

ELK MOVEMENTS, HABITAT USE, AND POPULATION DYNAMICS IN THEODORE ROOSEVELT NATIONAL PARK



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by

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EXECUTIVE SUMMARY

Since elk (Cervus elaphus) were reintroduced into the South Unit (SU) of Theodore Roosevelt National Park (TRNP) in March 1985, they have steadily extended their range and now occupy most of the eastern 2/3 of the Park. At least 10 elk have emigrated from TRNP, with additional reports of elk infrequently utilizing areas outside the Park. Elk were sexually segregated over most of the study, with ranges of the bull and cow-calf groups only overlapping during the rut. Females have changed calving areas since 1985, progressively using more westerly areas as they became familiar with the Park.

Elk have grown in number from the 1985 reintroduced population of 47 to 148 by September 1988. In September 1989, 176 were counted in an aerial survey of the Park. Rapid antler development, high reproductive performance, and low mortality, all indicative of a healthy population, were characteristic of the population at TRNP. The population grew at a logarithmic growth rate of 0.31 over 4 years, one of the highest growth rates reported for elk in North America. Ratios of calves to cows were >0.90 during 1987-89.

Differences were noted in habitat selection among sex/age classes, with adult and yearling bulls preferring rougher terrain. All elk preferred to forage in open grassland habitats during crepuscular hours during spring and summer and throughout the day in winter. Overhead cover was sought in Rocky Mountain Juniper (Juniperus

scopulorum) draws during warm midday hours of spring and summer but not in winter. Unlike the historical accounts of early elk in North Dakota, the reintroduced population at TRNP did not utilize riparian areas extensively.

Elk were more disturbed by humans on foot than in stationary vehicles or on horseback. No response was elicited by elk when humans were >1,000 m, but elk would always displace when approached <100 m. Recent reports indicate that elk have become more habituated to tourists than were observed during th's study.

Overlap in forage utilization among elk and other ungulates was minimal to moderate. Higher correlations were noted in Physiographic Type utilization, especially between elk and feral horses during the growing season and elk and mule deer over the entire study. A size-based dominance hierarchy of bison > feral horses > elk > mule deer was observed in TRNP.

Optimum carrying capacity was determined for ungulates in TRNP using a linear forage allocation model. This model identified winterfat (Ceratoides lanata) as the major constraining forage species for elk, bison (Bison bison), and feral horses (Equus caballus) populations in the Park. Chokecherry (Prunus virginiana) and skunkbush sumac (Rhus trilobata) were the major constraining species for mule deer (Odocoileus hemionus) and secondary constraints for elk. The level of foraging pressure at the projected optimum carrying capacity for elk (~240 for the eastern 2/3 of the Park and ~360 for the entire SU) is similar to or lower than that recommended for other elk herds in the Northern Great Plains. The stocking rate for all

large ungulates (≈ 0.03 Animal Unit Months/hectare) at our modeled optima is well below reported stocking rates for grazing animals in similar habitats.

We were unable to detect damage to Park resources or adjoining agricultural lands that were directly linked to elk. Wooded Habitat Types heavily used by elk did show a few detectable differences from similar habitats not used by elk, but variability in vegetation characteristics in and among sites sampled was so great that any attempt to declare trends would be premature.

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INTRODUCTION

With the recession of glaciers at the end of the Wisconsin glacial stage 10,000 years ago, elk spread south and east from non-glaciated Alaskan refugia to inhabit prairies, parklands, and open forests. Elk became the most widely distributed North American cervid, extending their range as far south as northern Mexico, Louisiana, and Alabama (Hall and Kelson 1959, Curren 1977, and Boyd 1978). By the end of the Wisconsin glacial stage, elk were segregated into 4 geographic regions: 1) the northwestern Pacific coast; 2) western and central California; 3) the southwestern United States and northern Mexico; 4) the area east of the Cascade and Sierra Nevada ranges (Guthrie 1966).

The ranges of three presently recognized subspecies of the North American elk: Rocky Mountain elk (C. e. nelsoni), Manitoban elk (C. e. manitobensis), and Eastern elk (C. e. canadensis), overlapped in the area of the Northern Great Plains (Guthrie 1966). Guthrie (1966) suggested that a distinct subspecies uniquely adapted to the environment of the Great Plains may have been forming. However, Bryant and Maser (1982) asserted that elk in the Northern Great Plains were Manitoban elk. With the extirpation of elk in the eastern 2/3 of the continent, any subspeciation that may have been occurring was forever halted.

In North Dakota, elk were abundant before European settlement. Audubon, Lewis and Clark, and Alexander Henry all reported seeing vast herds along the Missouri River. Remington Kellogg hypothesized, based on reports of early explorers and settlers of the region, that elk migrated to river bottoms in the fall and back to the open prairies in late spring (Bryant and Maser 1982). Riparian areas presumably provided ideal winter range, with thermal cover and abundant browse. However, the last reported elk killed in North Dakota occurred in Cavalier County in 1883, precluding any further research into this phenomenon (Kruckenberg 1973).

In 1942, 25 Rocky Mountain elk were released in the Killdeer mountains, western North Dakota, by the North Dakota Department of Game and Fish (Bryant and Maser 1982). This transplant failed and future reintroductions were not attempted. In 1979, however, a small herd of elk escaped from a holding pen on an Indian reservation 24 km northeast of the North Unit (NU) of TRNP into river breaks (Sullivan 1988). Within a few years this herd had grown in size to allow a limited hunt (25-30 animals per year) by the North Dakota Department of Game and Fish.

Plans to reintroduce elk into the SU of TRNP were initiated in 1984, in an attempt to restore one of the major ungulate species native to the area. Pronghorn (Antilocapra americana), bison, and California bighorn sheep (Ovis canadensis californica) were reintroduced into the SU in 1951, 1956, and 1959, respectively. Mule deer and white-tailed deer (O. virginianus) were present in the Park since its inception. Feral horses, from a variety of sources, have

established themselves in the Park, and are currently according to Park natural resources management object:

An elk reintroduction would complete the historic ungulate in the badlands ecosystem (TRNP 1984). In March 1985, 47 Rocky Mountain elk were acquired from Wind Cave National Park, South Dakota and released in the SU of TRNP on Buck Hill (Fig. 1).

This study represents the second phase of a 4-year investigation of the dynamics and ecology of a reintroduced elk population. M. Sullivan conducted research during phase 1 of this project from 1985-1986. Specific objectives of phase 2 (1987-1988) were:

1. Description of daily and seasonal movements of elk.
2. Description of the population dynamics of elk and determination of elk population levels that are consistent with Park management objectives.
3. Identification of seasonally important Habitat Types/Mapping Units/Complexes and Physiographic Types used for feeding, cover, mating, and calving.
4. Description of interactions between elk and other ungulates and identification of interactions that could detrimentally affect individual ungulate species.
5. Determination of human impacts on elk behavior and distribution in the Park.
6. Identification of damage to Park resources and property of adjoining landowners.

STUDY AREA

The study was conducted in the SU of TRNP in southwestern North Dakota (Fig. 1). The Park was originally created as Theodore Roosevelt National Memorial Park on 25 April 1947, but the name was changed to Theodore Roosevelt National Park in 1978. The Park is divided into 3 units, the SU near the town of Medora, the NU (80 km to the north), and the Elkhorn Ranch (27 km to the north). The SU of TRNP is bordered by U. S. Interstate Highway 94 to the south, private landholdings to the north and east, and USFS Little Missouri National Grasslands to the west. The SU covers 18,756 ha, and is bisected north to south by the Little Missouri River.

Geology

The SU of TRNP is part of the Missouri River Plateau of the Great Plains Province (Fenneman 1931). Soil substrates are from the Paleocene, Fort Union Group of the Tongue River Formation (Leonard 1930). Although TRNP was unglaciated during the last ice age, glacial diversion caused an eastern shift in the route of the Little Missouri River, which caused extensive downcutting in areas along the river channel creating an unique topography known as the badlands. The badlands are characterized by considerable erosion leaving resistant layers of sandstone, shale, and lignite.

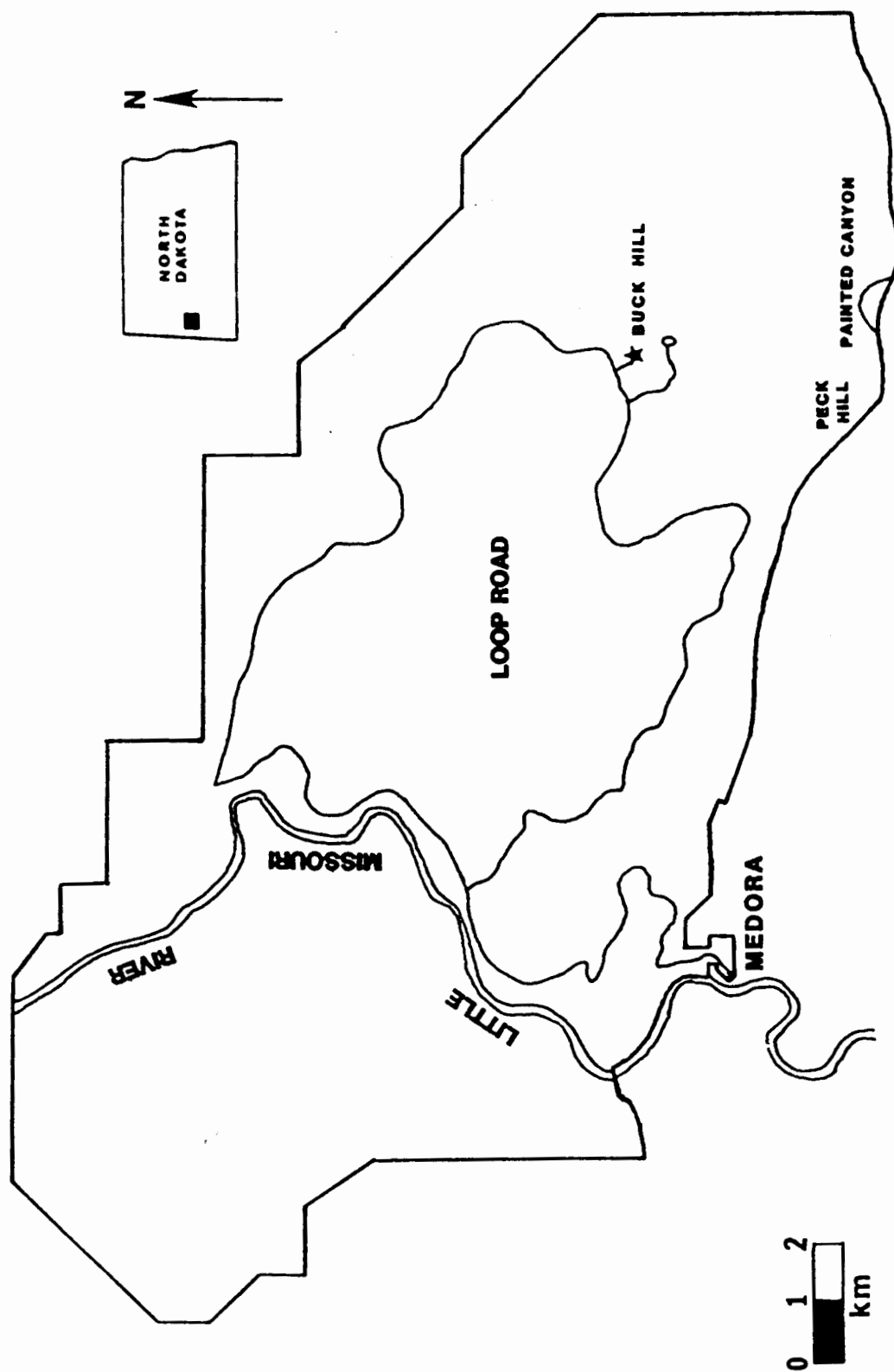


Figure 1. Map of the South Unit of Theodore Roosevelt National Park.

Often when partially exposed lignite beds became ignited by fires, they would bake overlying clay beds, forming a red, slaglike clinker locally known as "scoria" (Hanson et al. 1980). Scoria, which was more resistant to erosion than surrounding material, became the caps to small hills and buttes. Relics of the upland prairie can be found atop these buttes and on grassland plateaus (Sullivan 1988).

Climate

The climate of TRNP is semi-arid, continental, typical of the Northern Great Plains (Hirsch 1985). Long, cold winters and short, dry summers typify seasonal weather patterns. Over 70% of the annual precipitation occurs during the growing season (April through September), with 25% of the total precipitation as snow (Ramirez 1973). Annual precipitation averages 36 cm (TRNP 1984).

Vegetation

Vegetation in TRNP has been described as mixed prairie. Small, scattered stands of deciduous trees or Rocky Mountain juniper exist in ravines with mesic microenvironments. A large portion ($\approx 30\%$) of TRNP is unvegetated or covered only by scattered shrubs (Marlow et al. 1984). Detailed descriptions of the vegetation in TRNP are found in Nelson (1961), Whitman (1978), Hanson et al. (1980), Girard (1985), and Hirsch (1985).

Habitat classification used in this study followed the 2-tiered Physiographic Type and Habitat Type/Mapping Unit/Complex classification scheme developed by Norland (1984). Large areas of

TRNP were classified by Norland (1984) as Physiographic Types (PTs) based on topography and physiography, landform origin, and gross structure of associated vegetation. Classification of Habitat Types (HTs) within PTs (Norland 1984) were based on the vegetation assemblages that could eventually develop on the site, given the climate and substrate (Daubenmire 1968).

The actual classification of these sites followed similar HTs identified by: the Soil Conservation Service (range site guidelines for the North Dakota badlands), Whitman (1978), Hanson et al. (1980), Girard (1985), and Hirsch (1985) in and around TRNP. Mapping Units (MUs) were created by Norland (1984) to describe vegetative assemblages which had been disturbed by natural or anthropogenic forces, or were in the early stages of succession. Complexes were identified as assemblages of Habitat Types too small to map (Norland 1984). The area of individual HTs/MUs/Complexes and their composition in each PT was measured from aerial photographs by Marlow et al. (1984).

Vegetative production (the addition of vegetative tissue in 1 growing season), for major graminoid and shrub species in several HTs/MUs/Complexes in and around TRNP were reported by the Soil Conservation Service (range site guidelines for the North Dakota badlands), Whitman (1978), Hanson et al. (1980), Norland (1984), Marlow et al. (1984), Girard (1985), and Hirsch (1985). These production figures were later collected and revised by Norland (1988_a).

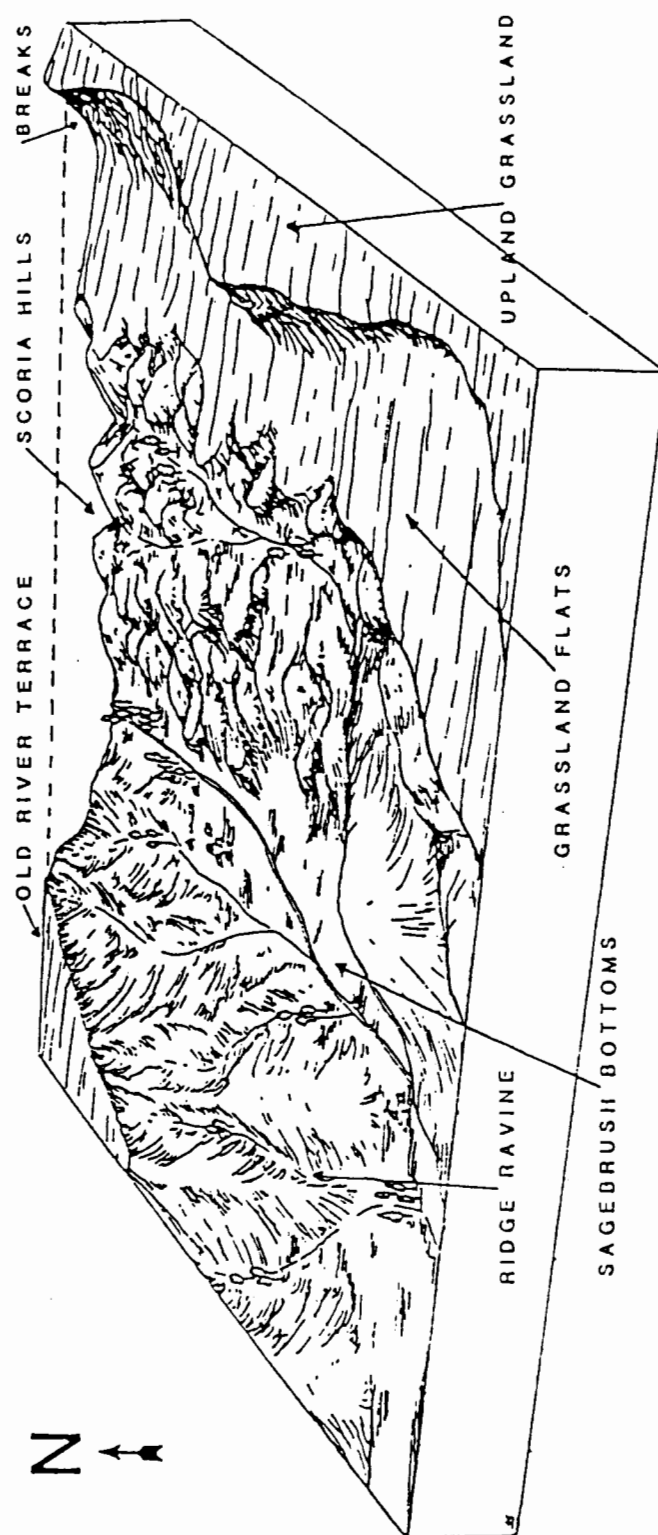


Figure 2. A view of the Physiographic Types within an idealized landform of the South Unit of Theodore Roosevelt National Park. From Norland (1984).

METHODS

Daily and Seasonal Movements

Eight elk, 3 males and 5 females, were equipped with radio-collars during phase 1 of the study. These animals were relocated with a radio receiver and a hand-held, 3-element, yagi antenna during phase 2. Most relocations were confirmed visually with 7x35 mm field binoculars and a 15-60X spotting scope. Locations of these elk groups were plotted on 1:24,000 topographic maps and Universal Transverse Mercator (UTM) coordinates were determined.

Seasonal home range sizes were determined for radio-collared and uncollared animals using McPaal, a computer software package (Stuwe and Blohowiak 1985). McPaal has several options for generating home range sizes, one of which uses the minimum convex polygon method (Mohr 1947) to determine the area within a polygon formed by connecting the outermost locations. Home ranges for females and males were found by combining all locations for each sex.

General information on elk distribution within the Park was based on elk pellet group transects walked along major hiking and game trails within TRNP in August 1988. The number of pellet groups were counted along 2-m strip transects in 9 geographical divisions (sections) delineated by Sullivan (1988). A minimum transect length of 6.0 km was walked in each section. All elk pellet groups along transects were counted regardless of age or condition of the group.

Sectional elk use indices were calculated by dividing the number of pellet groups seen in each section by the number of km walked in that section.

Habitat Use and Activity Patterns

Elk habitat use was quantified using the two-tiered PT and HT/MU/Complex system discussed in the Vegetation section. Descriptions of these PTs and HTs/MUs/Complexes are found in Appendix A, Tables 40 and 41. Information concerning the landform and vegetational features of areas used by elk were noted in the field and used to identify PTs and HTs/MUs/Complexes on respective overlay maps of the SU of TRNP created by J. Norland.

Considerable effort was made to avoid disturbing elk, so observations were conducted at distances where the elk could not spot the observer. Observations were logged on the first group of elk that were spotted. Elk were observed during diurnal hours for 1-7 hr periods. At each observation period the following information was collected: 1) the location of the elk group (plotted on 1:24,000 topographic maps); 2) the number of adult males (≥ 2 years), yearling males (1 year), females (≥ 1 year), and calves in each PT and HT/MU/Complex; and 3) the activity of each animal (recorded as feeding, bedding, standing, moving, other, or unknown). Calves were difficult to distinguish from yearling females after 7 months, so this class was recorded as "female" for observations beginning 15 January. Other activities included: interactions with other ungulates, mating activities, grooming, nursing, and other social behavior.

The activity of 1 animal recorded at the beginning of each 5-min interval was labeled an observation-minute. A minimum of 12 consecutive observation-minutes for 1 animal, or ≥ 6 consecutive observation-minutes for ≥ 2 animals was considered the minimum for inclusion of an observation period in the analysis.

Unknown activity was recorded when elk were known to be in a particular HT/MU/Complex even though they were not visible. This activity class was recorded most often during the spring and summer midday hours when elk were in wooded draws. If elk entered these draws and could not leave without the observer noticing, observation-minutes were recorded as unknown within that PT and HT/MU/Complex. The unknown category was necessary to determine relative diurnal habitat use.

When radio-collared animals were within wooded draws during spring/summer midday hours, the signal was checked at 15-min intervals for 30 sec to determine if the animal was active. Distinct changes in the strength of the signal during the 30-sec time period signal was identified as an "active" observation-minute. The number of observation-minutes recorded as unknown activity were multiplied by the percentage of radio-signal checks recorded as "inactive" to obtain adjusted diurnal activity and habitat utilization values. Irby (1976) reported that this technique was 89% effective in estimating activity in an ungulate study in Africa.

Data were collected for 4 seasons during phase 2. Each season was divided into 3 time periods (morning, midday, and evening). The lengths of these time periods were determined from natural breaks in

the feeding:bedding ratios during diurnal hours. The percentage of activities occurring in PTs and HTs/MUs/Complexes was calculated for each time period. Time was recorded as Mountain Standard Time for comparison between seasons.

Ungulate Interactions

PT utilization was determined for elk, bison, feral horses, mule deer and white-tailed deer over the entire study and during the growing season (spring and summer seasons). Spearman's Rank Correlation Coefficients (r_s) were used to compare PT selection. Similarities in PT selection were considered significant at $p \leq 0.05$.

Interactions between elk, and bison, feral horses, and mule deer were noted during the study. The frequencies of no reaction, awareness, alarm, aggression, or displacement exhibited by elk or the other ungulates were recorded for 5 distance categories. The distance between elk and the other ungulates was estimated when these animals were first observed. Additional interaction notes were taken only if the distance between these animals changed abruptly, or if the reactions were different than when animals first came into contact. Displacement included slow, gradual movement away from another species or an immediate withdrawal. The distance animals withdrew, or distance to where they were last observed was also estimated. A mean displacement distance was calculated for elk and the other ungulates when displacement occurred.

Human Impacts

The reactions of elk to humans on foot, horseback, and in stationary vehicles were noted during the study. The frequencies of no reaction, awareness, alarm, or displacement were recorded for 4 distance categories. Both the distance of elk from humans during the time of disturbance and displacement distance, if any, were estimated. Displacement distance included the distance moved to cover or the distance to where the elk were observed no longer to be fleeing from the disturbance. A mean displacement distance was calculated for each type of human caused disturbance when displacement occurred.

Population Dynamics and Carrying Capacity

Population Censuses

A complete ground count of all elk in TRNP was taken in September 1987, and a complete ground count of the calf crop and adult bulls was taken in September 1988. Ground censuses could only be conducted in late August/early September when the entire herd had coalesced for pre-rutting activities. Census data for 1985-1986 were from Sullivan (1988).

Population age structures were calculated for each year of the 4-year study from estimated ages of the transplanted elk and from elk born in the Park from 1985-1988. Because a few elk of unknown ages left the Park, the age structures represent approximations. Calf:cow ratios were determined in September from the previous year's adult

(≥2 years) and yearling (1 year) females and from adult females alone, to determine herd productivity.

The population growth rate was determined from the linear regression (least squares method) of the $\log_e$ of the population counts each year from transplant to 1988. The slope of the regression line was assumed to be an approximation of r_a , the Actual Rate of Increase for a population (Caughley and Birch 1971, Caughley 1977, Gogan and Barrett 1987). The growth rate generated was compared to growth rates in the literature. Annual growth rates (r) were generated by the formula $r = \log_e(\text{count}_{t+1}/\text{count}_t)$ after Caughley (1977).

