986	
Cover type	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

[a]tr = <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, most browsing occurred in small patches of hardwoods (chokecherry, snowberry, etc.) located within 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.

Other Herbivores

Greatest similarity in the use of physiographic types occurred between elk and mule deer ($p<.05$) (Table 15). Both of these ungulates utilized breaks, grassland flats and upland grassland physiographic types in that order of preference. Use of physiographic types 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 15. Percent diurnal use of physiographic types by large herbivores in Theodore Roosevelt National Park. 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.

	Animal species				
Physiographic type	Elk (104,813)[a]	Bison (298,016)[a]	Horses (1,811)[b]	WTD (74)[b]	MD (1,700)[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 fores	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 16 and Appendix C. Information pertaining to bison seasonal diets is from Marlow et al. (1984).

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 3 species. Yearly use of physiographic types was similar

Table 16. Percent composition of graminoids, browse, and forbs in the diets of elk, mule deer (MD), white-tailed deer (WTD), feral horses, and bison in the South Unit of Theodore Roosevelt National Park 1985-86.

	Animal species				
Season	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

[a]Bison diets are from 1983-84 (Marlow et al. 1984)
[b]tr = <0.5%

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 3 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 15) 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 15) should minimize food competition between these 2 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 adaptability of diet, elk are considered to be better competitors than mule deer.

There are few documented cases of competition between mule deer and elk. Situations where serious competition has occurred between these 2 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 Misssouri 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. If this use depressed the growth rate of survival of browse plants it could result in a depletion of browse during 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 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 draws during fall and winter when 16% and 45%, respectively, of all elk observations in bottomland areas 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 improve the condition of several grassland habitat types in TRNP 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 increases the potential for impacting heavily utilized 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.

CONCLUSIONS AND RECOMMENDATIONS

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.

The range of elk in TRNP doubled between the first and second summers of this study. Elk utilized a wider variety of habitat types as they increased their range. Habitat in TRNP appears to be adequate to maintain elk year around, at least under weather conditions and population levels observed during this study.

Habituation to visitors in the Park will probably be slow. Elk have become habituated to traffic outside the Park but are usually displaced >1 km by tourist activity within the Park.

Potential problems include: depletion of browse species preferred by elk and mule deer, adverse impacts on mule deer due to an overlap of food habits and habitat use with elk, and complaints of surrounding land owners when elk begin to leave the Park.

Mule deer should be monitored to detect changes in numbers and distribution which could be attributable to elk. Hardwood and juniper draw vegetation transects, established during this study, should be run every 3 - 4

years to determine if preferred browse species are being overutilized and if utilization is primarily occurring on leaves or stems. Elk movements should be monitored, especially along the east side of the Park which has agricultural land adjacent to it.

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APPENDICES

APPENDIX A

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

Table 17. Percent of elk-minutes spent feeding in each physiographic type in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

	Season				
Physiographic type	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 18. Percent of elk-minutes spent feeding in each habitat type (HT), mapping unit (MU) and complex in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

	Season				
HT, MU, and complexes	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 scoparious - *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 scoparius	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

[a]tr = <0.5%

Table 19. Percent of elk-minutes spent in bedding activity for each physiographic type in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

	Season				
Physiographic type	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

[a]tr = <0.5%

Table 20. Percent of elk-minutes spent bedding in each habitat type (HT), mapping unit (MU) and complex in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

	Season				
HT, MU, and complexes	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 scoparious - *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

[a]tr = <0.5%

Table 21. Percent of elk-minutes spent in 'other' activity for each physiographic type in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

	Season				
Physiographic type	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 22. Percent of elk-minutes spent in 'other' activity in each habitat type (HT), mapping unit (MU), and complex in winter 1985-87, spring 1986, summer 1985, summer 1986, and fall 1986.

	Season				
HT, MU, and complexes	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 scoparious - *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 scoparius	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 B

Means of vegetation transects in hardwood draws and juniper draws within and outside the range of elk in Theodore Roosevelt National Park

Table 23. Canopy coverage (%) in ground stratum (includes vegetation <1 m in height) for hardwood draws within and outside the range of elk in Theodore Roosevelt National Park. Six transects were located in both elk use and nonelk use areas. Standard deviation is in parentheses.

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

Table 23. Continued.

Plant species	Elk use 1985	Elk use 1986	No elk use 1985	No elk use 1986
Viola spp.	tr	tr	tr	tr
Unknown forbs	4 (6)	tr	1 (tr)	2 (5)
Total forbs	10	9	6	10
Ferns				
Cystopteris fragilis	tr	tr	0	tr
Shrubs and trees				
Artemisia ludoviciana	tr	0	0	0
Amelanchier alnifolia	1 (2)	tr	2 (1)	tr
Elaeagnus argentea	0	tr	0	0
Fraxinus pennsylvanica	tr	tr	2 (1)	2 (1)
Juniperus communis	0	0	tr	0
Prunus virginiana	7 (4)	8 (6)	2 (2)	7 (4)
Rhus trilobata	0	0	tr	1 (2)
Ribes odoratum	tr	0	tr	tr
Ribes setosum	tr	tr	tr	tr
Rosa woodsii	tr	tr	tr	tr
Shepherdia argentea	0	0	0	tr
Symphoricarpos occidentalis	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 = <0.5

Table 24. Canopy coverage (%) in ground stratum (includes vegetation <1 m in height) for Rocky Mountain juniper draws within and outside the range of elk in Theodore Roosevelt National Park. 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.

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

Table 24. Continued.

Plant species	Elk use 1985	Elk use 1986	No elk use 1985	No elk use 1986
Ferns				
Cystopteris fragilis	tr	tr	tr	tr
Shrubs and Trees				
Chrysothamnus nauseosus	0	tr	0	0
Fraxinus pennsylvanica	tr	tr	0	0
Juniperus communis	tr	1 (1)	2 (2)	1 (1)
Juniperus scopulorum	tr	tr	0	tr
Prunus virginiana	tr	1 (1)	1 (1)	3 (3)
Rhus trilobata	tr	tr	tr	0
Ribes odoratum	0	tr	0	0
Rosa woodsii	0	tr	0	0
Sarcobatus vermiculatus	0	0	tr	0
Symphoricarpos occidentalis	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

[a] tr = <0.5%

Table 25. Mean density (N/M^2) and percent utilization of shrubs in hardwood draws located within and outside the range of elk in Theodore Roosevelt National Park. Six transects were located in both elk use areas and in none elk use areas.

	Elk use				No elk use			
	1985		1986		1985		1986	
Plant species	X (S.D.)[a]	% Use	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
0 - 50 cm								
Amelanchier alnifolia	1 (1)	4	2 (3)	tr[b]	tr	3	4 (2)	4
Crateagus rotundifolia	tr	0						
Elaeagnus argentea			tr					
Fraxinus pennsylvanica	tr	25	tr	1	4 (3)	0	2 (3)	0
Juniperus scopulorum	0						tr	0
Prunus virginiana	5 (2)	6	9 (6)	tr	3 (3)	tr	12 (14)	tr
Rhus trilobata	0				tr	tr	tr	tr
Ribes odoratum	tr	0	tr	15			tr	0
Ribes setosum	tr	0	tr	0	tr	0	1 (4)	0
Rosa woodsii	tr	0	tr	0	tr	0	tr	0
Symphoricarpos occidentalis	7 (7)	22	10 (9)	10	4 (4)	10	5 (4)	9
Ulmus americana	0		tr	0			tr	0
Total	14	15	22	5	12	5	25	3
50 - 100 cm								
Amelanchier alnifolia	tr	24	2 (3)	0	tr	15	1 (tr)	0
Fraxinus pennsylvanica	tr	0	tr	10	1 (2)	2	2 (3)	8
Prunus virginiana	3 (2)	7	3 (1)	1	2 (2)	4	2 (1)	tr

Table 25. Continued.