Forage Allocation

Forage was allocated for 4 ungulate species in the SU of TRNP (elk, bison, feral horse, and mule deer) using the Ungulate Resources Allocation Model developed by Norland (1988b). Pronghorn and white-tailed deer also occurred at TRNP, but these species had limited distributions and were not considered in the model. The model utilizes LINPRO, a linear programming software package, which solves optimization problems using the simplex solution technique (James 1981). An objective function is formulated which defines how the resource (forage) will be efficiently allocated among the competing decision variables (the ungulates). The objective function is then solved within the constraints (forage available) arriving at an optimal solution (number of ungulates) from an infinite number of feasible solutions (Norland 1988b).

Six inputs were used in the model:

1. Size of each PT (hectares) within TRNP.
2. The amount of time spent in each region (defined below) by the various ungulates during the growing season (spring 1988, summer 1987-1988).
3. The diet (food habits) of each ungulate.
4. The production of the major dietary items within each PT, HT/MU/Complex, and region.
5. The average forage intake during the 6-month growing season for a typical animal of each ungulate species.
6. The percent allowable use of each dietary item.

Size of Each PT. Physiographic Types (PTs) used in this study were delineated by Norland (1984). A digitizing board was used to calculate areas of PTs outlined in aerial photographs (Marlow et al. 1984). Descriptions of these PTs are found in Appendix A, Table 40.

Amount of Time in Region. For analytical purposes, the Park was divided into 9 geographical regions, and the area of each measured by Marlow et al. (1984). Ungulate use of these regions was identified with the aid of an overlay map created by J. Norland. A 6-region area (123.9 km²) of TRNP, excluding the Cottonwood Forest and Old River Terrace PTs, was the only area used by elk. This area, hereafter referred to as the "Target Area", was the only area included in the model. Utilization of regions was based on observation-minutes for elk and on sightings for the other ungulates. Data collected during the growing season (summer 1987-1988, and spring 1988) were used. Utilization was determined during the growing season because plants are most susceptible to grazing damage at that time (Sampson 1952).

Ungulate Diets. Twenty fecal samples of elk, bison, feral horses, mule deer, and white-tailed deer were collected during late spring (15 May - 14 June) 1988, and late summer (1 August - 5 September) 1988, and 10 samples were collected for elk in early summer (15 June - 31 July) 1987. Each sample was collected from fresh fecal piles throughout the Target Area. These samples were shipped frozen to the Wildlife Habitat Laboratory in Pullman, Washington for microhistological identification of shrub, forb, and graminoid species composition. A reference collection of 104 plant species, collected in TRNP during phase 1 of the study (Sullivan 1988), was used to help identify forage items. Spearman's Rank Correlation Coefficients (r_s) were used to compare the similarities of growing season diets. Similarities in diet composition were considered significant at $p \leq 0.05$.

Microhistological analysis of food items in animal stomachs was first described by Baumgartner and Martin (1939) and later refined by Dusi (1949). Analyses of fecal samples follow similar procedures (Sparks and Malechek 1968, Ward 1970, Dearden et al. 1975). Forbs, which are the most digestible and least identifiable forage class, are often under-represented, and graminoids and browse over represented, in ungulate diet estimates using this technique (Bergerud and Russell 1964, Dearden et al. 1975, Vavra et al. 1978). Hanley and Hanley (1982) concluded that this analysis was sufficient for gross diet comparisons of ungulates. Accuracy could be improved by using digestion coefficients for individual forage species, but these coefficients were not available for most forage species in TRNP.

Production of Major Dietary Items. Production for major forage species was determined for selected HTs/MUs/Complexes by Norland (1988a), and the percentage of HT/MU/Complex composition for the various PTs in TRNP was determined by Marlow et al. (1984). Production for the major forage species in each region and in the Target Area were estimated from the percent composition of PTs in each region (Marlow et al. 1984).

Growing Season Intake. Forage intake rates during the growing season were determined for a "typical animal" (based on the mean body size for a population) of each ungulate species from reported live weights, population estimates, sex ratios, and reported daily intake rates. Estimates of live weights for adult male elk (317 kg), adult females (236 kg), and calves (100 kg) were from Sullivan (1988). Feral horse weights for stallions, mares, and colts were visually estimated at 522 kg, 454 kg, 181 kg, respectively, by researchers at TRNP (L. Gagnon, pers. comm. 1989). Estimates of mule deer weights were from R. Mackie, pers. comm. 1989. Estimates of typical animal size, daily intake, and growing season intake for bison were from Marlow et al. (1984).

Intake rates have been calculated for elk (Murie 1951, Nelson and Leege 1982), and deer (French et al. 1955). Sex ratios and population censuses of feral horses were recorded by Park personnel in 1989 (J. Bradybaugh, pers comm. 1989). Population estimates and buck:doe:fawn ratios of mule deer were from aerial surveys conducted in 1988 by the North Dakota Department of Game and Fish.

Percent Allowable Use. Production values for the forage species used in the model were multiplied by an Allowable Use Factor (AUF) of 0.35 (35%). Sullivan (1988) chose an AUF of 0.35 when estimating the carrying capacity for elk in TRNP during phase 1. Marlow et al. (1984) adopted an AUF of 0.40 when determining the optimum carrying capacity for bison in TRNP. Long-term herbage production was reported to have substantially declined after season-long grazing by cattle at 35-50% utilization levels in the Central Great Plains (Kipple 1964).

Damage to Park Resources

We investigated 4 areas of potential damage elk might produce in the TRNP area:

- 1) Damage to structures or tourists within the Park.
- 2) Negative impacts on other ungulates within the Park.
- 3) Damage to agricultural lands adjacent to the Park.
- 4) Damage to specific vegetation communities within TRNP.

Field observations and reports by or to Park personnel were used to identify damage in the first 3 areas. The fourth area of potential damage was addressed by vegetation monitoring.

One of the major management goals of TRNP is to maintain populations of ungulate species historically present in the Northern Great Plains at levels that do not adversely impact native vegetation within the Park. Vegetation monitoring is essential to this goal. A monitoring system for major grassland communities was instituted in 1982 (Marlow et al. 1984). This system was expanded to include woodland and shrubland types in 1985 (Sullivan et al. 1988). This

report summarizes the results of vegetation measurements in woodland and shrubland types during 1985-88 and presents recommendations for future monitoring.

Eighteen transects (12 in hardwood draws and 6 in juniper draws) were located, marked and measured in 1985, 1986, and 1988. Six additional transects (3 in cottonwood forests and 3 in shrubby ecotonal areas heavily used by elk) were marked and measured in 1986 and 1988. All transects were marked with metal reinforcement rods painted orange or yellow. Locations, characteristics, and descriptions to be used in relocating transects are given in Appendix F, Table 64.

Woodland Transects

Transects placed in hardwood, juniper, and cottonwood stands were 20-m long. Canopy coverage of all grasses, forbs, shrubs, and nonliving ground cover <50 cm in height were estimated at 1-m intervals along the transect using 20x50-cm plots in 1985 and 1986. An 8-class canopy coverage rating system (Table 1) modified from that of Daubenmire (1959) was used to estimate canopy coverage in individual plots. Canopy coverage for each category over the entire transect was calculated using the median percentage value within each coverage class as a point estimate and averaging the values recorded in 20 individual plots per transect.

In 1988 we incorporated the "ecoplot" system, used on adjacent USFS National Grasslands, into our sampling scheme. This system uses a slightly larger frame (10x20 inches or 25x51 cm), a 13-class canopy

coverage system (Table 1), and a 4-class frequency estimation system. Ecoplot data will be given to the staff of TRNP for future comparisons with data collected by the Forest Service. For analyses, the 13-class canopy coverage system was converted into an analog of the 8-class system used in 1985-86 (Table 1) and canopy coverage values were calculated using the approach described for the 1985-86 data.

Table 1. Canopy coverage classes used in the modified Daubenmire, ecoplot and microplot (shrublands 1988) systems, percent canopy coverage ranges in each class, and values (usually the median) used to enter plot values for calculating transect canopy or basal coverage averages.

Daubenmire			Ecoplot			Microplot (1988)		
Class	Range (%)	Value (%)	Class	Range (%)	Value (%)	Class	Range (%)	Value (%)
0	0	0.0	0	0	0.0	0	0	0.0
1	<1	0.5	t	<1	0.5			
2	1-<5	2.5	p	1-<5	2.5	1	<11	2.5
3	5-<25	15.0	1	5-<15	15.0			
			2	15-<25	15.0	2	11-20	15.0
4	25-<50	38.0	3	25-<35	38.0	3	21-30	25.0
			4	35-<45	38.0	4	31-40	35.0
			5	45-<55	38.0	5	41-50	45.0
5	50-<75	62.0	6	55-<65	62.0	6	51-60	55.0
			7	65-<75	62.0	7	61-70	65.0
6	75-<95	85.0	8	75-<85	85.0	8	71-80	75.0
			9	85-<95	85.0	9	81-90	85.0
7	95-100	98.0	10	95-100	98.0	10	91-100	95.0

Density of shrubs (woody species <2 m in height) was calculated for transects in hardwood (1985, 1986, and 1988), juniper (1985, 1986,

and 1988), and cottonwood (1986 and 1988) stands by counting shrubs by height class (<50 cm, 50-100 cm, and 100-200 cm) in 7 1-m² plots placed at 3-m intervals along the transect baseline (to the right of the transect when facing uphill). Mammal utilization of the current year's growth of individual shrub species/height classes was classified for each plot using a 4 category system (1 = no apparent use by mammals; 2 = 1-10% removal of vegetation by mammals; 3 = 10-50% removal of vegetation by mammals; 4 = >50% removal of vegetation by mammals). Transect values were based on the median utilization values among plots for each species/height class.

Sapling and tree densities were measured in a 20x3-m plot parallel to transect baselines in hardwood (1985, 1986, and 1988), juniper (1985, 1986, and 1988), and cottonwood (1986 and 1988) stands (to the right of the transect when facing uphill). All living saplings (>2 m in height with a diameter at breast height [dbh] <10 cm) and trees (>2 m in height with dbh >10 cm) in each 60-m² plot were identified by species, counted, and classified as having browse available to ungulates (leaves and current year's twigs 0-2 m above the ground) or unavailable to ungulates. Trees and saplings with browse available to ungulates were classified as "used" (evidence of ungulate removal of any of the current year's vegetative growth - including twigs that supported buds in the previous winter) or "not used" (no evidence of ungulate browsing on the current year's growth). Multiple trunks in 1 plant were counted as individual plants if the trunk division began above ground level.

Shrubland Transects

Shrubland transects were placed in ecotonal areas of primarily the SCSC, SCSC/JUHO, and ARTR/ATCO HTs. Transect baselines were 30-m in length. Transects were only measured in 1986 and 1988.

Ground coverage of soil, litter, moss, and creeping juniper (Juniperus horizontalis) and basal coverage of other plants were estimated using 30 2x5-cm microplots placed at 1-m intervals along the transect baseline. Coverage for each category in individual plots was estimated using the modified Daubenmire class system (Table 1) in 1986 and an 11-class system similar to the 13-class ecoplot system (Table 1) in 1988.

Shrub (woody species <2 m in height) cover along transect baselines was measured by species using the line intercept technique (Canfield 1941). Juniper (J. communis and J. scopulorum) density was calculated by counting all plants in a 30x10-m plot (5 m on either side of the transect baseline) by height class (50-100 cm, 100-200 cm, >200 cm). An estimate of juniper canopy coverage by height class within the 300-m² plots was obtained by measuring the canopy width of each plant along its widest axis and along an axis perpendicular to the widest axis. The product of these measurements was used as an index of canopy coverage.

Analysis

The hardwood transects were divided into 3 elk use classes (1 = moderately to heavily used by elk during 1985-88; 2 = used by elk in 1 or more but not all years between 1985 and 1988; and 3 = little or

no use by elk in 1985-88) based on relative distribution of elk in the Park during the study and abundance of elk pellets in the stand. One factor analysis of variance (ANOVA) was used to test 1 null hypothesis (No difference in changes in vegetation values between 1985 and 1988 among transects in different elk use classes) for a variety of characters measured on the transects. These tests were limited to vegetation characters that were found in measurable quantities on most of the transects and those that might be influenced by elk. Comparisons were made only between 1985 and 1988 because both were dry years. Sullivan et al. (1988) demonstrated the variability that can be encountered between measures taken in dry (1985) and wet (1986) years.

Transects in juniper stands were analyzed in a similar manner. By 1988, all transects in TRNP were in the range of elk and use in or near all had been noted. The 6 transects were divided into 2 elk use classes (1 = transects with elk pellets in the stand; and 2 = transects with no elk pellets in the stand) for analysis.

Transects in cottonwood forests and shrubland ecotones were sampled in 1986 and 1988. A 1-factor ANOVA was used to test changes between 1986 and 1988, but much of the change would likely be attributable to differences between wet (1986) and dry (1988) years.

Given the small sample sizes, changes in personnel measuring the vegetation, and changes in techniques (made to align the Park's data base with the Forest Service data base), we only expected our analyses to pick up major changes which would have necessitated immediate management action. To increase the utility of our data for future

vegetation monitoring, we included a sensitivity analysis based on our data to help Park personnel recognize the magnitude of changes they are likely to be able to detect. Standard deviations were used for measured variables, sample sizes, dummy data sets, and Stein's 2-stage sampling formula (Steel and Torrie 1960) to calculate the percent change in a variable that could be detected at 2 levels of precision, given varying numbers of transects and varying magnitudes of standard deviations. Results were declared significant at the 95% ($p \leq 0.05$) confidence level.

RESULTS AND DISCUSSION

Distribution

Since the reintroduction, elk have expanded their range from the southeast corner of TRNP (Sullivan 1988) to include northcentral and southcentral areas. The region within the Park Loop Road (Fig. 1) appeared to receive heavier use by elk during phase 2 than was noted by Sullivan (1988) during phase 1. The Loop Road received considerable vehicular traffic during the tourist season, but the terrain within this loop was highly dissected and provided seclusion from human disturbance. The expansion of elk within TRNP can be attributed to an increased familiarity of areas with preferred forage and security cover, but the slow rate in which it occurred suggests that elk were conservative in selecting new habitats. Dispersal of individuals typically occurs under high density dependent pressures (Caughley 1970) and should not be expected to occur immediately following the introduction of animals into a relatively unrestricted environment.

Elk had not used areas west of the Little Missouri River extensively as of summer 1988, although forage and developed water sources were abundant. Elk were observed west of the river only once, when a Park employee saw two adult bulls 0.75 km west of the river in August 1988. As the elk population grows, this area should receive

greater use and could potentially lessen relative grazing pressure in the eastern 2/3 of the Park.

Most elk have remained within TRNP since the reintroduction. A 2.3 m fence, which enclosed TRNP to prevent bison damage to surrounding private property, may have acted as a partial barrier to elk emigration. Vehicular traffic along an interstate highway which paralleled the Park's southern boundary and oil production activity along the northern boundary may have deterred elk from leaving TRNP. However, some elk were reported in areas outside TRNP, and these absences were reflected in population censuses.

Four reports of animals outside the Park were filed in 1987-1988 (Table 2). Two bulls (1 radio-collared in March 1987, identification number 0926, and 1 unmarked bull) left the Park in spring 1987. Reports of two adult bulls, including 1 with a radio-collar, were received throughout summer and fall 1987, at distances of 160-515 km east of the Park. The radio-collared bull was observed in TRNP on 18 January 1988 unaccompanied by the other bull.

On 4 November 1987, ~20 cow and calf elk evidently leveled a 10-20 m section of fence on the eastern boundary and grazed on cropland adjacent to the Park for a short period of time before being herded into TRNP by Park rangers. Additional elk have been seen in the same area by Park employees during 1989. Fifteen to 17 elk were reported 18 km southeast of TRNP and 2-3 bulls 50 km east of TRNP during June 1988 (J. Bradybaugh, pers. comm. 1988). It was not determined whether the latter two groups were from TRNP.

Sullivan (1988) reported 3 incidences of elk leaving TRNP during 1985-1986 and noted that several other reported sightings outside the Park could have involved elk from a herd established ≈ 150 km to the north. All verified reports of elk leaving TRNP or missing from population censuses over the 4-year project are presented in Table 2.

Table 2. Verified reports of elk leaving and later returning to TRNP from 1985-1988. Reports for 1985-1986 are from Sullivan (1988).

Season	Number leaving	Age/sex	Number returning
Summer 1985	1	cow	0
Summer 1985	1	calf	0
Summer 1985	2	bulls	1
Fall 1986	5	cows	0
Winter 1986	1	cow	0
Spring 1987	2	bulls	1
Fall 1988	<u>20</u>	cows/calves	<u>20</u>
Total	32		22

Pellet Group Survey

In August 1988, an elk pellet group survey was conducted on major hiking and game trails within sections delineated by Sullivan (1988), to assess elk distribution within TRNP. Pellet group distribution roughly followed elk distribution based on observations (Fig. 3). However, this association was not exact because: 1) elk use of game trails may have varied among seasons; 2) the habitats used by elk during times of high defecation rates may have been over or under sampled; 3) feces decomposition and elk distribution varied by season; 4) the spatial distribution of elk along pellet group transects.

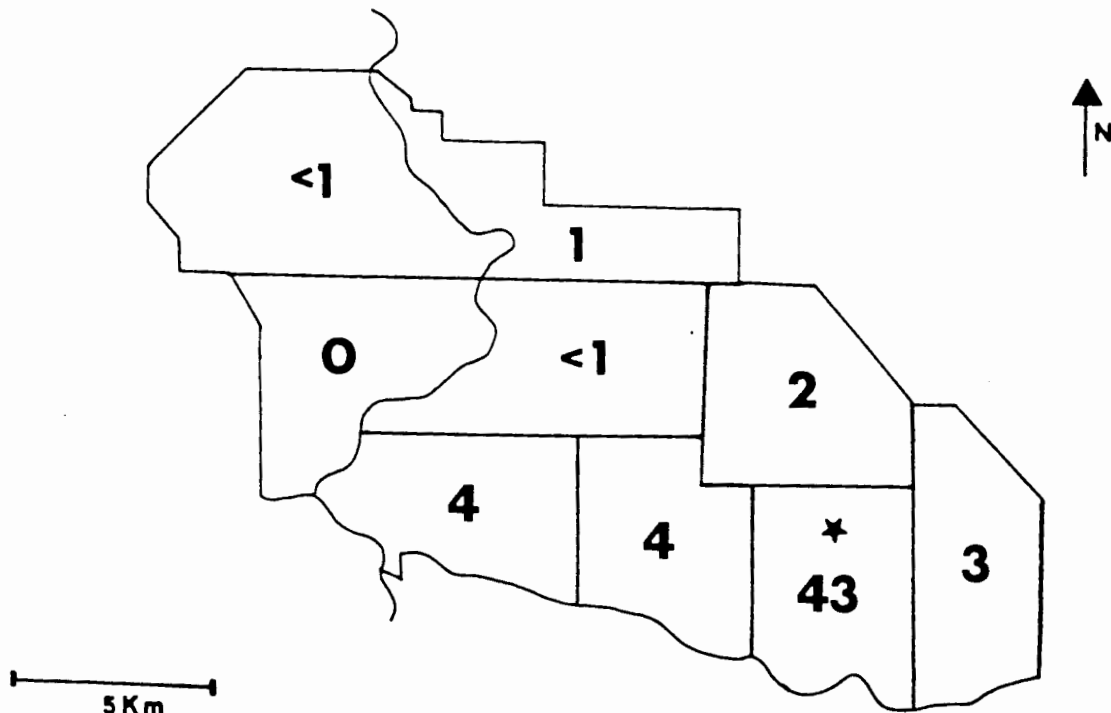


Figure 3. Elk pellet group survey in Theodore Roosevelt National Park, 1988. Numbers in sections = pellet groups per km. Map drawn by Sullivan (1988). ★ = release site of elk.

Transects were also walked along fencelines in several regions to determine if elk had been outside the Park. Three pellet groups were found outside the fenceline of the northernmost section east of the Little Missouri River. Apparently elk were occasionally using these areas, sites of active oil wells and livestock but no human residences, and returning to the Park. The fence in this area is as low as 1.5 m in some places, relative to the terrain, and may have been easily cleared by elk. Movement out of the Park probably occurred at night since there were no reports of elk north of TRNP during phase 2.

Herd Organization

Elk were sexually segregated into a bull and a cow-calf group for most of the year and only associated in late summer and early fall with the onset of rutting activities. Cow-calf groups consisted of adult females (≥ 2 years), yearling females (1 year), calves and occasionally yearling males. Although temporary divisions in the cow-calf group occurred, no permanent discrete units formed. These divisions occurred sporadically, and the associations between individuals were ephemeral. Craighead et al. (1973) noted that elk cow-calf groups in Yellowstone National Park were in a constant state of flux, with individuals moving often between groups.

The cow-calf group numbered 107 animals (excluding yearling males) at the last population census in 1988 but still appeared relatively stable, with all females associating frequently. In Wind Cave National Park, the origin of the transplanted elk at TRNP, 3 discrete cow-calf groups were observed that numbered 170, 90, and 40 animals, respectively (Varland et al. 1978). Wind Cave National Park is 114 km² (about 3/5 the size of TRNP) yet the home ranges of these cow-calf groups seldom overlapped (Varland et al. 1978). Based on cow-calf group sizes in Wind Cave National Park, the cow-calf group at TRNP may reach 170 animals before becoming unstable and dividing into discrete groups.

Yearling males were forced from the cow-calf group by adult females both before and after calving, although a few remained on the periphery of the group throughout the year. Franklin and Lieb (1979)

found that yearling males, but not yearling female elk, were forced from cow-calf groups by their dams. Geist (1982) hypothesized that yearling bulls must leave cow-calf groups to seek higher quality forage because of their more demanding nutritional requirements compared to yearling females.

Most yearling bulls began a period of increased wandering, often in small groups of 2-3, after leaving the cow-calf group in summer. This continued throughout the year, except for a brief period of association with the cow-calf group in late August, when all animals coalesced for pre-rutting activities. Yearling males were first recorded with the bull group on 5 March 1988, when 9 of 12 yearling males were seen traveling with adult bulls. Three or 4 yearling males frequently associated with the cow-calf group until late May.

Adult males (≥ 2 years) segregated from the cow-calf group during most of the year. The ranges of adult bulls and cows seldom overlapped (Figs. 4-7). Geist (1982) suggested that adult bulls become more solitary after the rut to regain depleted fat reserves by feeding on more nutritious forage than what is selected by the cow-calf population. Sexual segregation has been identified in red deer (Darling 1937, Raesfeld and Vorreyer 1964) and elk (Flook 1970, Knight 1970, Franklin and Lieb 1979) populations.

The single bull group was often divided into subgroups with animals forming loose associations. However, because the home ranges of all adult bulls overlapped extensively and because all bulls were seen in 1 group on several occasions, only 1 group was recognized. Varland et al. (1978) identified 3 discrete bull groups in Wind Cave

National Park, with the largest numbering 35 individuals. During an aerial survey of the TRNP elk herd in winter 1989, all 25 adult bulls were observed in 1 group. Based on bull group sizes in Wind Cave National Park, it is conceivable that the bull group in TRNP will become unstable and segment with the addition of the 1988 yearling male cohort.

Seasonal Distribution and Home Range

The seasonal distribution of the bull (Male) and cow-calf (Female) groups are shown in Figures 4-7. Yearling male locations were recorded as "adult male" locations when these animals were with the bull group or isolated from the cow-calf group. Home range sizes were derived for all radio-collared and uncollared elk within TRNP for each season (Table 3). The home range of animal 0926 was impossible to determine over some of the study due to the animal temporarily leaving the Park. Radio transmitters for animals 1200 and 1251 worked only intermittently throughout the study and precluded large relocation sample sizes. Additionally, there is some evidence that these animals may have been using areas outside the Park.