Plant species	Elk use 1985 X (S.D.)	Elk use 1985 % Use	Elk use 1986 X (S.D.)	Elk use 1986 % Use	No elk use 1985 X (S.D.)	No elk use 1985 % Use	No elk use 1986 X (S.D.)	No elk use 1986 % Use
50 - 100 cm								
Rhus trilobata					tr	2	tr	2
Ribes odoratum	tr	55	tr					
Ribes setosum	tr	75	0					
Rosa woodsii	tr	5	tr	1	tr	0	tr	0
Symphoricarpos occidentalis	tr	32	1 (1)	14	1 (1)	4	2 (3)	20
Total	4	12	6	4	5	4	7	9
100 - 200 cm								
Amelanchier alnifolia	1 (1)	32	1 (1)	6	tr	15	tr	2
Fraxinus pennsylvanica	tr	35	tr	1	tr	0	tr	2
Prunus virginiana	2 (1)	15	2 (1)	2	1 (1)	1	1 (1)	tr
Rhus trilobata					tr	0	tr	5
Ribes odoratum	tr	24	tr	15				
Ribes setosum	tr	30	0		tr	1		
Total	4	20	3	3	2	1	3	1

[a]Mean (standard deviation)

[b]tr = <0.5

Table 26. Mean density (N/M^2) and percent utilization of shrubs in Juniper draws within and outside the range of elk in Theodore Roosevelt National Park. Six transects were located in both elk use areas and none elk use areas.

	Elk use				No elk use			
	1985		1986		1985		1986	
Plant species	X (S.D.)[a]	% Use	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
0 - 50 cm								
Chrysothamnus nauseosus					tr[b]	5		
Fraxinus pennsylvanica	tr	30						
Juniperus communis	tr	0	4 (4)	0	1 (1)	0	1 (1)	0
Juniperus scopulorum	1 (1)	0	2 (3)	0	2 (1)	0	2 (2)	0
Prunus virginiana	tr	12	1 (2)	tr	2 (1)	tr	4 (2)	0
Rhus trilobata	1 (1)	9	1 (1)	0	tr	13		
Ribes setosum	tr	0	tr	0	tr	0		
Rosa woodsii	tr	0	tr	0	tr	0		
Symphoricarpos occidentalis	3 (2)	7	4 (2)	11	3 (3)	25	2 (1)	tr
Total	6	7	11	6	9	14	9	tr
50 - 100 cm								
Chrysothamnus nauseosus			tr	0				
Fraxinus pennsylvanica	tr	30	0					
Potentilla fruticosa	tr						tr	0
Prunus virginiana	tr	25	1 (1)	3	3 (2)	1	2 (0)	0

Table 26. Continued.

Plant species	Elk use 1985 X (S.D.)	Elk use 1985 % Use	Elk use 1986 X (S.D.)	Elk use 1986 % Use	No elk use 1985 X (S.D.)	No elk use 1985 % Use	No elk use 1986 X (S.D.)	No elk use 1986 % Use
50 - 100 cm								
Rhus trilobata	tr	15	tr	4	tr	0	tr	5
Rosa woodsii	tr	1						
Symphoricarpos occidentalis							tr	0
Total	1	19	1	3	3	1	3	1
100 - 200 cm								
Prunus virginiana					2 (3)	0	tr	0

[a]Mean (standard deviation)
[b]tr = <0.5%

Table 27. Mean Density (N/60 m^2) and percent of saplings and trees browsed in hardwood draws within and outside of elk range in Theodore Roosevelt National Park. Six transects were located in both elk use and nonelk use areas.

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

[a]Mean (standard deviation)

[b]tr = <.05%

Table 28. Mean density (N/60 m^2) and percent of saplings and trees browsed in juniper draws within and outside the range of elk in Theodore Roosevelt National Park. 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.

	Elk use				No elk use			
	1985		1986		1985		1986	
Plant species	X (S.D.)[a]	% Use	X (S.D.)	% Use	X (S.D.)	% Use	X (S.D.)	% Use
Saplings								
Fraxinus pennsylvanica	1 (2)	0	2 (2)	0	4 (4)	0	4 (6)	0
Juniperus scopulorum	15 (12)	0	15 (6)	3	10 (6)	0	7 (8)	0
Prunus virginiana					3 (5)	1	4 (6)	0
Total	16	0	17	3	17	1	15	0
Trees								
Fraxinus pennsylvanica					tr[b]	0	2 (2)	0
Juniperus scopulurum	9 (4)	0	8 (3)	0	5 (2)	0	5 (3)	0
Total	9	0	8	0	5	0	7	0

[a]Mean (standard deviation)

[b]tr = <0.5%

APPENDIX C

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

Table 29. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of elk in Theodore Roosevelt National Park, 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								
Agropyron cristatum					10.7	10.1		
Agropyron smithii	7.5	11.9	16.9	11.5	5.8	5.2	6.4	1.6
Andropogon gerardii			.5	2.8		0.3		
Aristida spp.				1.5				
Bouteloua gracilis	0.6	9.0	3.2	5.8	2.5	0.5	0.7	1.8
Bromus inermis					16.3	7.6		
Bromus tectorum			0.7					
Bromus spp.				3.0				
Calamovilfa longifolia	0.5	0.6	1.1	3.4	1.6	1.2		0.6
Carex filofolia			14.1	14.6	20.8	4.8		
Carex sprengellii	0.4	8.0					1.0	
Echinochla crusgalli				1.3				
Elmus virginicus	3.2	4.2	0.5					5.5
Koeleria pyrimidata			1.5					
Muhlenbergia spp.	0.2	0.4	1.1	3.1	0.8	0.5	1.5	1.2
Oryzopsis micrantha	6.3	6.6	5.7	3.7	5.1	2.9		0.5
Poa spp.	15.8	14.4	4.0	1.0	4.1	6.8	1.9	3.1
Schizachirium scoparium	0.8	0.8	3.0	6.3	8.6	2.7	1.3	
Stipa comata		2.8	12.3	17.3	5.5	5.2	2.5	2.8
Stipa viridula	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								
Achillea millefolium					0.8	0.3	1.4	1.8
Allium spp.					0.4		2.1	
Arabis holboelii		0.5				1.2		
Aster spp.								1.1
Calochortus nutallii						0.5		
Cystoptera fragilis						0.3		
Echinacea angustifolia						0.8	0.3	
Erysimum asperum							0.2	
Gaura coccinea							1.0	1.2
Latuca oblongifolia						0.7		0.4
Lichen	0.2							

Table 29. 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)								
Lithospermum incisum						0.7		
Lysmachea ciliata						0.6		
Melilotus spp.							2.5	0.7
Moss						0.7		
Penstemon albidas		2.4				0.6		
Phlox spp.							2.8	0.7
Psoralea spp.							0.4	
Ranunculus glaberrimus							1.9	
Ratibida columnifera						0.2	0.3	2.0
Smilacina stellata							1.2	0.5
Sphaeralcea coccinea		0.4			0.2	4.4	3.5	4.7
Taraxacum officinale							2.5	
Thermopsis rhombifolia								0.9
Unknown Forb					1.9	1.6	7.2	
Vicia americana							1.0	0.9
Viola spp.						2.4	1.4	
Total forbs	0.2	3.3			3.3	15.0	29.6	14.9
Browse								
Amelanchier alnifolia							2.3	
Artemisia spp.[a]	0.6	2.5	2.0	0.2	1.1	0.2		
Artemisia frigida	1.3	5.8	5.4	5.0	2.6			6.6
Betula occidentalis[b]								12.2
Eurotia lanata	20.5	20.5	10.7	8.8	6.4	18.3	24.4	14.1
Juniperus spp.	0.5							
Prunus virginiana	14.6	0.3				11.3	4.5	17.1
Rhus trilobata	1.4	0.7					1.3	
Ribes setosum	5.5	0.6				1.2	3.4	2.4
Rosa spp.						4.8	1.5	1.9
Shepherdia argentea							15.2	1.8
Symphoricarpos occidentalis	6.5	3.3				0.7	1.4	9.4
Yucca glauca			6.8	8.3				
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 30. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of mule deer in Theodore Roosevelt National Park, 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								
Agropyron smithii	1.7	1.4			2.6			
Carex sprengellii		0.5			1.2		0.6	2.2
Carex spp.								
Elmus virginicus	4.2	2.4			1.9	2.5		1.1
Muhlenbergia spp.						0.5		
Oryzopsis micrantha	2.2	1.0		0.8	2.9	0.3		1.4
Poa spp.	1.2	0.6			12.8	3.0		2.2
Schizachirium scoparium	0.6							
Stipa comata	2.3					1.2		2.9
Stipa viridula	2.6	0.7			1.5	0.5		
Total graminoids	14.9	6.5		0.8	23.0	8.1	0.6	9.7
Forbs								
Achillea millefolium	0.3							
Arabis holboelii					0.2	1.4		
Arctium minus	0.7	0.3						
Aster spp.	2.3	0.4				2.9	0.2	1.6
Astragalus spp.						12.2		
Campanula rotundifolia				1.1				
Erigeron spp.		0.4						
Erysimum asperum						3.5		0.3
Galium boreale		4.7				1.2		1.5
Gaura coccinea						8.3	0.5	
Glcyrrhiza lepidota		0.9						
Latuca oblongifolia	1.1	0.4	0.9			2.0		
Lesquerella spp.		2.2						
Lithospermum incisum						0.5		
Linum spp.						1.0		
Melilotus spp.					0.3	3.8	0.4	
Monarda fistulosa								1.4
Opuntia spp.				1.9				