Summer 1987

Most individuals of the cow-calf group were located near the Peck Hill area (Fig.1) during calving in early June. Cows were segregated into small nursery groups ($\approx$ 4-5 adult females) near calving areas following parturition. Larger groups of yearling males and females were assembled on the peripheral ranges of these nursery groups and

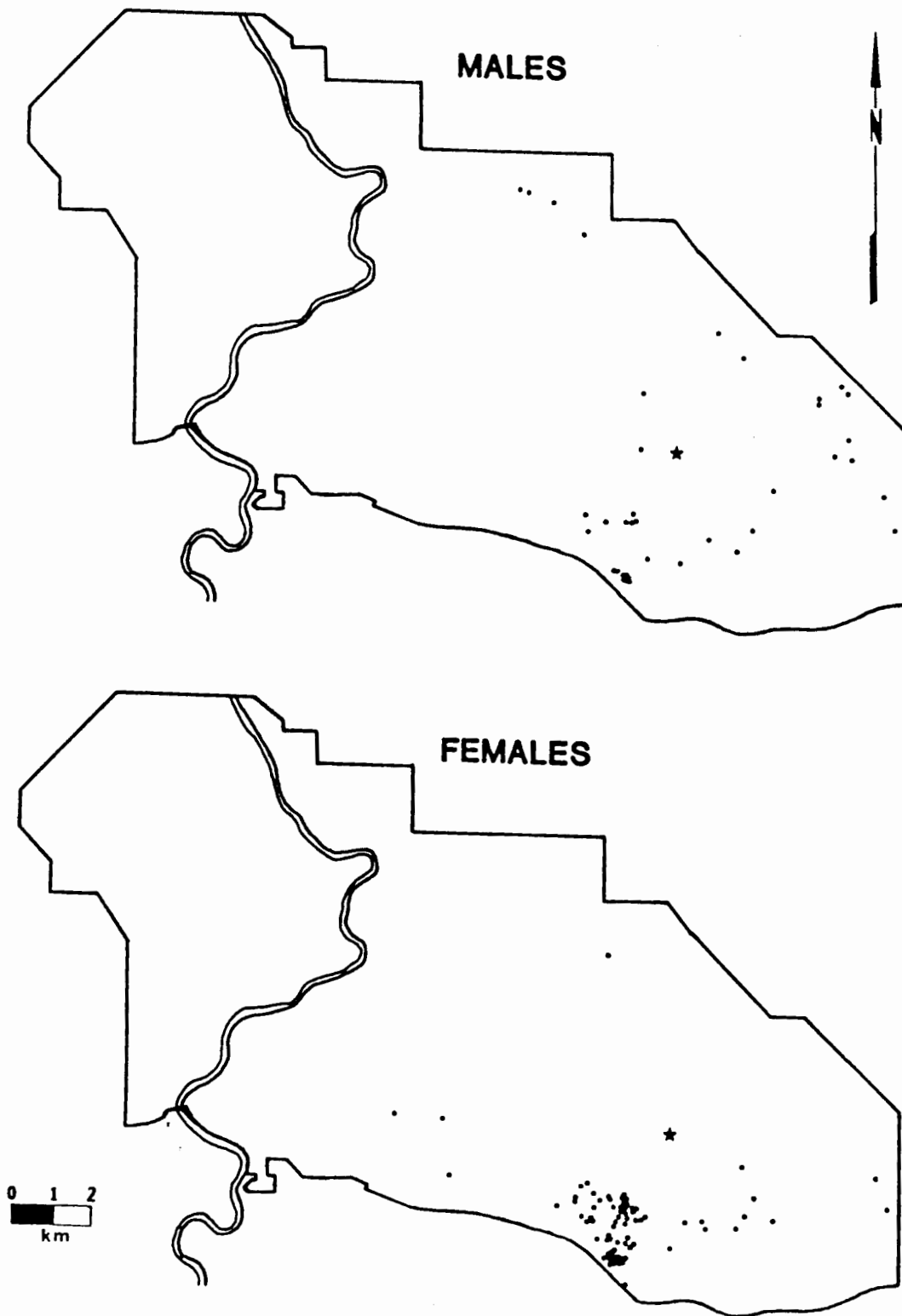


Figure 4. Locations of adult male and female elk during summer 1987.
★ = release site of elk.

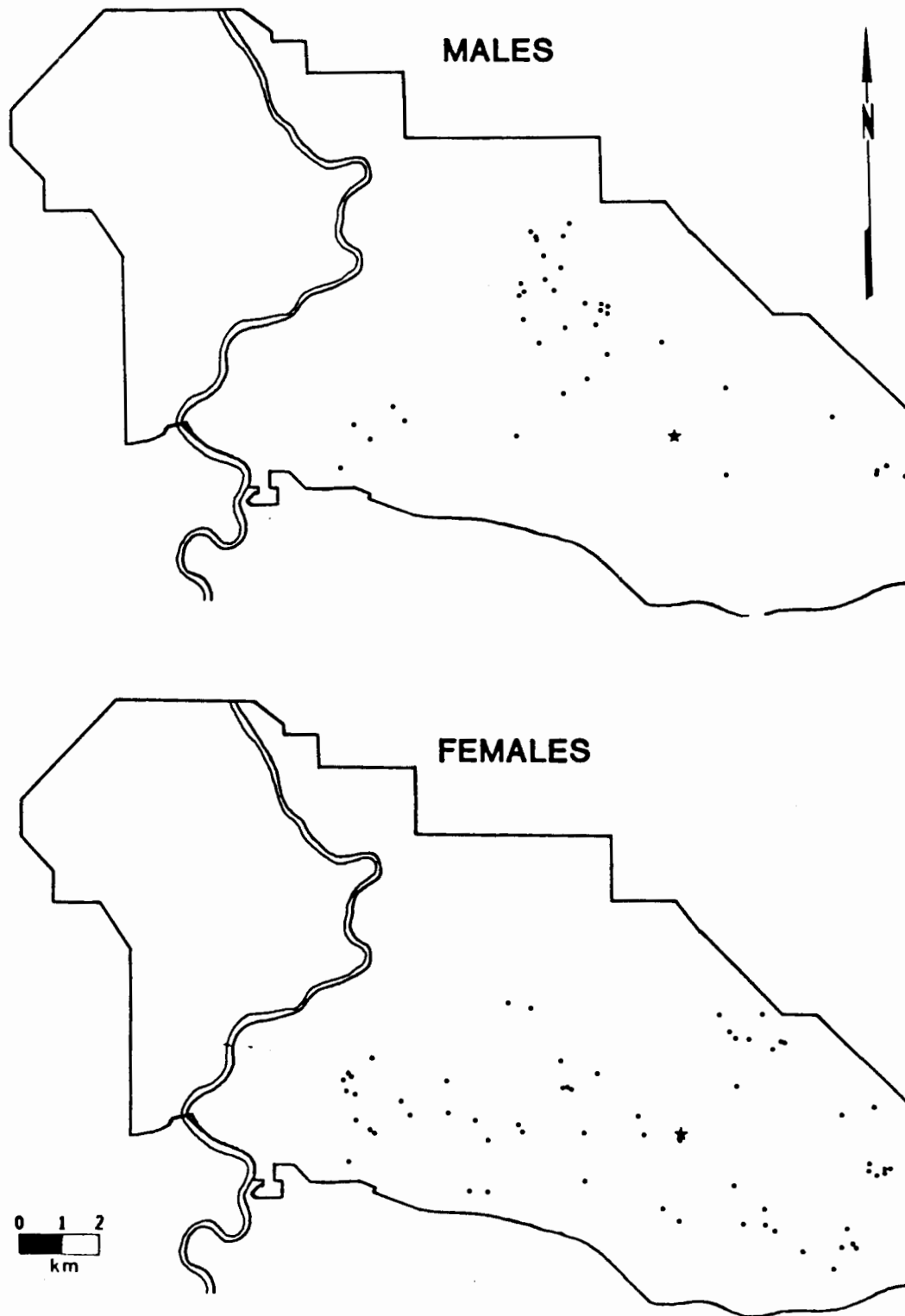


Figure 5. Locations of adult male and female elk during winter 1988.
★ = release site of elk.

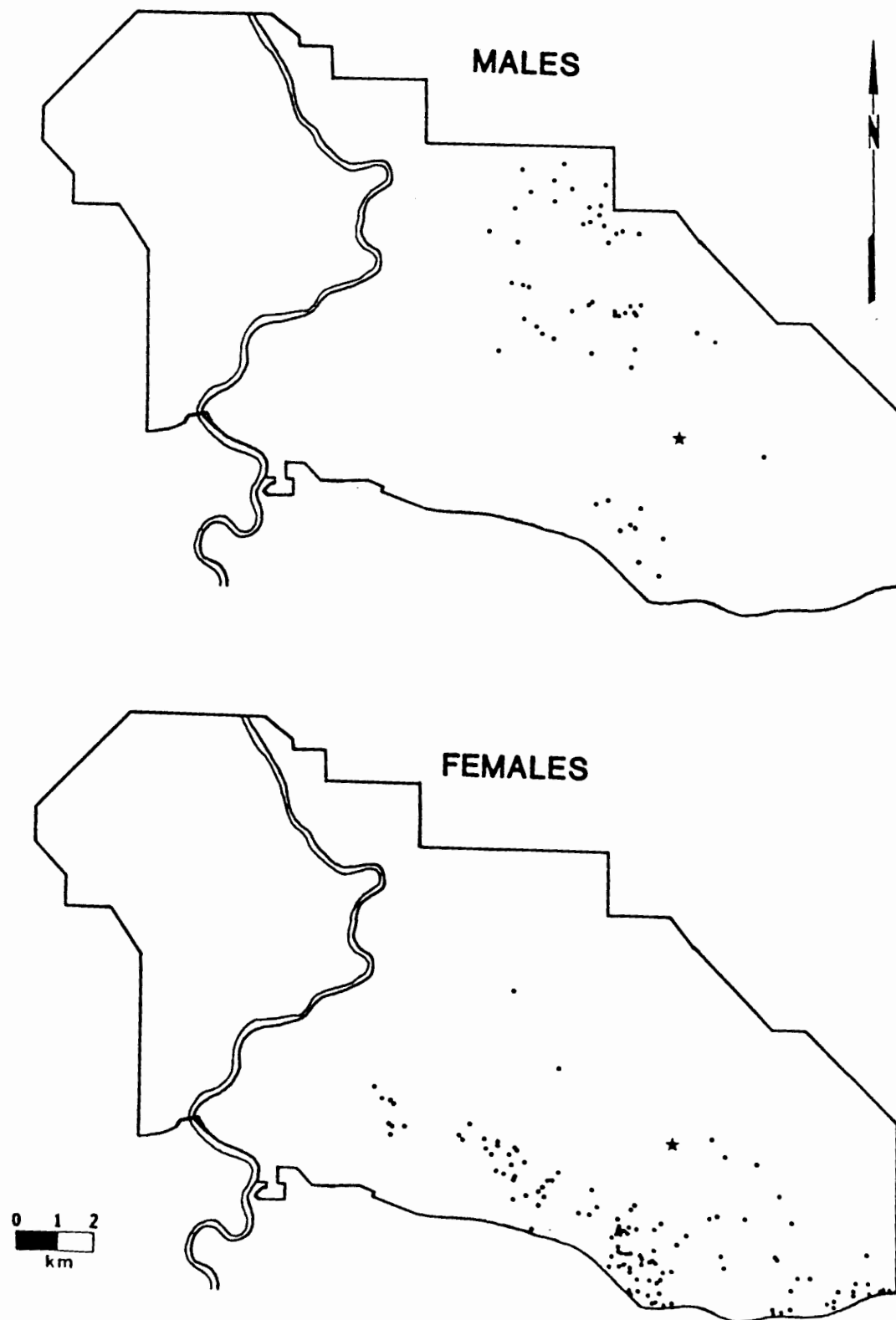


Figure 6. Locations of adult male and female elk during spring 1988.
★ = release site of elk.

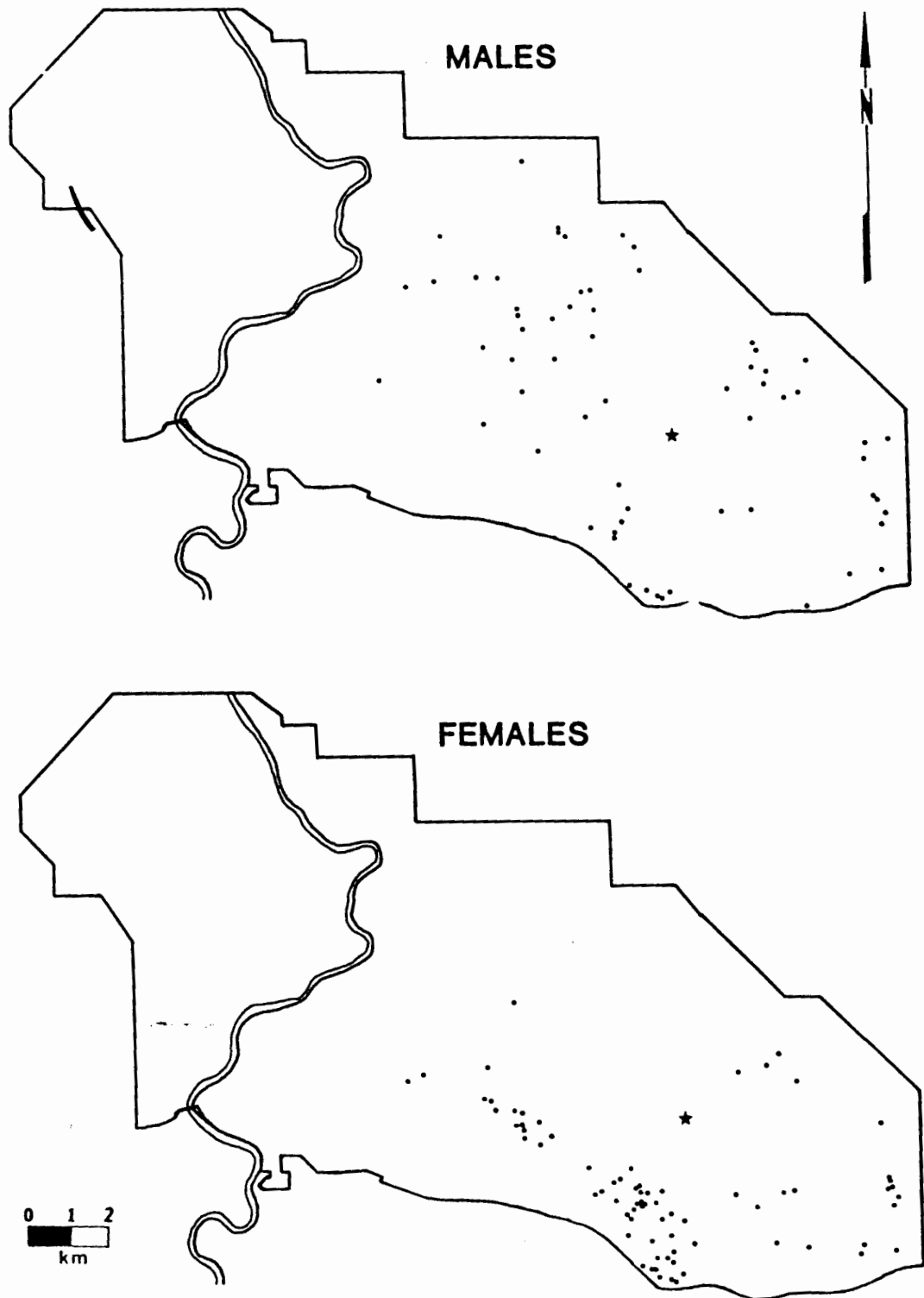


Figure 7. Locations of adult male and female elk during summer 1988.
★ = release site of elk.

occasionally associated with them. Nursery groups began coalescing by late June, and by 26 June, the cow-calf group was once again united.

After the nursery groups united, the cow-calf distribution was concentrated in the southcentral area of TRNP. Yellow sweetclover (Melilotus officinalis), a biennial forb, was very abundant in 1987 and seemed to be the preferred forage of the cow-calf group. Upland grassland plateaus in this area provided the highest concentration of yellow sweetclover in TRNP. Because of these concentrated foraging areas and the use of a single calving area, home range sizes were lowest for females during summer 1987. Home ranges of radio-collared females were similar to one another (9.8 - 20.9 km²) and to the cow-calf group overall (25.8 km²). The entire cow-calf group relocated to the eastern boundary of TRNP on 24 August, where pre-rut activities (bugling, sparring, and attempted harem formation by adult bulls) were first observed.

The bull group was observed most frequently in the northeastern and northcentral portion of TRNP in early summer 1987. Most adult bulls remained apart from the cow-calf group, although a raghorn bull (probably a 2-year-old) was observed with the cow-calf group throughout the summer. Larger bulls were infrequently seen with the cow-calf group for 1-3 days at a time starting in late July until the onset of pre-rutting activities on 24 August. After this time, the dominant adult bull (a large 6-point animal) was always seen with the cow-calf group, with subordinate bulls often on the periphery of the group. Because of this association with females, home range size for

the bull group was large during summer 1987 (49.2 km²). Home range sizes varied greatly between the two radio-collared bulls in TRNP. Animal 0926, who had left the Park in spring 1987, was still outside TRNP in summer 1987.

Table 3. Seasonal home range sizes (km²) for radio-collared and uncollared elk in TRNP.

Animal I.D.	Sex	Age ^a	<u>Summer 1987</u>		<u>Winter 1988</u>		<u>Spring 1988</u>		<u>Summer 1988</u>	
			Size	N	Size	N	Size	N	Size	N
0888	F	A	20.9	34	60.1	32	32.9	35	42.1	39
0980	F	A	15.4	41	54.3	24	27.0	48	36.0	40
0999	F	A	12.2	44	50.9	34	38.6	47	43.9	49
1055	F	A	9.8	46	55.6	30	47.1	45	23.7	37
1350	F	A	12.1	52	50.4	19	16.1	24	23.8	29
0926	M	A			47.1	21	38.2	30	53.2	25
1200	M	A	44.7	18	5.7	14	20.9	18		
1251	M	A	15.6	14	2.3	8	26.7	19	29.8	15
Cow-calf group			25.8	76	62.6	62	51.7	123	51.1	75
Bull group			49.2	38	50.4	38	39.7	53	80.0	62

^a Adult = ≥2 years.

Winter 1988

The cow-calf group was most gregarious and cohesive during the winter season. The entire group was often seen feeding and bedding in large assemblages and traveled as a unit. The cow-calf group was also most mobile during the winter season, with daily movements from 0 (rarely) to 3 km. In January, the month with the greatest average movement, cows moved an average of 1.2 km / 24 hours. The winter 1988 home ranges were the largest for the cow-calf group (62.6 km²) and for individual females during the entire study. Varland et al. (1978) recognized no major seasonal shifts in home range for 3 established cow-calf groups in Wind Cave National Park. Mackie (1970) found elk

in the Missouri River Breaks, Montana to be most dispersed during the winter season, with constant "wandering" in search of forage which was locally abundant or had received little previous use by livestock.

Cows extended their range westward during the winter season. The western edge of their winter range brought them within sight of the Little Missouri River. An increased distribution and movement pattern may have been a strategy to utilize forage which had received little previous use. Elk in TRNP during winter 1988 frequently moved to isolated wind-swept buttes to graze. Although snowfall was minimal during winter 1988, it was energetically efficient for elk to graze in areas with the least snowfall and in areas that had little ungulate use during the spring and summer. Additionally, low snow cover during December 1987 - March 1988 probably allowed more extensive movement than was observed in winter during phase 1 by Sullivan (1988).

The bull group was most sedentary during the winter season, with its distribution concentrated in the rugged breaks and scoria hills in the northcentral part of TRNP. Bull movement was least during the winter season, with home range sizes for animals 1200 and 1251 only 5.7 and 2.3 km², respectively. Marked bulls in Wind Cave National Park did not make long-range movements during winter (Varland et al. 1978). All adult bulls (≥ 2 years) in TRNP closely associated during winter, and were often seen in 1 group. Varland et al. (1978) recorded the largest mean sizes for the bull groups in Wind Cave National Park during the winter season.

The adult bull home range increased dramatically when animal 0926 returned to TRNP on 18 January 1988 after being outside the Park for

10 months. Upon entering TRNP, animal 0926 associated with the cow-calf group and traveled with them throughout the southern portion of the Park. Most of the southern winter relocations for adult males (Fig. 5) were attributed to this animal. Animal 0926, along with several yearling males, joined the bull group on 5 March, but were low in hierarchal status, as was indicated by their submissive behavior in encounters with other adult males.

Spring 1988

The cow-calf group continued to function as a single unit during the early part of the spring 1988 season. Home range size for the cow-calf group remained high in spring 1988 (51.7 km²). Occasionally, small subgroups would separate from the main group for 1-3 days, often relocating 1-5 km away, but would invariably return. Travel was considerably reduced compared to the winter season, and areas in the southcentral and southeastern part of TRNP were used more extensively.

Cows began dispersing on 11 May, with the onset of calving season, and by 17 May, 4 of 5 radio-collared females had relocated to within the Loop Road (Fig. 1), the area of most calving in 1988. Cows became solitary during the calving season. The radio collar on animal 1350 ceased to operate during spring 1988, and most relocations for this animal were when it accompanied other radio-collared females. This was also the only radio-collared female to calve east of the Loop Road in 1988, which accounts for the small home range of this animal (16.1 km²). Small nursery groups formed near calving areas $\approx$ 2 weeks following the presumed peak calving time (1 June).

The bull group, which included most of the yearling males by early March, occupied the same area during early spring as during the winter season. In late spring, daily movement and range increased slightly compared to winter. Most bulls increased their home range in spring 1988 (20.9 - 38.2 km²). Antler drop, which occurred from 13 April - 22 April, was accompanied by decreased tolerance among adult bulls (Geist 1982) and led to the breakup of the bull group into subgroups. Several subgroups roamed the southern portions of TRNP occasionally associating with groups of immature males and females on the periphery of female calving grounds. Bulls remained in these subgroups throughout the spring season.

Summer 1988

Cow nursery groups began to coalesce in late June, but remained near the calving grounds. Two large cow-calf groups, the largest inside the Loop Road and a smaller one in the southcentral portion of the Park near Peck Hill (Fig 1.), formed from the combined nursery groups and persisted throughout June and the first half of July. The cow-calf home range in summer 1988 was similar in size (51.1 km²) to spring 1988 because of the extended period of time that nursery groups remained on the calving grounds.

On 18 July, the cow-calf groups reunited east of the Loop Road and remained united throughout the summer. The late reunion of cow-calf groups following calving in summer 1988 compared to summer 1987 was due to the greater distance between calving areas and, possibly, to a hesitancy to leave available water during a drought year. This

separation following calving may become prolonged in the future and lead to a permanent division in cow-calf group.

Bull distribution and home range (80.0 km²) was greatest during the summer 1988 season because: 1) bulls remained intolerant of each other throughout early summer; 2) bulls had gained a greater familiarity with the Park than during earlier seasons; 3) bulls began associating and traveling with the cow-calf group in August, and the cow-calf group had increased their distribution from summer 1987 to summer 1988. Adult bulls did not associate with the cow-calf group in July, as in summer 1987, and were first seen with females on 13 August. Pre-rutting activities were first observed on 25 August, when several bulls joined the cow-calf group on the eastern boundary of TRNP. Most bulls followed the cow-calf group as it moved to the southcentral portion of TRNP.

Population Dynamics

The population dynamics of the TRNP elk herd was recorded for each year of the 4-year project (Table 4). The number of yearling animals for 1985 and 1986 were extrapolated from earlier census data of Sullivan (1988). Sullivan (1988) noted 5 females of unknown age in summer 1986 and 1 in winter 1986 were missing from population censuses, and reported that local hunters and ranchers had observed 5-6 animals outside of TRNP about that time. It was assumed in this study that these animals left TRNP and, for the purposes of population modeling and cow:calf ratios, that these were 3 adult (≥ 2 years) and 3 yearling (1 year) females.

Table 4. Population dynamics of adult male and female (≥ 2 years), yearling male and female (1 year), and calf elk in TRNP. Data for 1986-1987 are from Sullivan (1988).

Sex/Age class	Phase 1			Phase 2	
	(Transplant)				
	Mar 1985	Sept 1985	Aug 1986	Sept 1987	Sept 1988
Adult females	33	35	35 ^a	40	53
Yearling females	3	2	6 ^a	13	17 ^b
Adult males	0	7	8	13	25
Yearling males	8	1	7	12	16 ^b
Calves (male:female)	3 (1:2)	16 (7:9)	25 (12:13)	33 (16:17) ^b	37 (18:19) ^c
Total	47	61	81	111	148

^a Extrapolated from censuses by Sullivan (1988).

^b Estimates based on near complete censuses during phase 2.

^c Estimated during phase 2.

^d Elk leaving and entering TRNP in Table 2.

Complete censuses were obtained for calves and adult bulls in 1988, but only "near complete" censuses were obtained for adult females and yearling animals. Only one instance of mortality was verified during the study, when an adult bull was found dead after falling into a sinkhole in spring 1988. Therefore, because of the relatively young age of the herd, and because extensive groundwork revealed no other elk carcasses, we assumed that no other mortality had occurred between 1987 and 1988. Recently, 2 adult cows have been found dead by Park personnel, 1 in August 1989 and another (animal

1350) in October 1989. Because previous calf crops at TRNP yielded ~50:50 sex ratios (slightly favoring females), and other researchers have found near equal sex ratios in calf elk (Johnson 1951, Picton 1961), the calf crops in 1987 and 1988 were estimated to be 16 male : 17 female and 18 male : 19 female, respectively.

Population dynamics of elk in TRNP during 1985-1988 (Table 4) were indicative of a healthy, rapidly expanding population. Male antler development during 1987-1988 indicated bulls were receiving near optimal nutrition. Five out of 14 (36%) bulls 2 1/2 to 4 1/2 years of age had antlers with 6 points in 1987. Only 1 of the 14 (7%), probably a 2 1/2 year old, had antlers with <5 points. Nine out of 12 (75%) yearling bulls had 2 points on 1 or both antlers. Only 28% of the yearling bulls examined in Colorado by Boyd (1970) had 2 or more tines per antler.

Population growth rates and sex ratios were calculated from all known animals in the TRNP herd (Table 5). Only 10 elk (3 males and 7 females) were known to have emigrated from TRNP during the 4-year study. The fates of these individuals were not known, but they were included in the growth rate and sex ratio estimates to better understand the biological characteristics of the herd.

The male:female ratio of elk at TRNP increased from 24:100 for the original transplanted herd to 65:100 in September 1988 (Table 5), including those animals which left the Park (Table 2). A preponderance of females were introduced into TRNP to rapidly build up the population and because it is traditionally more difficult to capture, contain, and transport males during a reintroduction (J.

Bradybaugh, pers. comm. 1989). Elk sex ratios of established populations, such as reported by Flook (1970) in Banff National Park (36:100) and by Cole (1969) at the National Elk Refuge, Wyoming (31:100), are often low because of excessive mortality in adult males resulting from rutting injuries and/or from hunting in unprotected areas near reserves. Because of the near even calf sex ratios observed at TRNP, the overall sex ratio should continue to rise until mortality becomes a factor, and then decline, approaching the level of established herds (Peek 1982).

The Actual Rate of Increase of elk at TRNP (r_a), approximated by the least squares method (linear regression), was 0.31 over the 4-year study. Annual growth rates (r) varied from 0.33 from 1985-1986 to 0.26 from 1987-1988, the last year of the study. An aerial survey of the Park in September 1989 produced a count of 176 elk, indicating that the population is still increasing at a rapid rate.

Few studies have documented growth rates for liberated or naturally colonizing populations of elk in North America. A captive herd of Rocky Mountain elk on an ammunition storage depot in Missouri grew at 0.29 over an 8-year period (Murphy 1963). The growth rates of 2 reintroduced populations of Tule elk (*C. e. nannodes*) in southern California differed significantly, at 0.31 and 0.17, over a 6-year period (Gogan and Barrett 1987). McCorquodale et al. (1988) estimated the rate of increase in a colonizing population of Rocky Mountain elk in the shrub-steppe region of southcentral Washington to be 0.30 over a 4-year period beginning 9 years after colonization. The highest reported rate of increase in elk, 0.37, occurred 6 years after a

reintroduction project on Afognak Island, Alaska (Burris and McKnight 1973).

Calf:cow ratios were calculated for each year of the 4-year study for all females ≥ 1 year and for adult females ≥ 2 years of the previous year (Table 5). Overall ratios were high, 66:100, when yearling females were included, and 77:100, when they were excluded. The decline in the calf:cow (≥ 1 year) ratio in 1988 was due to the growth of the yearling population segment. However, the calf:cow (≥ 2 years) ratio in 1987 and 1988 were similar, at 94:100 and 93:100, respectively, indicating that the herd remained productive and did not suffer from density dependent factors.

Calf:cow (≥ 1 year) ratios at TRNP exceeded those of most established populations, which range from 18:100 (Cole 1969) to 71:100 (Boyd 1970). Craighead et al. (1973) found calf-cow (≥ 1 year) ratios in a non-migratory, non-exploited elk herd in Yellowstone National Park at 31 and 38:100 over 2 summers. These values were considered normal to low productivity for that area. Calf:cow ratios recorded during an aerial census of elk at TRNP in September 1989 also exceeded 90:100.

Calf:cow ratios at TRNP were similar to reported values in other newly established elk herds in North America. Gogan and Barrett (1987) recorded calf:cow (≥ 2 years) ratios of 64:100 and 87:100 for two reintroduced populations of Tule elk over 6 and 7 years, respectively. McCorquodale (1988) recorded calf:cow ratios of 76:100 (including yearlings) and 91:100 (excluding yearlings) for a colonizing Rocky Mountain elk population.

Table 5. Male:female ratios and logarithmic growth rates based on elk within and outside TRNP, and calf:cow ratios based potential breeding females within TRNP during previous years.

Year	Total population ^a	Male: 100 females	Growth rate (r) ^b	Calves : 100 cows	
				All cows (≥1 year)	Adult cows (≥2 years)
1985 ^c	47	24	--	--	--
1985	64	36	0.31	47	52
1986	89	48	0.33	68	71
1987	122	58	0.32	80	94
1988	158	65	0.26	70	93
			$r_a = 0.31$	$\bar{X} = 66$	77

^a Total population of elk within and outside TRNP.

^b $r = \ln(\text{count}_{t+1}/\text{count}_t)$.

^c Transplant.

^d r_a = Actual Rate of Increase over 4 years.

Food Habits

Plant species composition in the fecal samples of elk, bison, feral horses, mule deer, and white-tailed deer was determined for late spring 1988 and late summer 1988 (Appendix D, Tables 57-61). Plant species composition in elk feces was also determined for samples collected in early summer 1987 (Appendix D, Table 57). Plant species composition for the growing season (spring and summer seasons) was calculated from the mean of seasonal percentages. Percent species composition in fecal samples was assumed to be approximately equivalent to diet composition.

Elk Diets

Forage items which composed ≥3% of elk diets in any seasonal sample are listed in Table 6. In late spring (15 May - 15 June) 1988 graminoids and forbs were selected in roughly equal proportions, with

browse being less important. A wide variety of forbs were selected but only scarlet gaura (Gaura coccinea), wild bergamot (Monarda fistulosa), and scarlet globemallow (Sphaeralcea coccinea) were >3% of the spring diet composition. Western wheatgrass (Agropyron smithii) and sedges (Carex spp.) were the most abundant graminoids in fecal samples during late spring 1988.

Other studies have shown the importance of western wheatgrass (Mackie 1970) and carices (Wydeven and Dahlgren 1983, Sullivan 1988) in the diets of elk in the Northern Great Plains. Spring elk diets in TRNP had a higher percentage of forbs than reported in most studies (Kufeld 1973). Precipitation was below normal during spring and summer 1988, and low precipitation and high temperature typically advance plant phenology (Bell 1973). In spring 1988, elk in TRNP may have shifted to a typical summer diet (i.e. high in forbs) (Kufeld 1973) early because of the drought.

In early summer (16 June - 31 July) 1987, browse was the most abundant forage class in fecal samples. Winterfat and snowberry (Symphoricarpos occidentalis) were the major browse species in elk diets during early summer. Female elk observed at TRNP increased their browsing prior to calving in both years of the study and continued to browse heavily throughout the early summer. Elk need high levels of protein during this time for gestation, lactation, and body growth (Nelson and Leege 1982). Flowers and succulent stems of woody vegetation were evidently the best source of available protein in TRNP.

Table 6. Seasonal percent elk diet composition of graminoids, forbs, and browse comprising $\geq 3\%$ of any seasonal diet.

Plant species	Late spring 1988	Early summer 1987	Late summer 1988
Graminoids			
<u>Agropyron smithii</u>	7.8	3.4	4.2
<u>Bromus inermis</u>	5.7	1.2	1.0
<u>Carex</u> spp.	7.2	2.4	
<u>Poa</u> spp.	1.1	9.5	0.3
<u>Schizachirium scoparium</u>	3.8		
<u>Stipa viridula</u>	5.4	8.7	4.8
Total graminoids	36.3	26.4	12.5
Forbs			
<u>Gaura coccinea</u>	3.6	1.6	4.2
<u>Lactuca</u> spp.	1.3	3.2	0.3
<u>Monarda fistulosa</u>	3.3	2.8	3.2
<u>Sphaeralcea coccinea</u>	4.5	6.0	21.5
Total forbs	38.8	25.4	45.9
Shrubs			
<u>Artemisia frigida</u>	0.3	1.6	4.9
<u>Ceratoides lanata</u>	2.2	18.1	17.5
<u>Prunus virginiana</u>	3.5	6.8	4.6
<u>Rhus trilobata</u>	4.0	4.8	2.1
<u>Ribes</u> spp.	1.6	1.2	3.5
<u>Rosa</u> spp.	3.1		2.0
<u>Shepherdia argentea</u>	4.7		0.5
<u>Symphoricarpos occidentalis</u>	3.1	14.3	5.0
Total shrubs	24.9	47.0	41.6

Cool season grasses were selected in early summer, with bluegrass (Poa spp.) and green needlegrass (Stipa viridula) constituting the majority of the graminoids eaten. In summer 1987, TRNP received above average precipitation, and the proportion of forbs to graminoids selected by elk was roughly equivalent to late spring 1988, a drought

year. The major forb species selected were also similar to late spring 1988, except for the increased importance of wild lettuce (Lactuca spp.). Although yellow sweetclover did not appear as a major dietary item, observational data indicated that elk were selecting for yellow sweetclover and were often seen in concentrated stands. Elk fed mostly on the flowers of yellow sweetclover, the most digestible and least identifiable structure in microhistological analysis. This may explain the limited amount of yellow sweetclover in elk feces collected during early summer. Mackie (1970) found yellow sweetclover to comprise over 1/2 the total summer diets of elk in the Missouri River Breaks, Montana.

In late summer (1 August - 5 September) 1988, elk diets were composed mostly of forbs and browse with minimal graminoids. As graminoids begin to mature and desiccate in late summer, elk in several studies have been reported to switch to forbs and the succulent twigs and leaves of browse (Nelson and Legee 1982). Scarlet globemallow was once again an important food component, comprising 21.5% of the total late summer elk diets. Sullivan (1988) found scarlet globemallow to be the only forb to constitute >3% diet composition for elk at TRNP during any season. Scarlet gaura, a forb of dietary significance in late spring 1988, also received substantial use by elk in late summer 1988.

Winterfat was the most common browse species, constituting 17.5% of the estimated elk diets in late summer 1988. Sullivan (1988) found winterfat to be the most important browse species in elk diets for every season at TRNP. Fringed sage (Artemisia frigida), snowberry,

and chokecherry (Prunus virginiana) were also important browse species in late summer 1988. Elk evidently still preferred cool season grasses over warm season grasses in late summer. Cool season grasses at TRNP are often associated with moist sites, which may produce some regrowth in late summer.

Comparison of Ungulate Diets

Comparisons of ungulate diets during the growing season were based on all items identified in fecal analysis (63 items) (Appendix D, Tables 57-61), and on the percentages of graminoid and browse species which composed $\geq 3\%$ of any growing season diet and for which production was available (11 items) (Tables 7 and 27). Comparisons of growing season diets assessed potential competition for forage species regardless of the plant phenology or seasonal ungulate preference.

In comparisons of total diets, elk diets were most closely correlated with feral horses diets ($r_s=0.49$ $p<0.01$), followed by bison diets ($r_s=0.39$ $p<0.01$). These correlations were significant but not very strong because bison and feral horses tended to use more grass and elk more forbs during the growing season. When the relative utilization of the 11 major forage items was compared, elk were not correlated to bison or feral horses.

Table 7. Spearman's rank correlations (r_s) of total diets (TOT) and diets of 11 major forage items (MAJ) for elk, bison, feral horses, mule deer (MD), and white-tailed deer (WTD).

	Bison		Horse		MD		WTD	
	TOT	MAJ	TOT	MAJ	TOT	MAJ	TOT	MAJ
Elk	0.39 p<0.01	-0.25 p=0.44	0.49 p<0.01	-0.11 p=0.76	0.32 p=0.01	0.25 p=0.46	0.21 p=0.10	0.23 p=0.48
Bison			0.82 p<0.01	0.94 p<0.01	-0.14 p=0.29	-0.66 p=0.03	-0.14 p=0.29	-0.47 p=0.14
Horse					0.07 p=0.60	-0.60 p=0.05	0.08 p=0.55	0.87 p=0.19
MD							0.48 p<0.01	0.87 p<0.01

Total elk and deer diets were not closely correlated, due to a greater use of browse by deer, utilization of different forbs, and greater use of graminoids by elk. When use of the 11 major forage items were compared (Table 7), elk were positively, but nonsignificantly, correlated with both mule deer and white-tailed deer. Sullivan (1988) found significant, positive correlations between elk and mule deer diets in summer, fall, and spring and felt that competition may become acute for certain browse species. In this study, the most selected browse item by elk, winterfat, was not eaten by mule deer or white-tailed deer in spring or summer. Based on feeding site data, Mackie (1970) found mule deer diets to consist of 48% browse during the spring and summer seasons combined, while elk diets included only 10% browse.

The correlation between total bison and feral horse diets was very high ($r_s=0.82$ p<0.01). Bison and feral horses fed primarily on

graminoids. Forbs were somewhat more important in bison diets. Graminoid species, such as western wheatgrass, sedges, and bluegrass, were important in both diets. One shrub, winterfat, was also of dietary significance. When diet composition of the 11 major forage items was compared, bison and feral horse diets were almost identical ($r_s=0.94$ $p<0.01$).

Total diets of mule deer and white-tailed deer were significantly similar, although this correlation was not strong ($r_s=0.48$ $p<0.01$). Although both herbivores selected mostly for browse, the forb and browse species found in white-tailed deer diets were associated with the more mesic river bottom sites. Two browse species, chokecherry, used heavily by white-tailed deer, and silver buffaloberry (Shepherdia argentea), used mostly by mule deer, were important in both diets. Chokecherry, and to a lesser extent buffaloberry, were found to be important in white-tailed deer diets in eastern Montana (Allen 1971). Mackie (1970) found chokecherry second in importance to skunkbush sumac (Rhus trilobata) as primary browse in mule deer diets in the Missouri River Breaks, Montana. The correlation between mule deer and white-tailed deer diets was much higher ($r_s=0.87$ $p<0.01$) when the 11 major forage items were compared.

Activity Patterns

Season lengths and the number of observation-minutes of elk are noted in Table 8. Activity was similar for summer 1987 and summer 1988 ($r_s=0.82$ $p<0.01$) so these seasons were combined for analysis. Hours of each season were divided into morning, midday, and evening

time periods based on distinct breaks in feeding:bedding ratios (Table 9). Percentage elk activity recorded for each diurnal hour during summer 1987-1988, winter 1988, and spring 1988 is shown in Figs. 8-10.

Table 8. Season lengths and number of observation-minutes recorded for elk during each season.

Season	Starting date	Ending date	Observation-minutes
Summer 1987 ^a	June 15	Sept. 5	21,284
Winter 1988	Jan. 15	March 15	23,008
Spring 1988	March 16	June 14	32,073
Summer 1988 ^a	June 15	Sept. 5	29,249

^a These seasons were combined for analyses.

Elk exhibited crepuscular peaks in feeding in spring 1988 (hours 5 and 18) and summer 1987-1988 (hours 4-6 and 16-20). Bedding was the dominant activity during midday hours in spring and summer. Bedding reached daily highs during hours 9, 11, and 13 in spring and hours 11 and 13 in summer. Standing and other activities were minimal throughout the day during each season. Moving occurred most often in the morning and evening as animals moved to and from feeding and bedding areas. Spring and summer patterns were roughly similar, but elk exhibited a slightly stronger crepuscular pattern in spring than summer. Sullivan (1988) noted similar spring and summer activity patterns during phase 1 but found elk to be slightly more active during midday hours than was observed in this study.

During the winter 1988 season, elk also exhibited morning and evening peaks of activity but fed throughout the day. Diurnal feeding may have been an energy conservation strategy in that elk could reduce

heat loss by concentrating activity during the warmer diurnal hours and seeking thermal shelter during the colder nocturnal hours (Beall 1974). Bedding showed similar, but less dramatic, patterns to spring and summer. Bedding reached a midday high at hours 10 and 11, and daily lows at hours 7 and 18. Elk were more gregarious during the winter season than the spring and summer seasons; and because elk tend to conform to herd activity patterns (Craighead et al. 1973), showed less variation in hourly activities than during spring and summer.

Table 9. Feeding to bedding ratios of elk during diurnal hours in each season, and the time period designation for morning (AM), midday (MD), and evening (PM).

Hour	Feeding:bedding ratio					
	Winter 1988		Spring 1988		Summer 1987-1988	
4			3.07	AM	3.22	AM
5			10.70	AM	2.07	AM
6	3.00	AM	2.29	AM	1.89	AM
7	17.70	AM	0.68	MD	0.37	MD
8	1.38	AM	0.27	MD	0.30	MD
9	0.43	MD	0.06	MD	0.14	MD
10	0.43	MD	0.23	MD	0.26	MD
11	0.51	MD	0.07	MD	0.30	MD
12	0.63	MD	0.13	MD	1.03	MD
13	0.72	MD	0.04	MD	0.19	MD
14	1.28	MD	0.99	PM	0.78	MD
15	0.70	MD	1.40	PM	0.66	MD
16	1.66	PM	2.55	PM	2.75	PM
17	1.19	PM	3.56	PM	1.86	PM
18	72.00	PM	9.11	PM	3.87	PM
19			6.62	PM	3.74	PM
20					3.65	PM

When elk were in cover during spring and summer midday hours they were recorded as being inactive 76% and 70% of the time, respectively, based on radio-signal checks. New diurnal activity percentages were

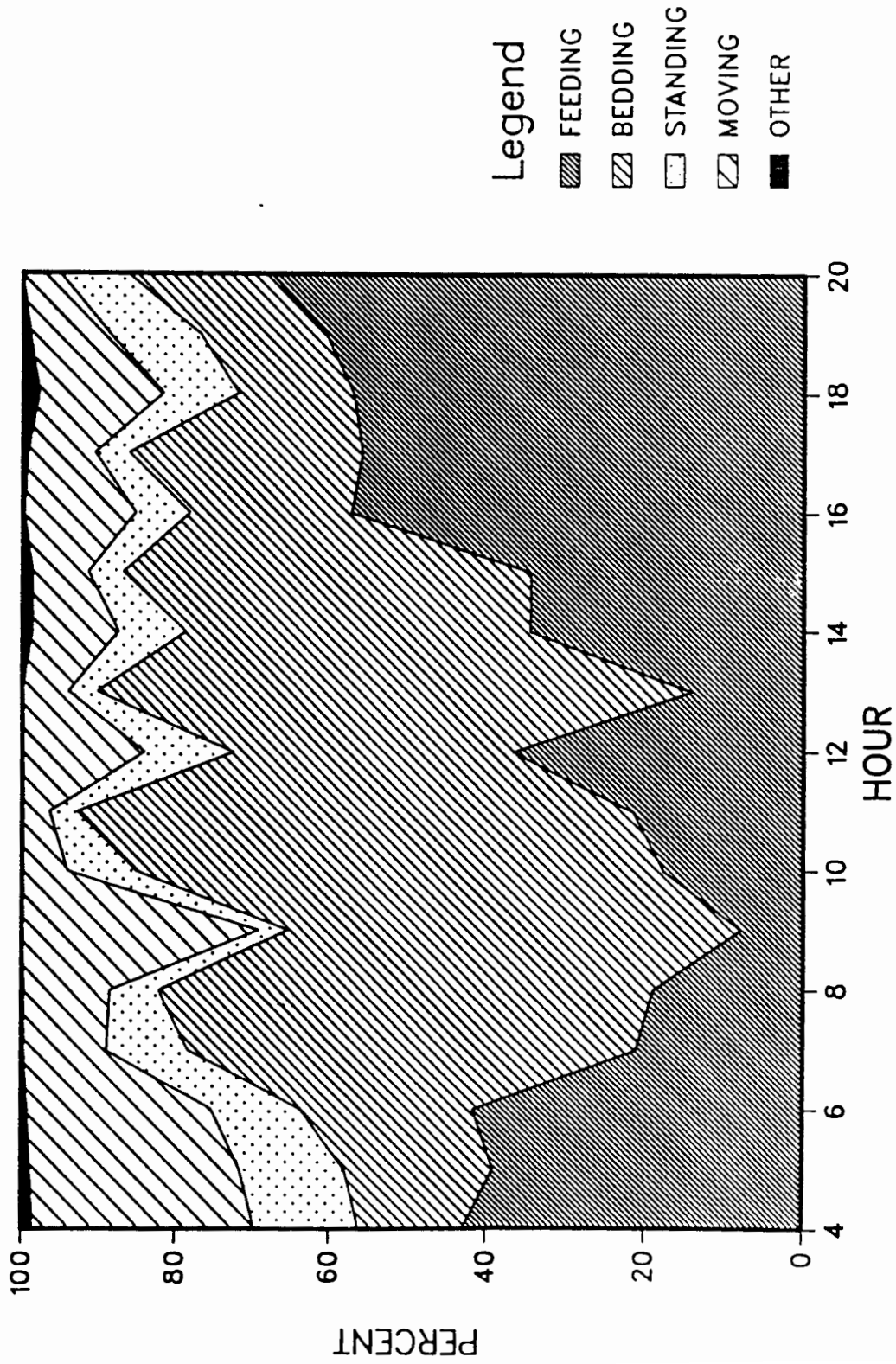


Figure 8. Percent observation-minutes spent feeding, bedding, standing, moving, and other by elk during summer 1987-1988.

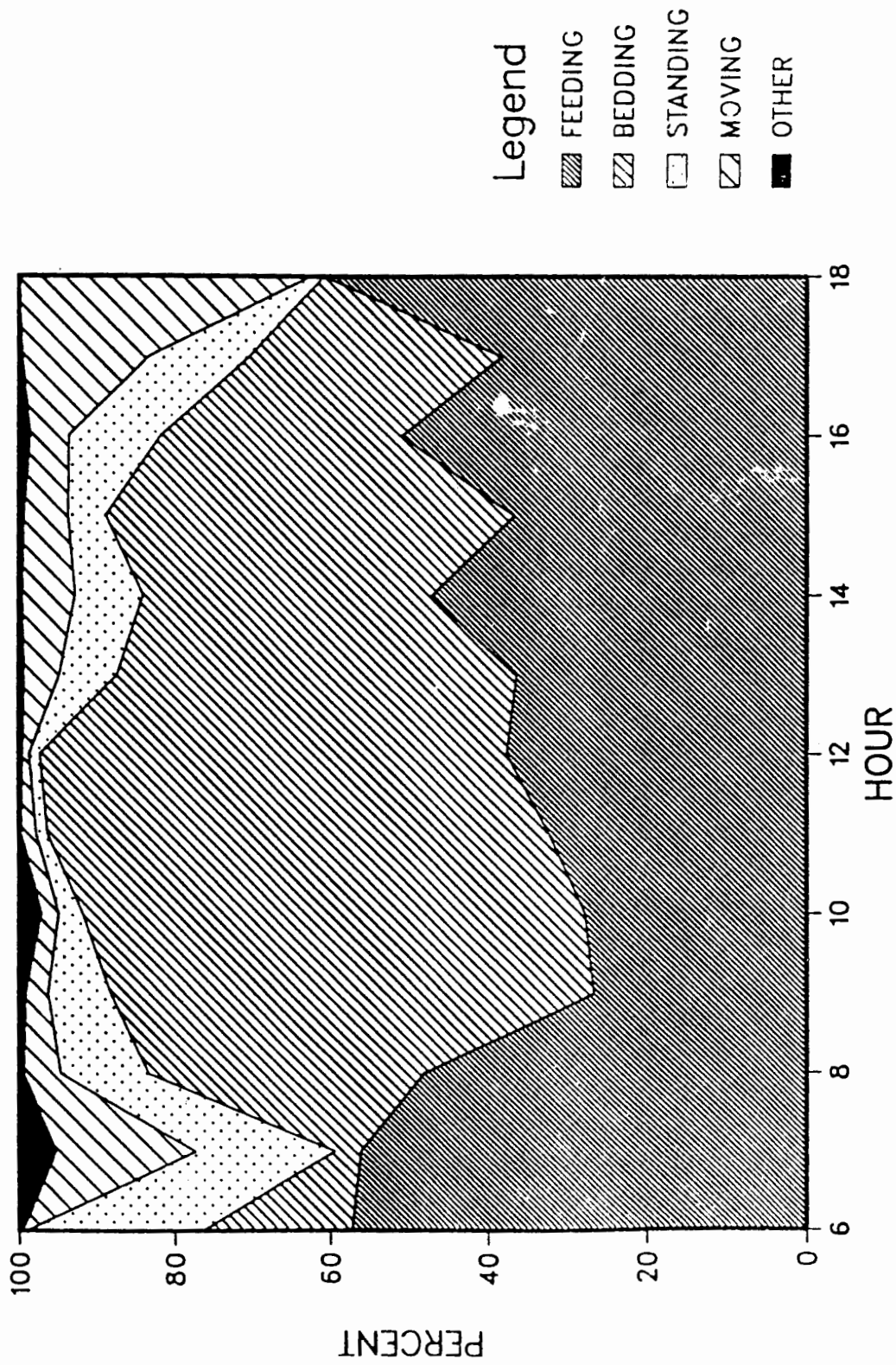


Figure 9. Percent observation-minutes spent feeding, bedding, standing, moving, and other by elk during winter 1988.