Table 30. 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)								
Penstemon albidas					0.8	3.5		1.7
Ratibida columnifera		0.2		1.4		0.3		
Sphaeralcea coccinea						2.4		
Taraxacum officinale						0.7		
Thermopsis rhombifolia	2.7	0.3			0.3			
Viola spp.						1.6		
Total forbs	7.1	9.9	0.9	4.4	1.6	45.5	1.1	6.4
Browse								
Amelanchier alnifolia	2.9	1.8					0.3	
Artemisia spp.[a]	7.7	31.4	36.4	61.5	58.6	5.2		0.1
Artemisia frigida	0.5	3.1	0.2		3.0	3.8		
Artemisia ludoviciana		1.9				0.6		
Atriplex confertifolia		0.3			1.2			
Chrysothamnus nauseousus		4.0	0.6					
Clematis ligusticifolia				0.3			0.3	
Eurotia lanata		0.4		0.5		0.5	0.2	
Gutierrezia sarothrae	4.2		0.6					
Juniperus spp.	6.7	5.2	51.6	27.7				
Prunus virginiana	5.9	2.2	3.9		7.5		3.2	13.1
Rhus trilobata	8.1	5.5	0.5		1.3		3.6	2.1
Ribes setosum	3.6	5.0				10.2	2.4	3.1
Rosa spp.	5.8	2.7	2.4	1.1			0.4	1.7
Rubus idaenus								0.5
Shepherdia argentea	4.5	0.9				23.2	69.6	49.7
Symphoricarpos occidentalis	28.0	18.9	2.7	0.9	3.6	2.8	18.1	13.5
Yucca glauca				2.8				
Total browse	77.9	83.5	99.1	94.8	75.3	46.4	98.2	83.8

[a]includes primarily A. cana and A. tridentata

Table 31. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of white-tailed deer in Theodore Roosevelt National Park, 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								
Agropyron smithii		1.0		3.0	7.9	1.8	2.5	4.1
Calamovilfa longifolia					1.6		0.9	
Carex sprengellii		1.9			1.4	0.9		
Elmus virginicus	5.2	10.9	3.2	12.3	19.9	1.0		1.5
Muhlenbergia spp.					2.0			
Oryzopsis micrantha	1.4			4.3	0.9			
Poa pratensis							4.9	
Poa spp.	6.4	17.0		20.8	13.6	3.0		1.3
Stipa viridula		2.4	1.9	1.4	2.2	0.4	2.2	
Total graminoids	13.0	33.2	5.1	41.7	49.4	7.2	10.5	6.9
Forbs								
Achillea millefolium		0.6	0.6			1.1		
Allium spp.							0.3	1.9
Apocynum spp.							2.8	3.0
Arabis holboelii	1.4	7.9			13.3	1.4		
Arctium minus	0.2							
Calochortus nutallii							0.9	
Campanula rotundifolia							0.4	
Chenopodium album							1.4	
Cystoptera fragilis								0.9
Erysimum asperum					0.6			
Fragaria virginiana							8.1	2.4
Galium boreale						3.1	2.3	3.4
Gaura coccinea					2.7	1.4	1.4	1.9
Heuchera richardsonii							4.6	0.6
Latuca oblongifolia					2.7	17.7		0.6
Lesquerella spp.	0.3	1.8			7.2	4.1		
Lichen			2.8		0.6			
Linum spp.							0.5	
Melilotus spp.	2.3				1.2	10.2	5.0	4.4
Monarda fistulosa	2.3						0.9	
Moss						0.6		
Osmorhiza longistylis							0.4	