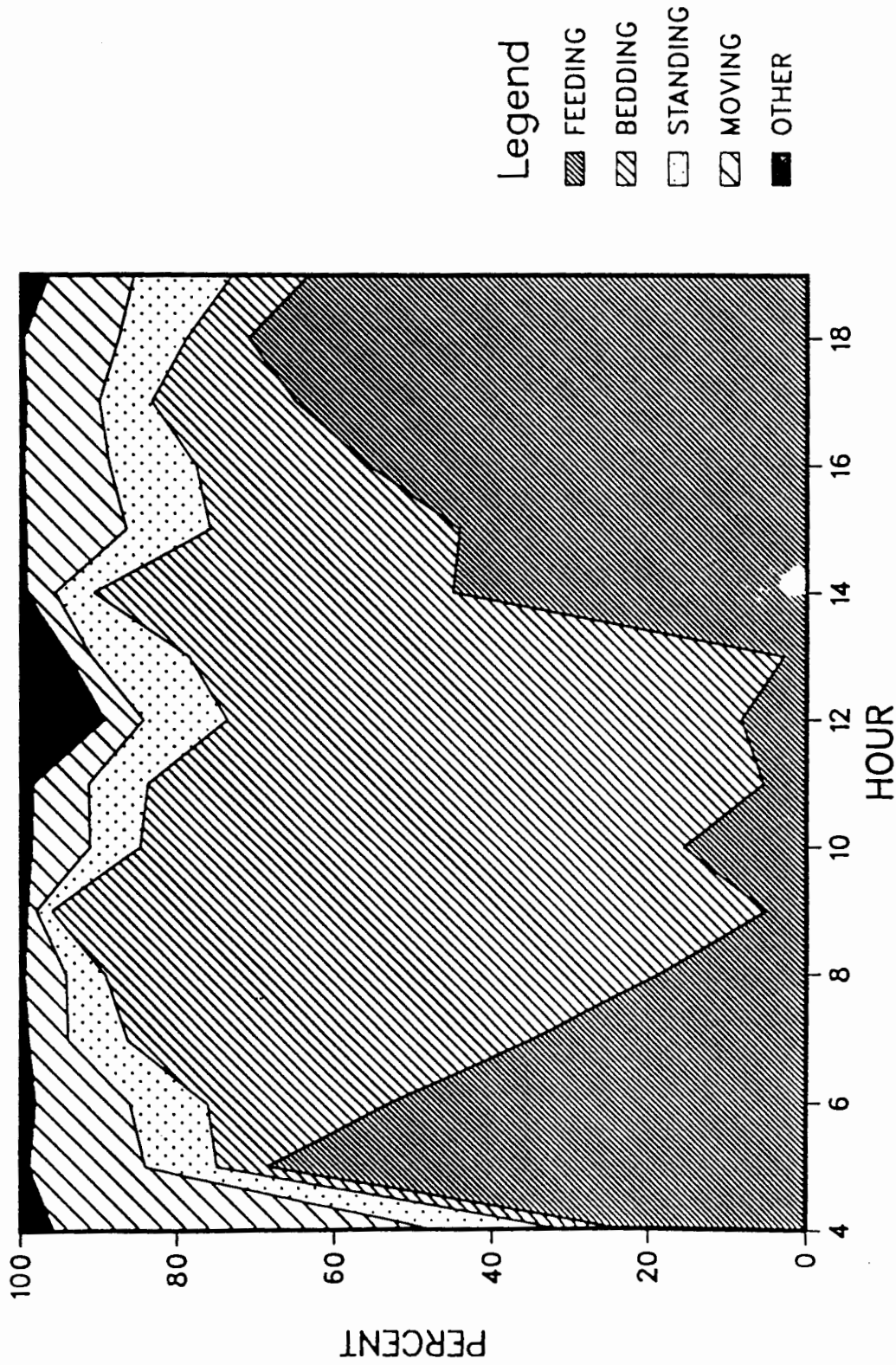


Figure 10. Percent observation-minutes spent feeding, bedding, standing, moving, and other by elk during spring 1988.

calculated using these figures (Table 10). Percent bedding was more realistically expressed, but the amount of feeding, standing, moving, and other activities that occurred in cover could not be accurately estimated.

Table 10. Percent elk activity for each season and adjusted activity for the spring 1988 and summer 1987-1988 seasons. Adjusted activities are in parentheses.

Season	Activity				
	Feeding	Bedding	Standing	Moving	Other
Winter 1988	40	46	7	5	1
Spring 1988	46 (38)	35 (47)	8 (7)	10 (8)	1 (1)
Summer 1987-1988	46 (37)	26 (40)	10 (8)	17 (14)	1 (1)
Total	44 (38)	34 (44)	9 (7)	12 (10)	1 (1)

Over the course of the study, elk were observed feeding and bedding 44% and 34%, respectively. When activity figures were adjusted, bedding became the dominant diurnal activity, at 44%, followed by feeding at 38%. Craighead et al. (1973), when monitoring the 24 hour activities of 7 female elk in Yellowstone National Park (recorded as feeding, bedding, and moving) also found bedding to be the dominant activity, at 46%, followed by feeding at 44%. Sullivan (1988) observed elk in TRNP feeding and bedding 49% and 41%, respectively, but noted that feeding, which occurred mostly in open grassland habitats, might be over estimated.

In summer 1987-1988, adjusted bedding (40%) was slightly higher than adjusted feeding (37%). Because the amount of feeding that occurred in wooded draws could not be observed, it is possible that true diurnal percentages of feeding and bedding were near equal. Craighead et al. (1973) noted that feeding and bedding by elk occurred in similar proportions in summer, at 40% and 41%, respectively. In TRNP, adjusted moving was highest in summer (14%) than in any other season because of extensive movement between feeding and bedding areas in the late morning and early evening. Craighead et al. (1973) also noted traveling (moving) to be highest during the summer season.

Bedding was the dominant diurnal activity (46%) in the winter 1988 season. Midday cover was not used, and elk bedded in open areas. Feeding in winter, at 40%, was higher than adjusted feeding in spring and summer. However, Craighead et al. (1973) noted that elk adopted a conservative strategy during winter, feeding less and bedding more during the nocturnal and diurnal hours than in other seasons. Standing, moving, and other activities were minimal for elk at TRNP during the winter diurnal hours.

During the spring 1988 season, adjusted bedding (47%) was the dominant activity. Craighead et al. (1973) found feeding to be dominant spring activity because of a response to newly available food sources. The changes in seasonal forage availability is less dramatic in the Northern Great Plains than in the Rocky Mountains because of substantially less snow accumulation. Elk at TRNP followed similar activity patterns in the early spring as in the winter, until high midday temperatures forced elk to seek cover.

Habitat Use

Sex/Age Classes

Adult males were most often observed in Breaks (50%) and Scoria Hills (35%) PTs (Table 11), mostly the Steep Scoria Complex (Table 12). Females selected for Breaks (39%) and Scoria Hills (18%) PTs, but used the less precipitous Rolling Scoria Complex. Calf use of PTs closely followed that of females. Males selected for more rugged habitat than females throughout the year, except during the rutting season when sexes were together. Adult males were most often sighted in the northern regions of TRNP where highly dissected terrain and large expanses of juniper cover (JUSC/ORMI HT) were most prevalent. Juniper draws provided shade during the hot midday hours of spring and summer which minimized evaporative cooling by elk. Males made greater use of wooded draws during all seasons than females.

Other researchers have also found male elk to utilize rougher terrain and higher elevations than females (Flook 1970, Franklin and Lieb 1979). Geist (1982) attributed differences in habitat selection between males and females to the need of males for protected areas with high quality forage to gather nutrients, recuperate from the rut, and avoid predators. Raesfeld and Vorreyer (1964) noted that red deer males selected heavily wooded areas following the rut, and Franklin and Lieb (1979) found Roosevelt elk (*C. e. roosevelti*) to exhibit this same pattern.

Yearling bull PT selection differed from females and adult males. Because cow-calf groups may be able to subsist on lesser quality

forage than yearling males (Geist 1982), young bulls should leave female home ranges to seek areas with more nutritional food. Yearling males are also harassed by their dams at calving and begin a period of increased wandering following the birth of new calves (Altman 1952, Lowe 1966, Franklin and Lieb 1979). During the late winter and spring seasons, yearling males were often seen with or in close proximity to the bull group, although a few remained with the cow-calf group throughout the year.

Table 11. Percent feeding (F), bedding (B), and total activities (TOT) by adult male, yearling male, female, and calf elk in Physiographic Types (PTs) of TRNP.

Physiographic Type	Adult males			Yearling males			Female			Calves		
	F	B	TOT	F	B	TOT	F	B	TOT	F	B	TOT
Bottom Grasslands	5	1	3	10	10	8	13	9	10	7	9	6
Breaks	30	43	50	13	29	36	25	41	39	24	37	43
Sagebrush Bottoms	tr ^a	tr	tr	1	tr	1	1	tr	1	2	tr	1
Upland Grasslands	20	10	10	42	31	25	41	27	29	38	30	21
Prairie Dog Towns			0			0	tr	0	tr	tr	tr	tr
Ridge & Ravine	4	tr	2	tr	tr	tr	2	6	3	0	0	0
Old River Terrace			0			0			0			0
Scoria Hills	40	45	35	34	30	31	18	17	18	29	24	28

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

Habitat Type (HT) selection was more similar than PT selection among sex/age classes (Table 12). Juniper draws (JUSC/ORMI HT), which occurred mostly in the Breaks PT, was heavily used by all sex/age classes but females. This HT was used most for midday cover. Females, which lived in large aggregations and were presumably less vulnerable to ambush by predators or displacement by other ungulates

(Geist 1982), may have felt more secure and, therefore, were willing to spend a greater proportion of diurnal hours in open habitats. The heavy use of AGSM/STVI HT, an open prairie HT which occurs in both the Upland and Bottom Grassland PTs, was important to all sex/age classes, but was especially preferred by females.

Table 12. Percent feeding (F), bedding (B), and total activities (TOT) by adult male, yearling male, female, and calf elk in Habitat Types (HTs), Mapping Units (MUs), and Complexes of TRNP.

HTs, MUs, and Complexes	Adult males			Yearling males			Females			Calves		
	F	B	TOT	F	B	TOT	F	B	TOT	F	B	TOT
AGSM/STVI	10	8	6	16	30	17	27	34	25	11	24	14
AGSM/STCO			0	1	0	tr ^a	1	tr	1			0
STCO/BOGR	6	5	4	3	1	2	5	4	4	3	6	3
SCSC	8	4	6	4	9	5	12	10	10	7	12	7
SCSC/JUHO	0	0	tr	1	4	1	tr	4	1	tr	2	1
ARTR/ATCO	3	1	2	5	7	5	8	13	9	4	2	4
ARTR/BOGR	tr	0	tr	tr	2	1	1	2	1	0	0	tr
ARCA	tr	tr	tr	1	tr	1	2	tr	1	2	tr	1
JUSC/ORMI	2	14	30	1	4	19	tr	3	11	tr	2	21
POTR/BOEC	0	0	tr	tr	0	tr	tr	0	tr	tr	0	tr
Hardwood Draws	2	2	3	3	4	6	3	7	7	10	15	16
Brush			0	tr	0	tr	1	tr	tr	tr	tr	tr
Rolling Scoria	18	18	11	25	18	19	13	11	11	24	18	15
Steep Scoria	19	24	17	8	11	8	4	5	4	3	4	3
Introduced Grass	12	1	4	33	8	14	21	4	11	32	15	13
Prairie Dog Towns			0			0	tr	0	tr	tr	tr	tr
Man-Managed	tr	0	tr	tr	0	tr	1	0	tr	1	tr	tr
Unvegetated Areas	19	24	15	tr	1	1	1	3	2	1	tr	1

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Feeding by adult bulls was observed primarily in the unvegetated areas, but this was sporadic and mostly during the late morning, midday, or early evening when bulls were moving to and from bedding

sites. Active feeding in the early morning and late evening, and presumably overnight, was in the AGSM/STVI HT, similar to the cow-calf group. The low frequency of observed feeding by bulls during daylight hours suggested that they relied heavily on nocturnal feeding. Feeding during nocturnal hours was possibly a energy conservation strategy to minimize activity during warm diurnal hours.

Overall and Seasonal Habitat Use

Even though differences in habitat selection existed among the sex/age classes, the data were collected for these classes in proportions similar to the occurrence of each class in the population. Therefore, observational data were pooled for further analyses. Habitat selection was similar between summer 1987 and summer 1988 ($r_s=0.81$ $p<0.01$) so observational data for these seasons were combined.

Elk were observed in the Breaks PT 40% of the time during the study (Table 13). Use of this PT was much greater than its proportionate occurrence in the Park, indicating a strong preference of elk for sloping, timbered habitat. Sullivan (1988), in phase 1 of the study, also found that elk selected for the Breaks PT 40% of the time during diurnal hours. The Upland Grasslands PT was second in overall importance, and also used much greater than which it occurred in TRNP. Upland grasslands received considerable use in every season, but were most important in the winter (Table 13). The Scoria Hills PT, which ranked third in total utilization in phase 2, was found by Sullivan (1988) to be only of minor importance during phase 1. This

change occurred because elk expanded their range to include central areas of the Park, where the Scoria Hills PT was more prevalent.

The AGSM/STVI HT received the highest proportion of elk use of any HT/MU/Complex in winter, spring, and over the entire study (Table 14). This HT makes up a substantial part of TRNP, and its proportionate use was similar to its proportionate availability in all seasons except winter 1988. In winter, elk increased use of this HT above proportionate availability. Juniper draws (JUSC/ORMI HT) ranked first in summer use and second in spring use. This Habitat Type was most important during the midday hours of both seasons (Appendix B, Table 53).

Table 13. Percent utilization of Physiographic Types (PTs) by elk during summer 1987-1988, winter 1988, spring 1988, the growing season (summer 1987-1988 and spring 1988) and over the entire study, and the percent of Physiographic Types available.

Physiographic Type	Winter 1988	Spring 1988	Summer 1987-88	Growing season	Total use	Percent available
Bottom Grasslands	14	6	8	7	9	15.64
Breaks	19	56	40	46	40	25.16
Sagebrush Bottoms	0	1	1	1	1	11.09
Upland Grasslands	38	23	24	24	27	0.69
Prairie Dog Town	0	0	tr ^a	tr	tr	7.45
Ridge & Ravine	8	1	0	1	2	34.91
Old River Terrace	0	0	0	0	0	4.04
Scoria Hills	21	13	26	21	21	1.02

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

Feeding Areas

The Upland Grasslands PT was the PT most used by elk for feeding during the growing season (Table 15) and during the spring 1988 and

Table 14. Percent utilization of Habitat Types (HTs), Mapping Units (MUs), and Complexes by elk during summer 1987-1988, winter 1988, spring 1988, the growing season (summer 1987-1988 and spring 1988) and over the entire study, and the percent of HTs, MUs, and Complexes available.

HTs, MUs and Complexes	Winter 1988	Spring 1988	Summer 1987-88	Growing Season	Total Use	Percent Available
AGSM/STVI	44	18	15	16	22	16.98
AGSM/STCO	1	1	0	tr ^a	tr	1.69
STCO/BOGR	8	4	2	3	4	1.67
SCSC	9	13	6	9	9	4.79
SCSC/JUHO	0	2	1	2	1	1.87
ARTR/ATCO	11	11	5	7	8	2.44
ARTR/BOGR	tr	3	tr	1	1	0.89
ARCA	tr	1	1	1	1	3.67
JUSC/ORMI	tr	17	18	18	14	2.26
POTR/BEOC	0	tr	tr	tr	tr	0.01
Hardwood Draws	1	5	13	10	8	1.82
Brush	0	1	tr	tr	tr	0.07
Rolling Scoria	12	7	15	12	12	10.29
Steep Scoria	8	4	4	4	5	19.22
Introduced Grass	0	11	16	14	11	1.48
Prairie Dog Towns	0	0	tr	tr	tr	0.69
Man-Managed	0	1	tr	tr	tr	0.23
Unvegetated Areas	6	1	1	1	2	29.93

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

summer 1987-1988 seasons individually (Appendix B, Tables 43 and 44).

Although production of graminoids was slightly lower for this PT than

the most productive Bottom Grasslands PT (Marlow et al. 1984), the

production of forbs was higher. Forbs were the dominant forage class

in late spring 1988 and late summer 1988 elk diets (Table 6)

indicating that elk at TRNP sought areas of greater forb concentration

for feeding areas during most of the growing season. Other

researchers have found that forbs contribute significantly to summer

elk diets (Rouse 1958, Mackie 1970, Knowles 1975, Singer 1975).

Vegetative production for HTs/MUs/Complexes in the Upland Grasslands PT is listed in Appendix E, Table 63, and the proportion of HT/MU/Complex occurrence in the Upland Grasslands PT is shown in Appendix E, Table 62.

Upland grasslands were often the first to produce new growth in spring. Smooth brome (*Bromus inermis*), and sedges, which were early growing species that contributed greatly to late spring elk diets (Table 6), were found in the highest densities in the upland grasslands. Upland grasslands were used for feeding in both the morning and evening time periods in spring, but mostly in the evening time period in summer (Appendix B, Table 45).

Table 15. Percent activity of elk within Physiographic Types (PTs) during the entire study and during the growing season (spring 1988, and summer 1987-1988). Growing season values are in parentheses.

Physiographic Type	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
Bottom Grasslands	12 (10)	9 (8)	8 (8)	13 (10)	6 (6)	1 (1)
Breaks	25 (26)	40 (54)	39 (41)	35 (38)	31 (33)	73 (74)
Sagebrush Bottoms	1 (2)	tr ^a (tr)	3 (4)	2 (2)	1 (2)	tr (tr)
Upland Grasslands	40 (40)	27 (18)	22 (20)	22 (22)	32 (35)	6 (6)
Prairie Dog Towns	tr (tr)	tr (tr)	tr (tr)	0 (0)	0 (0)	0 (0)
Ridge & Ravine	2 (1)	4 (tr)	2 (1)	1 (1)	1 (tr)	tr (tr)
Old River Terrace	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Scoria Hills	21 (21)	19 (20)	26 (26)	27 (27)	29 (25)	19 (18)

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

During the winter 1988 season the Upland Grasslands PT was most used for feeding (Appendix B, Table 42), especially during the morning and midday time periods (Appendix B, Table 45). Upland grasslands were swept free of snow by wind action. Although TRNP did not receive

enough snow during winter 1988 to hinder elk movement, it was more energy efficient for elk to graze in areas with minimal or no snow cover (Geist 1982). Breaks and Scoria Hills PTs were next in importance as winter feeding areas. These PTs were highly dissected, had southern slopes which were free of snow, and provided some topographic relief from high winds. Mackie (1970) noted that elk in the Missouri River Breaks used steep, snow-free slopes during winter. Elk at TRNP used the Breaks PT in higher proportions during the evening time period (Appendix B, Table 45) to possibly take advantage of a warmer microclimate (Moen 1968).

During the growing season, the most important HT/MU/Complex for feeding was the Introduced Grass HT (Table 16), which occurred entirely in the Upland Grasslands PT. An abundance of early-growing introduced grasses in the spring and forbs in the summer evidently made this a favored feeding site. The AGSM/STVI HT was an also important feeding area in spring and summer. Although the AGSM/STVI HT did not have the highest overall vegetative production for HTs/MUs/Complexes (Appendix E, Table 63), it did have the highest concentration of western wheatgrass and green needlegrass combined, the most preferred graminoid species by elk during the growing season (Appendix D, Table 57).

During winter 1988, the AGSM/STVI HT was the major HT/MU/Complex selected for feeding (Appendix B, Table 48). This HT occurred mostly in the Upland and Bottom Grasslands PTs. The Rolling Scoria Complex and ARTR/ARCO HT, which occurred mostly in the Scoria Hills and Breaks PTs, respectively, were selected next as feeding areas in winter 1988.

Table 16. Percent activity of elk within Habitat Types (HTs), Mapping Units (MUs), and Complexes during the entire study and during the growing season (spring 1988, and summer 1987-1988). Growing season values are in parentheses.

HTs, MUs and Complexes	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
AGSM/STVI	25 (19)	32 (23)	22 (18)	23 (19)	16 (13)	3 (3)
AGSM/STCO	1 (1)	tr ^a (tr)	1 (1)	1 (tr)	tr (tr)	tr (tr)
STCO/BOGR	5 (4)	4 (2)	3 (2)	5 (5)	2 (2)	2 (1)
SCSC	11 (11)	10 (11)	12 (11)	11 (11)	8 (9)	2 (2)
SCSC/JUHO	tr (tr)	3 (5)	1 (1)	1 (1)	tr (tr)	tr (tr)
ARTR/ATCO	8 (6)	11 (12)	14 (13)	11 (11)	11 (9)	2 (2)
ARTR/BOGR	1 (1)	1 (2)	1 (1)	2 (2)	1 (1)	tr (tr)
ARCA	2 (2)	tr (tr)	3 (3)	2 (2)	1 (1)	tr (tr)
JUSC/ORMI	tr (tr)	4 (6)	3 (4)	5 (5)	5 (6)	64 (64)
POTR/BOEC	tr (tr)	0 (0)	0 (0)	tr (tr)	0 (0)	tr (tr)
Hardwood Draws	4 (5)	8 (11)	5 (6)	4 (5)	5 (6)	19 (20)
Brush	tr (1)	tr (tr)	tr (tr)	tr (tr)	tr (tr)	tr (tr)
Rolling Scoria	15 (15)	12 (14)	16 (17)	16 (16)	17 (16)	3 (2)
Steep Scoria	5 (4)	6 (4)	7 (6)	7 (8)	9 (6)	2 (2)
Introduced Grass	22 (29)	6 (9)	8 (10)	8 (9)	21 (27)	2 (2)
Prairie Dog Towns	tr (tr)	tr (tr)	tr (tr)	0 (0)	0 (0)	0 (0)
Man-Managed	1 (1)	tr (tr)	1 (1)	1 (1)	tr (tr)	0 (0)
Unvegetated Areas	2 (1)	3 (1)	5 (4)	4 (4)	3 (3)	1 (tr)

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Bedding Areas

The percentage of diurnal bedding areas selected during the spring and summer seasons were adjusted using midday radio-signal checks during each season (Table 17 and 18). In spring and summer the Breaks PT was used most for bedding and adjusted bedding activities (Table 17), especially during the midday time periods (Appendix B, Table 46). Elk sought overhead cover in juniper draws (JUSC/ORMI HT), which occurred mostly in the Breaks PT, for adjusted bedding activities in spring and summer (Table 18). Juniper draws allowed elk to maintain

their body temperature within the thermal neutral zone (Moen 1973), and functioned as shelter from high winds and biting insects, and as hiding/escape cover. Mackie (1970) observed elk in the Missouri River Breaks of Montana, an environment similar to TRNP, bedding in Pinus-Juniperus and Pseudotsuga-Juniperus Habitat Types during hot midday hours.

Table 17. Percent bedding, unknown, and adjusted bedding activities during midday hours by elk in Physiographic Types (PTs) for spring 1988 and summer 1987-1988.

Physiographic Type	Spring			Summer		
	Bedding	Unknown	Adjusted bedding	Bedding	Unknown	Adjusted bedding
Bottom Grasslands	6	1	1	10	1	5
Breaks	66	79	84	43	71	57
Sagebrush Bottoms	0	tr ^a	0	tr	tr	tr
Upland Grasslands	10	9	3	25	5	15
Prairie Dog Towns	0	0	0	tr	0	tr
Ridge & Ravine	tr	1	tr	0	0	0
Old River Terrace	0	0	0	0	0	0
Scoria Hills	18	9	11	22	23	22

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

During the winter 1988 season, elk rarely entered juniper or hardwood draws and bedded in open areas when feeding bouts ended. Upland Grasslands PTs were selected most by elk for bedding during the entire winter season (Appendix B, Table 42), and during each time period (Appendix B, Table 46). Topographic relief was apparently used to dampen the effects of wind-chill or to maximize thermal insulation. Decreased use of cover in the winter season is a common phenomenon in most elk populations (Skovlin 1982). Sullivan (1988) also identified

this pattern during phase 1, but observed elk bedding mostly in the Bottom Grasslands PT rather than the Upland Grasslands PT.

Table 18. Percent bedding, unknown, and adjusted bedding activities during midday hours by elk in Habitat Types (HTs), Mapping Units (MUs), and Complexes for spring 1988 and summer 1987-1988.

HTs, MUs, and Complexes	Spring			Summer		
	Bedding	Unknown	Adjusted bedding	Bedding	Unknown	Adjusted bedding
AGSM/STVI	23	2	14	23	4	14
AGSM/STCO	tr ^a	tr	tr	0	0	0
STCO/BOGR	1	4	tr	2	tr	1
SCSC	8	3	6	14	1	7
SCSC/JUHO	6	tr	3	4	tr	2
ARTR/ATCO	22	4	20	2	tr	1
ARTR/BOGR	5	1	4	0	tr	tr
ARCA	0	tr	0	tr	tr	tr
JUSC/ORMI	7	63	35	5	65	34
POTR/BOEC	0	0	0	0	tr	tr
Hardwood Draws	5	11	8	16	24	20
Brush	tr	1	tr	tr	0	tr
Rolling Scoria	11	3	8	16	2	10
Steep Scoria	5	2	0	4	2	3
Introduced Grass	4	3	tr	13	2	7
Prairie Dog Towns	0	0	0	tr	0	tr
Man-Managed	0	0	0	tr	0	tr
Unvegetated Areas	2	1	2	tr	tr	tr

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and complexes and definition of acronyms in Appendix A, Table 41.

Calving and Rutting Areas

Radio locations during summer 1987 placed calving females in the Breaks and Scoria Hills PTs near Peck Hill (Fig. 1). A similar PT utilization pattern was noted in summer 1988, but scoria hills, mostly the Steep Scoria HT, were used to a greater extent. Nearly all the cow-calf herd (including 5 of 6 radio-collared females) relocated to

the large expanses of steep scoria within the Loop Road (Fig. 1) to calve in 1988. This area had complex topographic relief and offered ground cover concealment (Skovlin 1982). Additionally, it was most removed from the areas frequented by Park visitors.

Pre-rutting activities were observed most frequently in the Upland and Bottom Grassland PTs. Adult bulls adjusted their habitat utilization pattern to conform with adult females in late August and early September. Although elk were not observed during the peak of rutting activities in phase 2, Sullivan (1988) identified similar PT utilization patterns during the fall rut in phase 1.

Ungulate Interactions

Comparisons of PT selection during the entire study and during the growing season were made for the 5 ungulates in TRNP (Tables 19-21). Of these species, the behavioral interactions for 4 (elk, bison, feral horses, and mule deer) were quantified. White-tailed deer were limited in distribution, and interactions with other ungulates were seldom observed. The other 4 ungulates species observed shared similar habitats throughout the study, but incidents of agonistic threats or displays were infrequently observed.

Elk - Bison Interactions

The correlation of PT selection between elk and bison was very low and not significant ($r_s=0.01$ $p=0.98$). Elk selected mostly for breaks and bison for prairie dog towns (Table 19). However, the chief feeding area preferred by elk during the growing season, the Upland

Grasslands PT (Table 20), was of some importance to bison. Some similarities between elk and bison diets were observed (Table 7), principally the common use of some graminoids and winterfat (Appendix D, Tables 57 and 58). The potential for forage competition or "exploitative competition" (Nelson 1982) is low, but if exploitative competition ever occurs between these two species, it is likely to occur in the Upland Grasslands PT.

Elk showed a greater aversion to bison than to any other species and were displaced most frequently by them (Table 23). Elk were displaced by bison 371 m when displacement occurred. Bison were never displaced by elk and were the only species to exhibit active aggression towards elk (Table 22). McHugh (1958) noted that bison were dominant over elk and that bison calves could displace a 6-point bull elk. Other authors have suggested that bison occasionally harass and kill elk calves (Rush 1942, Mahan 1977).

Elk were most often displaced by bison at the upper and lower distance categories (Appendix C, Table 55). Although the number of bison or number of elk were not tallied, observational notes indicate that elk were displaced by large herds of bison when these groups were >50 m apart, but elk would allow a single bull bison to graze within 20 m before displacing. Twenty and 50 m, therefore, appeared to be the threshold distances that elk would allow a single bison or a herd of bison to approach, respectively, without displacing. In Yellowstone National Park, bison and elk have been observed foraging within 10 m of each other, despite their seeming intolerance (Reynolds et al. 1982).

Table 19. Total percent utilization of Physiographic Types (PTs) by ungulates. Utilization is based on observation-minutes for elk and on sightings for bison, feral horses, mule deer (MD), white-tailed deer (WTD). Sample sizes are in parentheses.

Physiographic Type	Ungulate species				
	Elk (105,614)	Bison (4,715)	Horse (809)	MD (2,116)	WTD (196)
Bottom Grasslands	9	13	31	7	7
Breaks	40	3	5	25	3
Sagebrush Bottoms	1	12	2	4	42
Upland Grasslands	27	17	44	15	3
Prairie Dog Towns	tr	25	0	4	28
Ridge & Ravine	2	14	2	15	14
Old River Terrace	0	3	0	4	4
Scoria Hills	21	14	17	27	0

^a Descriptions of PTs in Appendix A, Table 40.

Table 20. Percent utilization of Physiographic Types (PTs) by ungulates and percent feeding by elk during the growing season. Utilization is based on observation-minutes for elk and on sightings for bison, horse, mule deer (MD), white-tailed deer (WTD). Sample sizes are in parentheses.

Physiographic Type	Ungulate species					
	Elk (82,606)	% Elk Feeding (28,812)	Bison (3,932)	Horse (583)	MD (1,801)	WTD (194)
Bottom Grasslands	7	10	15	30	8	7
Breaks	46	26	2	7	25	3
Sagebrush Bottoms	1	2	14	3	4	42
Upland Grasslands	24	40	11	42	14	3
Prairie Dog Towns	tr	tr	29	0	4	28
Ridge & Ravine	1	1	10	0	15	14
Old River Terrace	0	0	2	0	4	4
Scoria Hills	21	21	16	19	26	0

^a Descriptions of PTs in Appendix A, Table 40.

Table 21. Spearman's rank correlations (r_s) of Physiographic Types (PTs) used during the entire study (TOT) and during the growing season (GRO) by elk, bison, feral horses, mule deer (MD), and white-tailed deer (WTD).

	Bison		Horse		MD		WTD	
	TOT	GRO	TOT	GRO	TOT	GRO	TOT	GRO
Elk	0.01 p=0.98	-0.02 p=0.96	0.82 p=0.01	0.88 p<0.01	0.85 p<0.01	0.66 p=0.08	-0.66 p=0.08	-0.61 p=0.11
Bison			0.16 p=0.71	0.16 p=0.71	0.06 p=0.90	-0.11 p=0.79	0.09 p=0.83	0.21 p=0.62
Horse					0.63 p=0.10	0.43 p=0.29	-0.56 p=0.15	-0.55 p=0.29
MD							-0.78 p=0.02	-0.74 p=0.04

Elk - Feral Horse Interactions

Elk were most correlated with feral horses in growing season PT use ($r_s=0.88$ $p<0.01$). Total PT utilization by these two species was also similar ($r_s=0.82$ $p=0.01$). Horses preferred the Upland Grassland PT, which was also the primary feeding area of elk during the growing season (Table 20). Also, elk were most correlated with feral horses for total diets (Table 7). Therefore, exploitative competition between these two species is a real possibility and may have a direct affect on their future well being.

Besides forage, these ungulate species evidently competed directly for the limited supply of developed water during summer 1988, a drought year. Small bands of horses were frequently seen around wildlife dish tanks in summer 1988. Recently, feral horses have been observed by researchers at TRNP to drive elk from these tanks (L.

Gagnon, pers. comm. 1989). Searches for fecal material around several dish tanks during summer 1988 revealed abundant horse droppings but no fresh elk pellets.

Although elk were observed to displace feral horses (Table 22), it was more common for elk to be displaced by horses (Table 23). Elk were also displaced by horses for greater distances (562 m) than by any other ungulate. This was attributed to the strongly gregarious nature of horses, which were presumably more disturbing to elk than a single bison. Elk were disturbed more frequently by horses at short distances than by any other ungulate (Appendix C, Table 55) but not at longer distances, indicating that elk would allow bands of horses to approach closer than large bison herds before being displaced. Elk may have been tolerant of individual horses, as they were of individual bison, but horses seldom moved as individuals. Apparently, elk had a threshold distance of 20 m for bands of horses, at which the percentage of no reaction decreased and displacement dramatically increased.

Elk - Mule Deer Interactions

Elk and mule deer had the highest correlation in total PT selection among elk and other ungulates ($r_s=0.85$ $p<0.01$), but growing season PT selection was less similar and not significant ($r_s=0.66$ $p=0.08$). Elk and mule deer had diets which had high amounts of browse, but similarities in forage species composition were minimal (Table 7). Because graminoids made up only a small part of mule deer diets, and because elk preferred graminoids when available (Murie

Table 22. Percent reaction of other ungulate species to elk with mean displacement distance.

Reaction	Ungulate species		
	Mule deer (n=101)	Bison (n=29)	Feral horse (n=16)
No reaction	45	97	88
Awareness	15	0	0
Alarm	2	0	0
Aggression	0	3	0
Displacement	39	0	13
Mean displacement distance (m)	63	0	28

Table 23. Percent reaction of elk to other ungulate species with mean displacement distance.

Reaction	Ungulate species		
	Mule deer (n=101)	Bison (n=29)	Feral horse (n=16)
No Reaction	75	48	56
Awareness	15	17	19
Alarm	0	0	0
Aggression	9	0	0
Displacement	1	34	25
Mean displacement distance (m)	10	371	562

1951), exploitative competition between elk and mule deer was minimal, despite similarities in PT use. Extreme competition between these two species should not occur in the future unless graminoids become overutilized by elk and other grazing herbivores, or elk and mule deer become overpopulated.

Because of habitat similarities, elk and mule deer were often seen in close proximity. Although researchers have noticed social compatibility between elk and mule deer (White 1958, Kirsch 1963), agonistic encounters between elk and mule deer occurred more frequently in TRNP than between any other ungulate pair. Mule deer were most often displaced ≤ 20 m, and aggression on the part of elk was noticed most at distances ≤ 20 m (Appendix C, Tables 54 and 55). Therefore, a threshold distance of 20 m existed between elk and mule deer. Because mule deer and elk did not respond to one another at distances ≥ 20 m, they were more socially compatible than elk with bison or horses.

Dominance Hierarchy

Our data corroborates Sullivan's (1988) dominance hierarchy of bison > feral horses > elk > mule deer in the SU of TRNP. The frequency that elk were displaced by these species, and the frequency other ungulates were displaced by elk supports this linear arrangement. McHugh (1958) observed that bison were dominant to elk and elk to mule deer.

Apparently, the dominance of one species over another in TRNP was based on size. However, other factors such as: number of

individuals, gregariousness of the species, and age and sex may have affected ungulate interactions. For instance, the only time elk were displaced by mule deer occurred when a yearling bull elk and an adult buck mule deer approached each other to within 10 m. Both quickly retreated (were displaced) 10 m. Individual bison could approach elk very closely without stimulating a reaction by elk, but large herds could not. Mule deer were often seen foraging ≥ 20 m from elk, but encounters of elk with horses or bison at distances < 100 m were rare.

Human Impacts

Three types of human interactions with elk were noted (Table 24). Elk were aware of human presence at distances $> 1,000$ m, but were displaced only at distances $< 1,000$ m (Appendix C, Table 56). Ward and Cupal (1979) found that the range at which elk responded to human disturbances was about 400 m. Flight distance "the distance to which a person can approach a wild animal without causing it to flee" (Altman 1958) is influenced by a number of factors such as: 1) seasonal change in reproduction and nutritional status; 2) type of habitat; and 3) previous experience of the individual or the group to human caused disturbances. Topographic relief may also influence flight distance by providing "line-of-sight" barriers which visually screen elk from human disturbances (Lyon 1979, Lyon et al. 1985).

When elk in TRNP were displaced they traveled 171-502 m, depending on the type of disturbance. Movements involved displacement to cover (most often) and movement away from the disturbance without visual concealment. Coop (1971) found that elk in the Little Belt Mountains,

Montana fled an average of 114 m to dense adjacent forest cover when disturbed by humans. Ward et al. (1973) indicated that elk maintain a "buffer zone" of 800 m between themselves and recreationists, and if this space is violated, will exhibit evasive movement to reestablish it.

Disturbances by humans on foot elicited the greatest response on the part of elk. Displacement occurred in 88% of observed incidences. Mean displacement from humans on foot was 471 m. Elk always ran when approached to within 100 m by humans on foot during 1987-1988 (Appendix C, Table 56). By 1989, some elk (animals near the interstate highway and in areas frequented by researchers during a horse study at TRNP) would tolerate humans on foot to a approach <100 m.

Stopped motor vehicles alarmed elk at distances of 301-1,000 m but displaced them only at 101-300 m. The elk in TRNP became habituated to traffic on the interstate highway along the southern boundary of the Park. Sightings of elk within 200 m of this highway were common. If vehicles stopped along the interstate or along the Park Loop Road, elk were alarmed and would usually run. Ward (1973) found that elk were easily conditioned to normal activities within their home range, but became alarmed at unusual disturbances. The mean displacement distance from motor vehicles in TRNP, 502 m, was comparable to displacement from humans on foot.

Humans on horseback, based on a small sample size, appeared to be less disturbing to elk than other human activities, when riders did not harass elk. Some riders were observed during phase 1 chasing elk (M. Sullivan, pers. comm. 1989). Observed frequency of displacement

of elk from horseback riders was less than that associated with foot-travel and similar to vehicular disturbance. As with other human disturbances, elk were invariably displaced when riders approached ≤ 100 m.

Table 24. Percent reaction of elk to human caused disturbances with mean displacement distance.

Reaction	Type of disturbance		
	On foot (n=48)	Vehicle (n=23)	Horseback (n=6)
No reaction	2	13	33
Awareness	8	35	17
Alarm	2	4	0
Displacement	88	48	50
Mean displacement distance (m)	471	502	171

Optimum Carrying Capacity

The optimum carrying capacity for elk, bison, feral horses, and mule deer was determined for a 6-region area (the Target Area) of TRNP. Population levels for bison (200) and feral horses (50) were set in the model based on recommendations by the Park (TRNP 1984). Mule deer numbers (312) were derived from population density figures of the 1988 aerial survey of the SU of TRNP conducted by North Dakota Department of Game and Fish. The relative distribution of each ungulate in the Target Area is shown in Table 25. Population

estimates, sex ratios, weights of the "typical animal", daily forage intake (percent of body weight) and growing-season forage intake (kg/6 months), for each ungulate species used in the Ungulate Resources Allocation Model is shown in Table 26.

Table 25. Percent utilization of regions in TRNP by elk, bison, feral horses, and mule deer (MD) during the growing season (spring 1988 and summer 1987-1988). Utilization is based on observation-minutes for elk and on sightings for the other ungulates.

Ungulate species	Region					
	1	2	3	4	5	6
Elk	20	71	3	3	2	tr ^a
Bison	11	11	15	7	4	52
Feral horse	36	39	22	1	2	0
MD	15	25	11	17	8	24

^a tr = <0.5%.

Table 26. Population estimates, weights of the typical animal, daily intake, and forage intake over the growing season for elk, bison, feral horses, and mule deer (MD).

Ungulate species	Number adult males	Number adult females	Number of juveniles	Weight typical animal (kg)	Average intake rate (% B.W./day)	Forage intake (kg)
Elk	41	70	37	228	2.4	983
Bison	--	--	--	454	1.8	1470
Horses	29	31	12	442	2.5	1988
MD	100	189	177	46	3.7	309

Nine graminoids and 8 browse species contributed $\geq 3\%$ to the growing season diets of elk, bison, feral horses, and mule deer (Appendix D, Tables 57-60). However, vegetative production figures were inadequate for wild-rye (Elymus spp.), currant/gooseberry (Ribes

spp.), silver buffaloberry, and poison ivy (Toxicodendron radicans). Two graminoid species, smooth brome and bluegrass - mostly Kentucky bluegrass (Poa pratensis), were introduced species and considered expendable. Vegetative production figures were unavailable for all forb species. No production figures were available for the JUSC/ORMI HT, POTR/BEOC HT, and Man-Managed MU. Production for only selected shrubs were available for the Hardwood Draws HT.

Typical animal intake of the 11 major forage items used in the model by elk, bison, feral horses, and mule deer is shown in Table 27. The optimum population of elk was determined by allocating 35% of the production for these forage species to each of the other ungulates in the model over the 6-month growing season and then allocating the residual to elk.

Winterfat was the forage species that most limited elk numbers in every region and in the Target Area overall (Table 28), based on present distribution within regions and food habits. The next most constraining forage species were: 2) chokecherry; 3) skunkbush sumac; and 4) green needlegrass. These species are decreasers under moderate to heavy grazing pressure (Lacey 1984) and could be adversely affected in the Park if overutilized.

Sullivan (1988) calculated a carrying capacity for elk in TRNP during phase 1 without consideration of other ungulate species. He listed 8 browse species: winterfat, chokecherry, snowberry, buffaloberry, yucca (Yucca glauca), golden currant (Ribes setosum), water birch (Betula occidentalis), and green ash (Fraxinus pennsylvanica); and 3 graminoids: big bluestem (Andropogon

gerardii), little bluestem (Schizachirium scoparium), and bluegrass, that would likely be overutilized at high elk populations.

Table 27. Typical animal intake (kg) during the growing season (spring and summer) by elk, bison, feral horses, and mule deer (MD) of the 11 major forage items used in the Ungulate Resources Allocation Model.

Forage item	Ungulate species			
	Elk	Bison	Horses	MD
<u>Agropyron smithii</u>	54.0	282.5	385.4	3.0
<u>Bouteloua gracilis</u>	9.9	60.0	32.0	0
<u>Carex</u> spp.	33.1	133.4	444.2	1.1
<u>Koeleria pyramidata</u>	5.7	125.1	237.9	0
<u>Stipa comata</u>	0	121.1	317.8	0.6
<u>Stipa viridula</u>	57.1	43.6	49.3	1.7
<u>Artemisia tridentata</u>	0	1.6	0	13.6
<u>Ceratoides lanata</u>	113.1	59.4	111.5	0
<u>Prunus virginiana</u>	45.1	0	0	23.3
<u>Rhus trilobata</u>	33.2	0	0	19.5
<u>Symphoricarpos occidentalis</u>	59.7	0	0	27.6

Although the carrying capacity for the target area was calculated 7 times (once from percent utilization of each region and once from utilization of the Target Area overall, these estimates differed due to ungulate distribution. High population estimates of elk in some regions was due to the low use of these regions in 1987-1988. Considering the increased western distribution of elk over the 4-year study, eastern sections should receive relatively less utilization in the future. Therefore, the final carrying capacity for elk, 243, was based on the estimate of the Target Area as a whole (Table 28). This figure should be considered the optimum population of elk at TRNP, if the number of the other ungulates are kept at the recommended levels. At these population levels, the possibility exists that some HTs may

be locally overutilized, but no vegetational communities are likely to be degraded throughout the Park.

Table 28. Optimum carrying capacity of elk in a 6-region area of TRNP based on utilization patterns for each region, population levels for bison (200), feral horses (50), and mule deer (312), and limiting forage species.

Region	Limiting forage species	Optimum carrying capacity
1	1. Winterfat	67
	2. Skunkbush sumac	89
	3. Chokecherry	230
2	1. Winterfat	46
	2. Chokecherry	108
	3. Skunkbrush sumac	157
3	1. Winterfat	1,255
	2. Chokecherry	2,864
	3. Skunkbush sumac	5,746
4	1. Winterfat	2,337
	2. Chokecherry	3,040
	3. Green needlegrass	8,358
5	1. Winterfat	2,476
	2. Chokecherry	4,014
	3. Green needlegrass	9,381
6	1. Winterfat	73,530
	2. Green needlegrass	301,380
	3. Chokecherry	307,273
Total ^a area (123.9 km ²)	1. Winterfat	243 ^b
	2. Chokecherry	533
	3. Skunkbush sumac	1,123

^a Does not include the Cottonwood Forest and Old River Terrace PTs.

^b Optimum carrying capacity.

At the projected optimum population, elk density in the Target Area would be 1.96 elk/km² (Table 29). The densities for the other ungulates would be: bison (1.61/km²); feral horses (0.40/km²); and

mule deer ($2.52/\text{km}^2$). Wydeven and Dahlgren (1985) found ungulate densities at Wind Cave National Park to be: elk ($3.96\text{--}4.40/\text{km}^2$); bison ($3.30\text{--}3.52/\text{km}^2$); mule deer ($0.70\text{--}0.80/\text{km}^2$); and pronghorn ($1.10\text{--}1.32/\text{km}^2$). Researchers at Wind Cave National Park had previously determined the optimum carrying capacity for elk to be 150-300 animals ($1.32\text{--}2.64/\text{km}^2$). Periods of extreme high numbers of elk at Wind Cave National Park in the past, 1,100 ($9.68/\text{km}^2$) in 1953 and 800 ($7.05/\text{km}^2$) in 1969 (Varland et al. 1978), may have severely reduced forage and restricted mule deer numbers and distribution (Wydeven and Dahlgren 1985).

Table 29. Population levels, densities, and stocking rates for elk, bison, feral horses, and mule deer at the optimum carrying capacity for a 6-region area (123.9 km^2) of TRNP.

Ungulate species	Population level	Density (no./ km^2)	Stocking rate	
			(AUM/ha)	(ha/AUM)
Elk	243	1.96	0.011	93.15
Bison	200	1.61	0.013	73.70
Feral horses	50	0.40	0.004	223.91
Mule deer	312	2.52	0.004	230.60
Total	805	6.50	0.033	30.54

When each herbivore was considered in terms of an Animal Unit Month (AUM), equivalent to the forage consumed by 1 adult domestic cow (*Bos* spp.) and her calf for 1 month, 405.7 AUMs were generated for each month at the optimum carrying capacity. The stocking rate for all ungulates on the target area would be 0.033 AUM/ha or 30.54 ha/AUM

(Table 29). Since this area consists of 30.2% bare ground (Marlow et al. 1984), the stocking rate on the vegetated areas would be 0.047 AUM/ha or 21.31 ha/AUM. In the USFS Little Missouri National Grasslands, adjacent to TRNP, cattle are grazed 8 months of the year at stocking rates of 0.35 ha/AUM (2.8 ha/AUM) to 0.82 ha/AUM (1.2 ha/AUM) (M. Walker, pers. comm 1989). These stocking rates may be somewhat high, considering the condition of the vegetation in the National Grasslands (M. Walker, pers. comm. 1989). Because of the strong grazing tendencies of domestic cattle, a stocking rate analysis may only be applicable to the chiefly grazing wild herbivores in TRNP: bison, feral horses and elk.