Table 31. 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)								
Penstemon albidas							1.4	1.5
Potentilla spp.						0.5	0.3	
Psoralea spp.					1.0	0.7		
Ranunculus glaberrimus						4.8	3.8	
Ratibida columnifera				2.5	0.5	0.2	0.4	
Sanicula marilandica							0.6	0.8
Smilacina stellata		1.5					0.6	
Sphaeralcea coccinea					1.5	5.0	2.4	2.2
Taraxacum officinale	3.4					9.0	5.7	3.3
Thalictrum venulosum							4.5	0.9
Tragopogon dubius	0.9				0.1		1.4	4.2
Trifolium pratense						2.1		1.9
Unknown Forb						7.8	5.7	3.0
Urtica dioica								1.0
Vicia americana							2.2	
Viola spp.					2.5	10.5		
Total forbs	10.8	11.8	3.4	2.5	33.7	80.3	58.0	38.0
Browse								
Acer negundo	0.3		3.6				0.9	
Amelanchier alnifolia	5.7	1.5	1.0					
Artemisia spp.[a]	0.3	0.9	0.3	3.4	2.8			
Artemisia frigida		8.1	2.6	15.4	2.1	0.1	0.1	
Artemisia ludoviciana						0.5		
Atriplex confertifolia								0.3
Fraxinus pennsylvanica	1.4		1.1					
Juniperus spp.		0.6	17.0	19.3				
Populus deltoides		2.5	3.5	0.7	0.6			
Prunus virginiana	27.1	5.4	18.1	3.6	2.3	2.9		3.9
Rhus trilobata	4.2	1.7	7.3	5.0	1.1		0.4	1.5
Ribes setosum	20.2	18.7	22.1	4.6	1.0	1.5	0.5	3.5
Rosa spp.	6.6	6.1	8.8	1.6				
Shepherdia argentea	0.5	0.5			4.2	5.0	26.9	37.3
Symphoricarpos occidentalis	9.9	6.4	6.2	2.1		0.8		1.8
Toxicodendron rydbergii		2.4			2.7	1.7	2.8	6.8
Total browse	76.3	54.9	91.4	55.8	16.8	12.6	31.6	55.1

[a]includes primarily A. cana and A. tridentata

Table 32. Seasonal diet composition (%) of food items identified in bimonthly fecal samples of feral horses in Theodore Roosevelt National Park, 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								
Agropyron cristatum		1.2		5.2	3.1	9.3	5.2	4.3
Agropyron smithii	24.1	16.5	13.8	10.4	5.9	8.6	20.2	19.4
Andropogon gerardii		3.0	2.2	0.6	0.8		2.6	3.8
Bouteloua gracilis	4.6	2.7	2.9	4.5	5.4	0.1	2.2	3.7
Bromus inermis	1.8				1.9	0.3		2.3
Bromus tectorum	4.3	0.5	1.3	2.8	2.7	3.3	1.9	
Bromus spp.	2.5	1.8	5.8	1.8				
Calamovilfa longifolia							1.9	3.7
Carex spp.				9.7	19.0	14.9	7.1	0.9
Distichlis stricta						0.6	1.4	
Elmus virginicus							2.4	
Muhlenbergia spp.	1.6	3.5	0.4	0.4		2.1	5.6	2.3
Oryzopsis micrantha	1.7	2.3	3.1	6.3	4.8	1.0	2.2	2.1
Poa spp.	26.7	21.3	25.0	18.5	8.3	36.2	7.3	9.2
Schizachirium scoparium	0.4	2.4	2.6	3.8	10.6	5.4	4.5	3.7
Stipa comata	14.3	13.4	16.3	14.4	23.9	7.4	22.4	21.5
Stipa viridula	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								
Achillea millefolium			0.3				0.5	
Lichen				0.7			0.2	0.5
Opuntia spp.							1.5	
Rumex spp.			0.7					
Sphaeralcea coccinea						0.4		
Unknown Forb	0.8		1.5			0.2	0.8	
Total forbs	0.8		2.5	0.7		0.6	3.0	0.5
Browse								
Artemisia frigida			3.6	7.0	1.4			
Eurotia lanata	4.8	5.7	6.2	4.7	4.3	0.2	0.3	10.2
Shepherdia argentea			0.9					
Total browse	4.8	5.7	10.7	11.7	5.7	0.2	0.3	10.2