When the modeled numbers of wild herbivores in the target area (123.9 km²) were applied to the entire SU (183.4 km²), ungulate densities were: elk (1.32/km²); bison (1.09/km²); feral horses (0.27/km²); and mule deer (1.70/km²). When the densities calculated for the Target Area were extrapolated to the entire park, numbers of ungulates were: elk (359); bison (295); feral horses (73); and mule deer (462). To support ungulates at these levels without damaging Park resources, the entire Park would have to be fully utilized by all ungulates. This has been observed in bison (Norland 1984) and mule deer, but elk and feral horses have yet to fully utilize all areas of TRNP.

Alternate ungulate population levels for elk, bison, and feral horses are feasible. An exchange rate coefficient was calculated for these animals based on winterfat intake (Table 30). A reduction in 1 species would free forage to support increases in other ungulate

species. For instance, if 275 bison are considered more desirable than the modeled number, elk numbers must be reduced to $243 - (75) (0.525) = 204$, or feral horses must be reduced to $50 - (75) (0.532) = 10$. If Park officials decide to hold elk numbers at 200, then bison numbers could be raised to $200 + (43) (1.904) = 282$, or feral horse numbers could be raised to $50 + (43) (1.014) = 94$.

Table 30. Exchange rate coefficients of ungulate species 1 for species 2, based on predetermined optimal population levels from winterfat intake.

Species 1	Species 2	Exchange rate coefficient
Elk	Bison	1.904
Elk	Feral horse	1.014
Bison	Elk	.525
Bison	Feral horse	0.532
Feral horse	Elk	0.986
Feral horse	Bison	1.878

These ungulate exchange coefficients are justified because winterfat limits elk, bison, and feral horses but not mule deer. Care should be taken not to elevate elk numbers much past the optimum carrying capacity because of potential conflict with mule deer over chokecherry and skunkbush sumac. These forage items were predicted to limit elk and mule deer numbers, but not bison or feral horse numbers.

Damage to TRNP and Adjacent Land

During 1985-89 no damages to Park buildings or to tourists were reported. However, a 20-m section of fence was found leveled on the east boundary in November 1987. This may have been attributed to elk.

We were unable to detect changes in distribution, productivity, or numbers of mule deer, the ungulate species most likely to be impacted by elk, that could be linked to elk.

Several elk left the Park during 1985-89, and elk within the Park may have established a regular pattern of use on fields east of the Park during summer 1989. However, we heard (third-hand) of only 1 complaint by farmers or ranchers about elk on their lands. No complaints were filed with TRNP. Because of the lack of impacts in these areas, we concentrated on the potential for damage to the relatively small areas of wooded vegetation in TRNP in this section of the report. Twenty-four vegetation transects (Fig. 11) were monitored to determine impacts.

Hardwood Draws

Bare ground and canopy coverage of vegetation increased and litter decreased between 1985 and 1988 (Table 31). Significant differences were not detected among elk use classes (ANOVA transformed by adding 20 to standardize all values as positive integers; F-values on individual tests: 0.13-1.96; $p=0.19-0.88$). A multivariate test (Hotelling's trace) indicated a general pattern of slightly greater increases (or smaller declines) of ground coverage in low elk use areas than in high elk use areas (Graminoids and litter: $\chi^2=67.25$, $p<0.01$; shrubs and forbs: $\chi^2=21.6$, $p=0.04$).

Most shrub species in the 0-50 cm height class counted in 7 1-m² plots increased between 1985 and 1988 (Table 32). Most shrub species in the 50-100 cm height class changed very little overall. Shrubs in

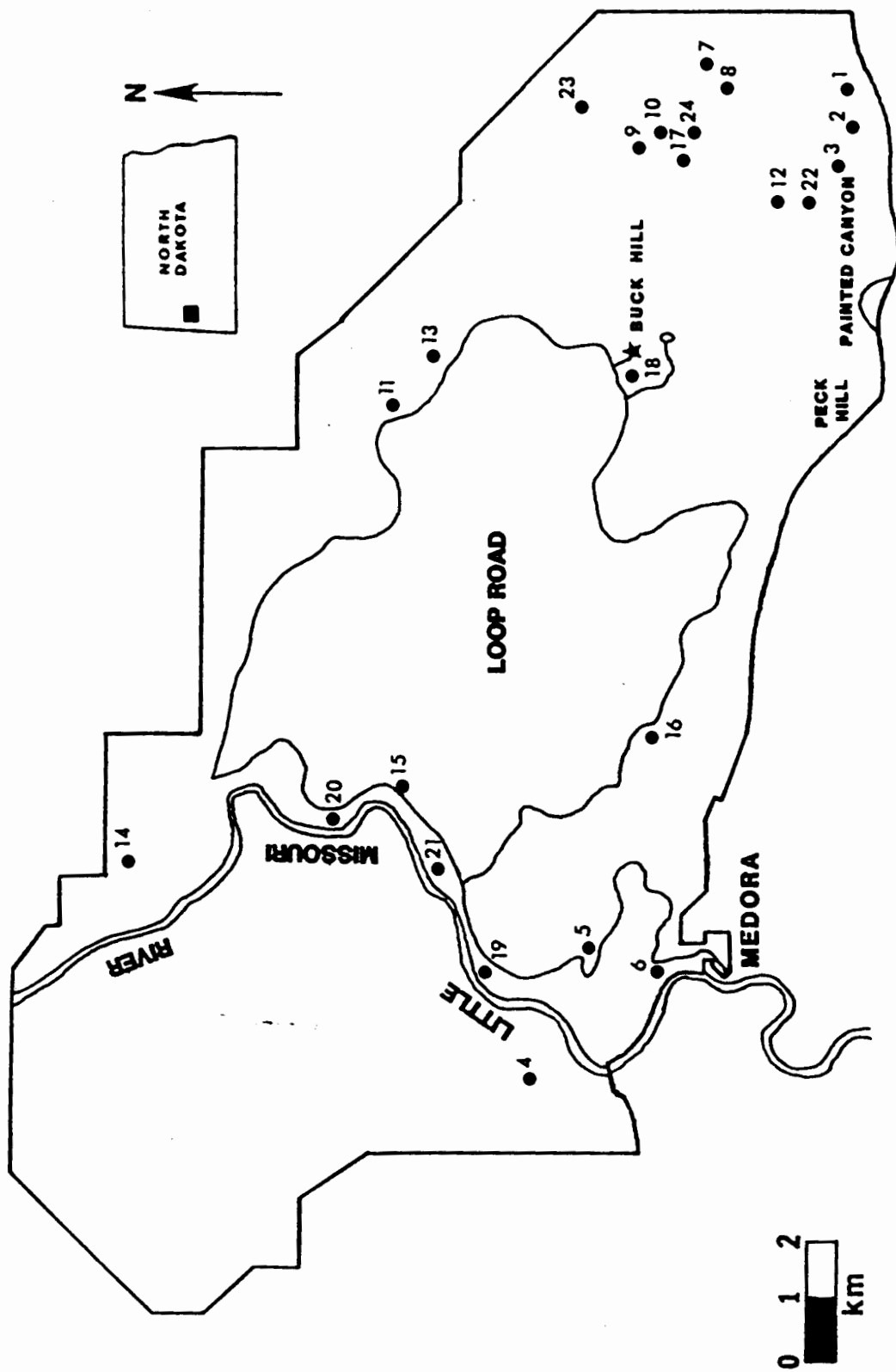


Figure 11. Locations of vegetation transects in wooded habitats in TRNP

Table 31. Percent change in canopy coverage^a between 1985 and 1988 and standard deviations on changes (in parentheses) for categories in the ground stratum of hardwood transects used by elk during 1985-88 (High use), 1985-86 or 1988 (Moderate use), or receiving little or no use during 1985-88 (Low use).

Category ^b	High use	Moderate use	Low use
Transect numbers ^c	1,3,8,9	2,7,13,15	4,5,6,14
Bare ground	7 (6)	6 (5)	5 (1)
Litter	-7 (6)	-4 (4)	-6 (2)
<u>Graminoids</u>			
Elvi	-t ^d (1)	0 (t)	1 (2)
Casp	2 (4)	8 (7)	2 (3)
Popr	1 (1)	t (t)	-t (1)
Total graminoids	9 (5)	11 (5)	9 (3)
<u>Forbs</u>			
Total forbs	-2 (9)	t (3)	3 (4)
<u>Shrubs</u> (<50 cm in height)			
Amal	t (t)	-t (2)	t (t)
Frpe	-t (1)	-t (t)	-1 (2)
Prvi	1 (4)	3 (3)	5 (5)
Syoc	4 (8)	2 (2)	1 (5)
Total shrubs	5 (8)	6 (9)	7 (8)

^a Positive numbers represent increases and negative numbers decreases between 1985 and 1988.

^b Species acronyms are defined in Appendix F, Table 65.

^c Transect locations are given in Fig. 11.

^d t = <1%.

the 100-200 cm height class tended to decrease. Of the individual species/height classes tested (1-factor ANOVA with 26 added to all values to eliminate negative numbers), only changes in rose (Ros sp) and chokecherry (Prvi) were significantly different, or approached significant differences among elk use classes (Ros sp 0-50: $F=7.13$, $p=0.014$; Prvi 50-100: $F=4.12$, $p=0.053$; Prvi 100-200: $F=4.74$, $p=0.039$).

Table 32. Change in number of common shrubs^a in 3 height classes counted in 7 1-m² plots between 1985 and 1988 and standard deviations on changes (in parentheses) for hardwood transects used by elk during 1985-88 (High use), 1985-86 or 1988 (Moderate use), or receiving little or no use during 1985-88 (Low use).

Category ^b	High use	Moderate use	Low use
Transect numbers ^c	1,3,8,9	2,7,13,15	4,5,6,14
<u>0-50 cm in height</u>			
Amal	t ^d (3)	-t (8)	1 (3)
Frpe	t (2)	3 (5)	5 (7)
Prvi	37 (16)	35 (15)	86 (124)
Ros sp	-1 (1)	-2 (1)	1 (1)
Syoc	21 (14)	12 (27)	11 (9)
<u>50-100 cm in height</u>			
Amal	-1 (1)	2 (2)	t (1)
Frpe	1 (2)	0 (2)	-1 (2)
Prvi	-4 (14)	8 (17)	2 (3)
Syoc	0 (2)	7 (15)	3 (6)
<u>100-200 cm in height</u>			
Amal	-1 (3)	-1 (3)	t (1)
Frpe	-1 (1)	-1 (1)	t (1)
Prvi	-7 (2)	-1 (3)	-t (2)

^a Positive numbers represent increases and negative numbers decreases between 1985 and 1988.

^b Species acronyms are defined in Appendix F, Table 65.

^c Transect locations are given in Fig. 11.

^d t = <1.

In these classes, high use stands generally showed a greater decrease in numbers than low use stands. Hotelling's trace was significant for the 50-100 cm (Chi-square=18.7, p=0.02) and 100-200 cm classes (Chi-square=17.8, p=0.01) and approached significance for the 0-50 cm class (Chi-square=18.1, p=0.053) supporting the pattern observed in Table 32 of greater increases in shrubs in the 0-50 cm height class in draws with low elk use and greater declines in 50-200 cm shrub numbers in draws with high elk use. Tree and sapling numbers

(Appendix F, Table 68) remained relatively constant and were not tested.

Juniper Draws

Juniper draws had fewer species and lower ground coverage than hardwood draws (Appendix F, Tables 69 vs. 66.). Ground coverage in juniper draws increased between 1985 and 1988 (Table 33). Significant differences (1-factor ANOVA with 20 added to each value to eliminate negative numbers) were not detected between draws with elk pellets and draws without elk pellets for any of the categories tested (F range: 0.02-3.29; p range: 0.14-0.89).

Shrubs counted on juniper transects also increased between 1985 and 1988 (Table 34). In the 6 height/species categories with sufficient numbers of stems for analysis of variance (1-factor ANOVA transformed by adding 10 to all values to eliminate negative numbers), no differences were detected between transects with elk pellets and transects without elk pellets (F range: 0.04 - 1.52; p range: 0.29-0.86). Tree and sapling numbers in 1988 (Appendix F, Table 71) were almost identical to those in 1985.

Table 33. Percent change in canopy coverage^a between 1985 and 1988 and standard deviations on changes (in parentheses) for categories in the ground stratum of juniper transects with elk pellets present in 1988 (Pellets present) and without elk pellets present in 1988 (No pellets).

Category ^b	Pellets present	No pellets
Transect numbers ^c	10,11,12,18	16,17
Bare ground	3 (3)	4 (3)
Litter	8 (10)	17 (2)
<u>Graminoids</u>		
Ormi	6 (4)	4 (1)
Total graminoids	10 (11)	4 (1)
<u>Forbs</u>		
Gabo	1 (1)	-t ^d (1)
Total forbs	2 (3)	9 (7)
<u>Shrubs</u> (<50 cm in height)		
Syoc	1 (1)	-t (t)
Total shrubs	2 (3)	5 (8)
Moss	6 (9)	4 (17)

^a Positive numbers represent increases and negative numbers decreases between 1985 and 1988.

^b Species acronyms are defined in Appendix F, Table 65.

^c Transect locations are given in Fig. 11.

^d t = <1%.

Table 34. Change in number of common shrubs^a between 1985 and 1988 in 3 height classes counted in 7 1-m² plots and standard deviations on changes (in parentheses) for juniper transects with elk pellets present in 1988 (Pellets present) and without elk pellets during 1988 (No pellets).

Category ^b	Pellets present	No pellets
Transect numbers ^c	10,11,12,18	16,17
<u>0-50 cm in height</u>		
Prvi	8 (11)	6 (8)
Syoc	4 (8)	8 (4)
<u>50-100 cm in height</u>		
Prvi	-1 (2)	1 (1)
<u>All stems 0-200 cm</u>		
Frpe	t ^d (1)	1 (1)
Prvi	8 (9)	6 (8)
Syoc	4 (8)	8 (3)

^a Positive numbers represent increases and negative numbers decreases between 1985 and 1988.

^b Species acronyms are defined in Appendix F, Table 65.

^c Transect locations are given in Fig. 11.

^d t = <1.

Cottonwood Forest

None of the transects in cottonwood forest stands along the Little Missouri River were in sites of known elk use during 1986-88. White-tailed deer use on the 3 transects was moderate to heavy. Despite large changes in some ground coverage categories in individual transects (Table 35 and Appendix F, Table 72), only significant changes in Bare ground (increase between 1986 and 1988, $F=12.44$, $p=0.02$) and Total graminoids (increase between 1986 and 1988, $F=21.1$, $p=0.01$) occurred. A blocked ANOVA (transects as blocks) was used to determine if differences among transects obscured changes between years. The block effect was nonsignificant in 9 of 11 tests.

Table 35. Mean percent canopy coverage during 1986 and 1988 (standard deviations in parentheses) for categories tested (1-factor ANOVA) in the ground stratum of 3 transects^a located in cottonwood forests.

Category ^b	1986	1988
Bare ground	1 (1)	9 (3)
Litter	95 (3)	90 (3)
<u>Graminoids</u>		
Agr sp	t ^c (t)	t (t)
Elvi	1 (1)	t (1)
Total graminoids	2 (1)	8 (2)
<u>Forbs</u>		
Eues	6 (10)	9 (14)
Meof	10 (10)	t (t)
Total forbs	21 (20)	11 (15)
<u>Shrubs</u> (<50 cm in height)		
Jun sp	t (t)	t (t)
Syoc	4 (3)	4 (2)
Total shrubs	6 (4)	6 (3)

^a Transect locations are given in Fig.11.

^b Species acronyms are defined in Appendix F, Table 65.

^c t = <1%.

Mean shrub numbers generally decreased between 1986 and 1988 (Table 36 and Appendix F, Table 73). Variation among transects was so great compared to changes in numbers, however, that we detected no significant differences between 1986 and 1988 for common shrubs (F range: 0.06-1.10, p range: 0.35-0.82). Blocking data by transect did not markedly reduce residual error. Tree and sapling numbers did not change appreciably between 1986 and 1988 (Appendix F, Table 74).

Table 36. Mean numbers of common shrub species in 2 height classes counted in 7 1-m² plots during 1986 and 1988 (standard deviations in parentheses) for 3 transects^a located in cottonwood forests.

Category ^b	1986	1988
<u>0-50 cm in height</u>		
Prvi	7 (7)	3 (1)
Syoc	89 (48)	80 (42)
<u>All stems 0-200 cm</u>		
Prvi	7 (7)	3 (1)
Jusc	2 (2)	1 (1)
Syoc	91 (50)	81 (44)

^a Transect locations are given in Fig. 11.

^b Species acronyms are defined in Appendix F, Table 65.

Shrubland Transects

Analysis of variance indicated only one of the 6 categories tested (Table 37) declined significantly between 1986 and 1988 (Total forbs: $F=9.98$, $p=0.03$). No significant differences were detected in any of the 5 shrub-intercept categories tested (F range: 0.01-0.88; p range: 0.40-0.94) or in the 2 categories tested for junipers in 300 m² plots (F range: 0.22-0.35; p range: 0.59-0.67). Values for individual transects are given in Appendix F, Tables 75-77.

Table 37. Categories included in analysis of variance for shrubland microplots, line intercept, and 300-m² plots. Values are means for 3 transects^a measured in 1986 and 1988. Standard deviations of means are given in parentheses.

Categories ^b	1986	1988
<u>Microplots (% ground coverage - mean of 30 2x5 cm microplots)</u>		
Bare	17 (21)	9 (5)
Litter	65 (21)	49 (2)
Moss	11 (13)	12 (15)
<u>Microplots (% basal coverage - mean of 30 2x5 cm microplots)</u>		
Total graminoids	5 (3)	4 (4)
Total forbs	t ^c (t)	1 (t)
Total shrubs	3 (5)	2 (3)
<u>Line intercept (cm intercepted by tape on 30 m line)</u>		
Arca	120 (120)	157 (95)
Juco	149 (130)	175 (170)
Jusc	378 (222)	316 (156)
Rhtr	317 (296)	337 (298)
Syoc	188 (119)	276 (110)
<u>Junipers in 100-200 cm height class in 300 m² plot</u>		
Number per plot	12 (5)	10 (7)
Estimated canopy coverage (m ²)	18 (6)	14 (11)

^a Locations of transects are given in Fig.11.

^b Species acronyms are defined in Appendix F, Table 65.

^c t = <1.

Overall Impacts of Elk on Woodlands

Overall, woodland communities in TRNP remained relatively stable between 1985 and 1988. Variability among transects and between years was high, as expected, but no obvious trends were detected. We were able to detect some changes in hardwood draws that were probably

attributable to elk use. These changes (declines or lower increases of a few species prevalent in elk diets in draws used by elk compared to draws not used by elk) were not serious and could be artifacts of the variability among transects.

Sensitivity Analysis

Throughout this section we have consistently referred to nonsignificant differences as "undetectable". There is always the possibility that real differences were present, but we did not have the sample size to detect them. Standard deviations in the vegetation variables measured averaged 120% of the means with a range of <10% to >1200%. Although the higher values were usually associated with uncommon plants, variation was also high among and within transects for most common species. This situation reflects reality in vegetative communities of the Northern Great Plains.

To aid TRNP staff in planning vegetation monitoring, we have prepared a list of CV's (Coefficients of Variability = standard deviation/mean x 100., i.e. "standard deviation as a percentage of the mean") in representative species/ground coverage categories (Table 38). We have also prepared a general chart of percent differences in means that should produce significant p values in ANOVA given variation in the number of transects used to compute means and variation in CV's (Table 39). This chart is conservative and will not serve as an absolute indicator of the results of ANOVA.

Table 38. Representative means and Coefficients of Variability (CVs)^a for categories measured in hardwood draws in TRNP.

Category	Number of transects	Mean	CV
<u>Hardwood - Ground Stratum</u>			
(1988 - no elk use):			
Bare ground	4	5.6%	23%
Litter	4	89.8%	2%
Elvi	4	1.3%	200%
Total forbs	4	10.2%	57%
Frpe	4	1.2%	161%
Prvi	4	7.9%	87%
<u>Hardwood - Ground stratum</u>			
(1988 - all transects):			
Bare ground	12	7.0%	67%
Litter	12	89.7%	6%
Elvi	12	0.7%	214%
Total forbs	12	9.6%	62%
Frpe	12	0.7%	186%
Prvi	12	7.9%	49%
<u>Hardwood - Shrub counts</u>			
(1988 - no elk use, N/7m ²):			
Frpe 50-100 cm	4	1.8	133%
Prvi 50-100 cm	4	9.2	95%
<u>Hardwood - Shrub counts</u>			
(1988 - all transects):			
Frpe 50-100 cm	12	1.4	114%
Prvi 50-100 cm	12	17.6	80%

^a CV = standard deviation/mean x 100.

Table 39. Percent differences between means that would be declared significant at a 95% confidence level (CI) ($p < 0.05$) and a 99% confidence level ($p < 0.01$) for different numbers of transects and means with different Coefficients of Variability (CVs)^a. Estimates are based on Stein's 2-stage sample formula with degrees of freedom for t-values taken as the number of degrees of freedom for ANOVA comparing the same transects in 2 different years (i.e. Number of transects $\times$ 2 - 1).

		Minimum significant percent difference between means					
Number of transects	Degrees of freedom	10% CV	20% CV	50% CV	80% CV	100% CV	200% CV
<u>95% CI (p < 0.05)</u>							
2	3	23	45	113	181	226	452
3	5	15	30	75	120	150	300
6	11	9	18	45	72	90	180
10	19	7	13	33	53	66	133
20	39	4	9	22	36	45	89
40	79	3	6	16	25	32	63
<u>99% CI (p < 0.01)</u>							
2	3	41	82	205	328	410	820
3	5	23	46	115	185	231	462
6	11	13	26	65	104	130	260
10	19	9	18	46	73	92	183
20	39	6	12	30	48	60	120
40	79	4	8	21	33	41	82

^a CV = standard deviation/mean $\times$ 100.

CONCLUSIONS AND RECOMMENDATIONS

Elk in TRNP during 1985-89 exhibited rapid antler development, high reproductive performance, and low mortality. The population prospered during a 4-year period that included 2 years of markedly below average precipitation. Most elk remained in the Park and slowly, but steadily, increased their range within TRNP. Performance by the population through summer 1989 indicates that the transplant was successful.

Problems with elk anticipated prior to the introduction (damage to vegetation within the Park, damage to adjacent agricultural lands, negative impacts on resident mule deer, etc.) were not evident during 1985-88. Some or all of these problems will likely occur in the future. Park management personnel can anticipate them by developing monitoring systems for ungulates and vegetation within the Park, preparing response plans for problems before they develop, and maintaining communications with adjacent landowners (private and federal) and the North Dakota Department of Game and Fish.

The Ungulate Resources Allocation Model used to develop estimates of optimal population levels for elk (≈ 240 for areas east of the Little Missouri River and ≈ 360 for the whole SU) should be regarded as a first approximation. The limitations of the linear equations in the LINPRO software package and lack of production estimates for many important forage species and HTs, reduced its validity as a predictor

of populations. However, as a tool for allowing managers to organize available data, identify missing data, and to make educated guesses based on present data, LINPRO or any of several related models, can be extremely useful. The secret to successful use of models is to avoid confusing their output with reality. Managers should constantly update their data base input into models and check output against reality by monitoring vegetation and animals.

Specific Recommendations

1) Numbers, distribution, and age/sex composition of all ungulate species in the Park should be routinely monitored. Winter counts from fixed-wing aircraft or helicopters, although expensive, may provide reasonable numerical estimates for all ungulate species except white-tailed deer and would not require large numbers of man-hours. Accuracy and consistency of censuses should be formally tested.

Indices to numbers of white-tailed deer and age/sex composition of all ungulates can probably best be determined from ground classification of representative samples. Most species would be most easily sampled via road counts or telescope surveys from high points during fall or winter, but the social organization and ecology of each species should be considered. (eg. In elk, September would be the best month for determining bull:cow ratios and survival of calves over summer; April or early May would be the best time to determine over-winter calf survival and number of males and females likely to enter the yearling age class).

2) Manipulation of existing water sources (opening and closing valves on wells or fencing around springs) and development of new sources could provide an effective tool for managing ungulate distribution. Although elk were able to survive drought conditions through use of surface water of very poor quality in summer 1988, the observed distribution of elk indicated that they preferred to stay near water sources (<1-2 km) during hot, dry weather.

3) Vegetative transects should be periodically monitored to assess the impact of herbivory on the vegetation, especially on the vulnerable species delineated by the model. The real value of the transect system we instituted will be realized only if long-term measurements of transects are made.

The ideal monitoring system would include at least a doubling of the current transect numbers and annual measurements on transects for a minimum of 10 years. Given the reality of time and personnel constraints at TRNP, we recommend increasing cottonwood and shrubland transects to 6, maintaining juniper transects at 6, decreasing hardwood draw transects to 6 in the main area of the Park (maintaining 2 near the southeast corner, 2 near Buck Hill, and 2 near the Loop Road) and adding 1 hardwood transect in the area between Medora and the Interstate to serve, with the established transect in that area, as a control.

This transect set along with the grassland transect set should be measured every other year (half of the transects in alternate years). Measurements in wooded communities could be streamlined by converting

to the Forest Service ecoplot technique for the ground stratum or simply recording percent coverage of bare ground, litter, grasses, forbs, shrubs, and moss. Counts of shrubs in 7 1-m² plots along transect baselines should be continued. Counts of trees in the 60-m² plot need be done only at 5-year intervals. Measurements should span a minimum of 10 years to determine variation associated with fluctuations in weather and trends attributable to ungulate use.

Maintenance of this schedule will not be easy given the demands on personnel in the Park to accomplish other tasks and the difficulty of locating transects should personnel changes occur. If the Park can adhere to this sampling scheme for woodlands and for upland grasslands, however, the data will support sophisticated regression analysis and will provide greater insight into the relationships between ungulates and vegetation than is available at any other site in the Northern Great Plains. This information could be crucial for effective management of TRNP in the 21st century should the predicted greenhouse warming occur.

4) Additional information on production in specific vegetation communities (the JUSC/ORMI HT, POTR/BEOC HT, Hardwood Draws HT, and Man-managed MU) and plant species (especially wild-rye, currant/gooseberry, silver buffaloberry, most shrub species in upland grasslands, and all major forb species) is needed.

5) Specific plans should be developed to deal with excess elk numbers. Manipulation of water sources in summer and elk emigration from the Park may delay the need for implementing elk reductions, but

the current population growth rate suggests that elk reductions will likely be necessary in the future. We suggest testing the efficacy of harassment by helicopters during upcoming bison roundups as a short-term population control method and as a means to redistribute elk. A trial aimed at forcing elk west of the Little Missouri River is feasible. If the trial were made within the next year, existing radio-collared elk could be used to determine if elk driven west of the river remained there.

Long-term control will presumably rely on hunting pressure outside the Park and/or capture and removal of elk inside the Park. Hunting on the periphery of the Park has the potential to discourage dispersal of elk from TRNP and should be managed carefully. Plans that designate shifting buffer zones closed to hunting should be considered. Efforts should be made to incorporate private lands into this system (through purchase of easements, lease arrangements, or grazing trades on public land) to avoid exacerbating damage to agricultural lands.

If harassment proves ineffective in reducing elk density within the Park, corral trapping with baits or helicopter drives should be considered as capture techniques. Baiting is less expensive but is time consuming and dependent on identifying baits that are attractive to elk and not to bison (the damage to corrals and time spent releasing unwanted species could be considerable). Helicopter drives are effective, if not used too frequently, but very expensive.

6) Plans for managing elk damage to adjacent agricultural lands should be developed now. Elk are evidently well adapted to northern prairie ecosystems, but at least one transplant in eastern Montana was ultimately unsuccessful due to complaints of agricultural interests. Wildlife managers were forced to institute lenient hunting seasons that eliminated a healthy, expanding elk herd. To avoid this problem, TRNP and the North Dakota Department of Game and Fish should decide what constitutes elk damage to agricultural interests and what techniques will be available to farmers and ranchers to alleviate damage. Communication of this information to local agricultural interests and prompt responses by agencies to complaints will do more to insure the survival of elk than any single habitat or population manipulation scheme available.

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APPENDICES

APPENDIX A

Description of Physiographic Types and Habitat
Types/Mapping Units/Complexes in TRNP.

Table 40. Description of Physiographic Types in TRNP (Norland 1984).

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1. Bottom Grasslands: large flat grassed alluvial deposits found on high floodplains of the Little Missouri River and its larger tributaries.
 2. Breaks: consists of areas noticeably devoid of vegetation, or if vegetation does exist, it is situated on steep slopes.
 3. Sagebrush Bottoms: floodplains dominated by silver sagebrush (Artemisia cana) along with substantial grass cover.
 4. Upland Grasslands: level to rolling grasslands found on plains above the river valley. These lands are typical of the Northern Great Plains.
 5. Prairie Dog Towns: lands which have been or are being influenced by prairie dogs. At the edges of the towns plants are still characteristic of the former plant community. Nearer the center, vegetation is absent or dominated by unpalatable perennial plant species.
 6. Ridge & Ravine: lands highly dissected by watercourses and covered by various grasses, shrubs, and trees.
 7. Old River Terrace: level grasslands 200 to 500 feet above the river which are situated on terraces formed before rapid downcutting of the river.
 8. Scoria Hills: lands influenced by scoria (a clinker formed from the baking of clays adjacent to burning coal veins) which produce differential weathering of the land. This weathering produces a very rugged topography which is covered by various grasses and shrubs.
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Table 41. Description of Habitat Types, Mapping Units, and Complexes in TRNP (Norland 1984, Sullivan 1988).

1. *Agropyron smithii* / *Stipa viridula* HT (AGSM/STVI HT):

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

2. *Agropyron smithii* / *Stipa comata* HT (AGSM/STCO HT):

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

3. *Agropyron smithii* / *Bouteloua gracilis* / *Distichlis spicata* HT (AGSM/BOGR/DIST HT):

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

4. *Stipa comata* / *Bouteloua gracilis* HT (STCO/BOGR HT):

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

5. *Schizachirium scoparium* HT (SCSC HT):

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

6. *Schizachirium scoparium* / *Juniperus horizontalis* (SCSC/JUHO HT):

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

Table 41. Continued.

7. *Artemisia tridentata* / *Atriplex confertifolia* (ARTR/ATCO HT):

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

8. *Artemisia tridentata* / *Bouteloua gracilis* HT (ARTR/BOGR HT):

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

9. *Artemisia cana* HT (ARCA HT):

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

10. *Juniperus scopulorum* / *Oryzopsis micrantha* HT (JUSC/ORMI HT):

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

11. *Populus tremuloides* / *Betula occidentalis* HT (POTR/BOEC HT):

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

12. Hardwood Draws HT:

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

13. Brush MU:

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

Table 41. Continued.

14. Rolling Scoria Complex:

Rolling lands influenced by scoria and composed of the following proportion of habitat types:

.25	SCSC HT
.2	AGSM/STVI HT
.2	STCO/BOGR HT
.15	AGSM/STCO HT
.1	SCSC/JUHO HT
.1	AGSM/BOGR/DIST HT

15. Steep Scoria Complex:

Rolling lands influenced by scoria and composed of the following proportion of habitat types:

.3	SCSC HT
.25	SCSC/JUHO HT
.15	AGSM/STVI HT
.15	STCO/BOGR HT
.1	ARTR/ATCO HT
.05	AGSM/BOGR/DIST HT

16. Introduced Grass MU:

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

17. Prairie Dog Towns MU:

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

18. Man-Managed MU:

Areas where the vegetation has been modified by human disturbance.

APPENDIX B

Percent elk activity in Physiographic Types and Habitat Types/
Mapping Units/Complexes for each season and time period.

Table 42. Percent activity of elk in Physiographic Types (PTs) during winter 1988.

Physiographic Type	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
Bottom Grasslands	18	10	7	33	6	3
Breaks	20	15	32	16	24	17
Sagebrush Bottoms	0	0	0	0	0	0
Upland Grasslands	37	44	31	17	23	15
Prairie Dog Towns	0	0	0	0	0	0
Ridge & Ravine	5	12	6	7	3	7
Old River Terrace	0	0	0	0	0	0
Scoria Hills	20	19	23	26	44	58

^a Descriptions of PTs in Appendix A, Table 40.

Table 43. Percent activity of elk in Physiographic Types (PTs) during spring 1988.

Physiographic Type	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
Bottom Grasslands	8	6	5	7	5	1
Breaks	36	66	57	43	48	79
Sagebrush Bottoms	1	0	4	1	1	tr ^a
Upland Grasslands	42	10	19	29	17	9
Prairie Dog Towns	0	0	0	0	0	0
Ridge & Ravine	2	tr	3	3	tr	1
Old River Terrace	0	0	0	0	0	0
Scoria Hills	11	18	13	17	30	9

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

Table 44. Percent activity of elk in Physiographic Types (PTs) during summer 1987-1988.

Physiographic Type	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
Bottom Grasslands	12	10	9	11	8	1
Breaks	19	43	33	36	22	71
Sagebrush Bottoms	2	tr ^a	3	3	2	tr
Upland Grasslands	39	25	20	20	47	5
Prairie Dog Towns	tr	tr	tr	0	0	0
Ridge & Ravine	0	0	0	0	0	0
Old River Terrace	0	0	0	0	0	0
Scoria Hills	28	22	34	30	21	23

^a tr = <0.5%.^b Descriptions of PTs in Appendix A, Table 40.

Table 45. Percent feeding by elk in Physiographic Types (PTs) for the morning (AM), midday (MD), and evening (PM) time periods during winter 1988, spring 1988, and summer 1987-1988.

Physiographic Type	Winter			Spring			Summer		
	AM	MD	PM	AM	MD	PM	AM	MD	PM
Bottom Grasslands	12	20	17	0	tr ^a	17	9	24	11
Breaks	20	15	37	43	66	20	32	66	6
Sagebrush Bottoms	0	0	0	0	0	2	2	tr	3
Upland Grasslands	50	35	30	51	14	45	16	0	57
Prairie Dog Towns	0	0	0	0	0	0	0	0	tr
Ridge & Ravine	0	8	0	tr	8	1	0	0	0
Old River Terrace	0	0	0	0	0	0	0	0	0
Scoria Hills	18	22	16	5	11	15	40	9	23

^a tr = <0.5%.^b Descriptions of PTs in Appendix A, Table 40.

Table 46. Percent bedding by elk in Physiographic Types (PTs) for the morning (AM), midday (MD), and evening (PM) time periods during winter 1988, spring 1988, and summer 1987-1988.

Physiographic Type	Winter			Spring			Summer		
	AM	MD	PM	AM	MD	PM	AM	MD	PM
Bottom Grasslands	tr ^a	11	15	0	2	19	2	13	12
Breaks	5	16	17	76	78	24	45	75	12
Sagebrush Bottoms	0	0	0	0	0	0	tr	0	tr
Upland Grasslands	69	40	48	18	5	24	16	0	55
Prairie Dog Towns	0	0	0	0	0	0	0	0	tr
Ridge & Ravine	0	15	0	0	tr	tr	0	0	0
Old River Terrace	0	0	0	0	0	0	0	0	0
Scoria Hills	25	18	19	6	15	33	37	12	21

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

Table 47. Percent utilization of Physiographic Types (PT) by elk for the morning (AM), midday (MD), and evening (PM) time periods during winter 1988, spring 1988, and summer 1987-1988.

Physiographic Type	Winter			Spring			Summer		
	AM	MD	PM	AM	MD	PM	AM	MD	PM
Bottom Grasslands	7	15	18	0	1	16	7	6	11
Breaks	16	16	32	52	82	26	39	77	11
Sagebrush Bottoms	0	0	0	0	0	2	2	tr ^a	2
Upland Grasslands	53	36	32	39	5	36	15	tr	50
Prairie Dog Towns	0	0	0	0	0	0	0	0	tr
Ridge & Ravine	0	13	tr	tr	2	1	0	0	0
Old River Terrace	0	0	0	0	0	0	0	0	0
Scoria Hills	24	20	18	9	10	20	37	17	25

^a tr = <0.5%.

^b Descriptions of PTs in Appendix A, Table 40.

Table 48. Percent activity of elk in Habitat Types (HTs), Mapping Units (MU), and Complexes during winter 1988.

HTs, MUs, and Complexes	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
AGSM/STVI	42	47	33	46	26	7
AGSM/STCO	1	tr ^a	tr	3	0	9
STCO/BOGR	9	9	5	3	3	5
SCSC	9	7	14	10	4	6
SCSC/JUHO	0	0	0	0	0	0
ARTR/ATCO	14	9	15	8	17	3
ARTR/BOGR	tr	0	tr	tr	0	1
ARCA	tr	0	tr	1	0	0
JUSC/ORMI	tr	0	0	1	0	1
POTR/BEOC	0	0	0	0	0	0
Hardwood Draws	tr	2	tr	tr	0	2
Brush	0	0	0	0	0	0
Rolling Scoria	14	10	14	16	22	27
Steep Scoria	5	9	9	7	22	30
Introduced Grass	0	0	0	0	0	0
Prairie Dog Towns	0	0	0	0	0	0
Man-Managed	0	0	0	0	0	0
Unvegetated Areas	5	7	10	3	6	9

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Table 49. Percent activity of elk in Habitat Types (HTs), Mapping Units (MUs), and Complexes during spring 1988.

HTs, MUs, and Complexes	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
AGSM/STVI	22	23	21	21	14	2
AGSM/STCO	2	tr ^a	2	1	1	tr
STCO/BOGR	5	1	3	5	3	4
SCSC	21	8	16	16	11	3
SCSC/JUHO	1	6	2	1	tr	tr
ARTR/ATCO	7	22	15	9	16	4
ARTR/BOGR	2	5	3	4	1	1
ARCA	1	0	4	1	1	tr
JUSC/ORMI	tr	7	5	6	14	63
POTR/BEOC	tr	0	0	0	0	0
Hardwood Draws	2	5	6	3	1	11
Brush	1	tr	1	tr	1	1
Rolling Scoria	7	11	6	7	22	3
Steep Scoria	4	5	4	8	5	2
Introduced Grass	22	4	7	13	5	3
Prairie dog towns	0	0	0	0	0	0
Man-Managed	1	0	2	1	1	0
Unvegetated Areas	1	2	3	3	4	1

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Table 50. Percent activity of elk in Habitat Types (HTs), Mapping Units (MUs), and Complexes during summer 1987-1988.

HTs, MUs, and complexes	Activity					
	Feeding	Bedding	Standing	Moving	Other	Unknown
AGSM/STVI	17	23	17	19	13	4
AGSM/STCO	0	0	0	0	0	0
STCO/BOGR	3	2	2	5	1	tr ^a
SCSC	5	14	9	9	7	1
SCSC/JUHO	tr	4	tr	1	tr	tr
ARTR/ATCO	5	2	12	12	4	tr
ARTR/BOGR	tr	0	tr	1	tr	tr
ARCA	2	tr	3	3	2	tr
JUSC/ORMI	1	5	3	5	1	65
POTR/BEOC	tr	0	0	tr	0	tr
Hardwood Draws	7	16	7	6	9	24
Brush	tr	tr	tr	tr	tr	0
Rolling Scoria	21	16	23	20	12	2
Steep Scoria	5	4	7	7	7	2
Introduced Grass	33	13	12	8	42	2
Prairie Dog Towns	tr	tr	tr	0	0	0
Man-Managed	tr	tr	1	1	0	0
Unvegetated Areas	tr	tr	5	5	1	tr

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Table 51. Percent feeding by elk in Habitat Types (HTs), Mapping Units (MUs), and Complexes for the morning (AM), midday (MD), and evening (PM) time periods during winter 1988, spring 1988, and summer 1987-1988.

HTs, MUs, and Complexes	Winter			Spring			Summer		
	AM	MD	PM	AM	MD	PM	AM	MD	PM
AGSM/STVI	48	45	27	23	25	20	16	29	16
AGSM/STCO	5	0	0	3	4	0	0	0	0
STCO/BOGR	9	11	0	10	tr ^a	4	3	0	3
SCSC	0	5	35	27	27	13	10	8	2
SCSC/JUHO	0	0	0	1	tr	1	1	2	tr
ARTR/ATCO	13	11	25	2	15	8	7	18	2
ARTR/BOGR	tr	0	tr	0	8	2	tr	0	tr
ARCA	0	1	0	0	0	3	2	tr	2
JUSC/ORMI	0	tr	0	tr	1	tr	tr	1	tr
POTR/BEOC	0	0	0	0	0	tr	0	0	tr
Hardwood Draws	0	tr	0	3	4	1	13	31	1
Brush	0	0	0	2	tr	1	1	tr	0
Rolling Scoria	8	16	13	3	11	8	31	7	18
Steep Scoria	10	5	0	2	tr	6	6	2	5
Introduced Grass	0	0	0	20	0	33	8	0	50
Prairie Dog Towns	0	0	0	0	0	0	0	0	tr
Man-Managed	0	0	0	3	1	tr	1	2	0
Unvegetated Areas	7	6	0	1	2	tr	tr	tr	1

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Table 52. Percent bedding by elk in Habitat Types (HTs), Mapping Units (MUs), and Complexes for the morning (AM), midday (MD), and evening (PM) time periods during winter 1988, spring 1988, and summer 1987-1988.

HTs, MUs, and Complexes	Winter			Spring			Summer		
	AM	MD	PM	AM	MD	PM	AM	MD	PM
AGSM/STVI	15	54	24	24	22	23	16	22	30
AGSM/STCO	tr ^a	0	0	0	tr	0	0	0	0
STCO/BOGR	54	4	0	tr	0	4	3	0	4
SCSC	0	3	41	22	8	1	25	10	10
SCSC/JUHO	0	0	0	28	4	1	2	10	tr
ARTR/ATCO	2	10	15	8	28	10	3	2	2
ARTR/BOGR	0	0	0	0	6	5	0	0	0
ARCA	0	0	0	0	0	0	tr	0	tr
JUSC/ORMI	0	0	0	0	9	6	1	10	1
POTR/BOEC	0	0	0	0	0	0	0	0	0
Hardwood Draws	0	3	0	10	6	0	13	35	1
Brush	0	0	0	tr	0	0	tr	tr	0
Rolling Scoria	5	9	19	0	13	12	33	8	13
Steep Scoria	20	8	0	4	0	19	3	1	6
Introduced Grass	0	0	0	2	0	20	tr	0	32
Prairie Dog Towns	0	0	0	0	0	0	0	0	tr
Man-Managed	0	0	0	0	0	0	tr	tr	0
Unvegetated Areas	3	9	0	1	2	0	0	1	tr

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

Table 53. Percent utilization of Habitat Types (HTs), Mapping Units (MUs), and Complexes by elk for the morning (AM), midday (MD), and evening (PM) time periods during winter 1988, spring 1988, and summer 1987-1988.

HTs, MUs, and Complexes	Winter			Spring			Summer		
	AM	MD	PM	AM	MD	PM	AM	MD	PM
AGSM/STVI	35	49	29	20	14	20	16	9	20
AGSM/STCO	4	0	0	2	1	0	0	0	0
STCO/BOGR	21	6	0	6	tr ^a	6	2	0	4
SCSC	0	5	35	22	9	10	12	4	4
SCSC/JUHO	0	0	0	4	2	1	1	3	tr
ARTR/ATCO	8	11	20	4	18	9	8	3	3
ARTR/BOGR	tr	0	tr	0	5	2	1	0	tr
ARCA	0	tr	0	0	0	3	2	tr	2
JUSC/ORMI	0	tr	tr	6	32	6	8	49	2
POTR/BOEC	0	0	0	0	0	tr	0	0	tr
Hardwood Draws	0	2	0	8	7	1	13	27	1
Brush	0	0	0	2	tr	1	tr	tr	0
Rolling Scoria	9	12	16	4	8	8	24	3	18
Steep Scoria	15	7	0	4	tr	9	6	1	6
Introduced Grass	0	0	0	14	tr	24	6	0	38
Prairie Dog Towns	0	0	0	0	0	0	0	0	tr
Man-Managed	0	0	0	2	1	tr	1	tr	0
Unvegetated Areas	7	8	0	2	2	tr	1	1	2

^a tr = <0.5%.

^b Descriptions of HTs, MUs, and Complexes and definition of acronyms in Appendix A, Table 41.

APPENDIX C

Ungulate interactions and reaction of elk to human caused
disturbances by distance category.

Table 54. Percent reaction of other ungulate species to elk within distance categories. Sample sizes are in parentheses.

Reaction	Ungulate species	Distance (m)				
		0-10	11-20	21-50	51-100	>100
Sample size (n)	Mule deer	(40)	(17)	(15)	(21)	(8)
	Bison	(6)	(4)	(5)	(8)	(6)
	Feral horses	(3)	(1)	(3)	(4)	(5)
No reaction	Mule deer	33	35	53	67	50
	Bison	83	100	100	100	100
	Feral horses	67	100	100	75	100
Awareness	Mule deer	8	12	13	19	50
	Bison	0	0	0	0	0
	Feral horses	0	0	0	0	0
Alarm	Mule deer	3	0	7	0	0
	Bison	0	0	0	0	0
	Feral horses	0	0	0	0	0
Aggression	Mule deer	0	0	0	0	0
	Bison	17	0	0	0	0
	Feral horses	0	0	0	0	0
Displacement	Mule deer	58	53	27	14	0
	Bison	0	0	0	0	0
	Feral horses	33	0	0	25	0

Table 55. Percent reaction of elk to other ungulate species within distance categories. Sample sizes are in parentheses.

Reaction	Ungulate Species	Distance (m)				
		0-10	11-20	21-50	51-100	>100
Sample size (n)	Mule deer	(40)	(17)	(15)	(21)	(8)
	Bison	(6)	(4)	(5)	(8)	(6)
	Feral horses	(3)	(1)	(3)	(4)	(5)
No reaction	Mule deer	65	82	87	81	75
	Bison	17	75	80	63	17
	Feral horses	33	0	67	75	60
Awareness	Mule deer	15	6	13	19	25
	Bison	23	0	20	13	17
	Feral horses	0	0	0	25	40
Alarm	Mule deer	0	0	0	0	0
	Bison	0	0	0	0	0
	Feral horses	0	0	0	0	0
Aggression	Mule deer	18	12	0	0	0
	Bison	0	0	0	0	0
	Feral horses	0	0	0	0	0
Displacement	Mule deer	3	0	0	0	0
	Bison	50	25	0	25	67
	Feral horses	67	100	33	0	0

Table 56. Percent reaction of elk to human caused disturbances by distance category. Sample sizes are in parentheses.

Reaction	Type of Disturbance	Distance			
		1-100 m	101-300 m	301-1000 m	>1000 m
Sample size (n)	On foot	(15)	(18)	(13)	(2)
	Vehicle	(6)	(7)	(4)	(6)
	Horseback	(1)	(5)		
No reaction	On foot	0	0	8	0
	Vehicle	0	0	25	33
	Horseback	0	40		
Awareness	On foot	0	11	0	100
	Vehicle	0	29	50	67
	Horseback	0	20		
Alarm	On foot	0	0	8	0
	Vehicle	0	0	25	0
	Horseback	0	0		
Displacement	On foot	100	89	85	0
	Vehicle	100	71	0	0
	Horseback	100	40		

APPENDIX D

Percent vegetative species composition identified in fecal analysis
of elk, bison, feral horses, mule deer, white-tailed deer
in TRNP.

Table 57. Percent vegetative species composition identified in fecal samples of elk during spring 1988 and summer 1987-1988 and during the growing season (spring 1988 and summer 1987-1988).

Plant species	Late spring 1988	Early summer 1987	Late summer 1988	Growing season total
Graminoids				
<u>Agropyron smithii</u>	7.8	3.4	4.2	5.5
<u>Bouteloua gracilis</u>	1.3	1.2	0.6	1.0
<u>Bromus inermis</u>	5.7	1.2	1.0	2.9
<u>Carex</u> spp.	7.2	2.4		3.4
<u>Koeleria pyramidata</u>	1.5			0.6
<u>Oryzopsis micrantha</u>	2.5		1.6	1.6
<u>Poa</u> spp.	1.1	9.5	0.3	2.5
<u>Schizachirium scoparium</u>	3.8			1.5
<u>Stipa viridula</u>	5.4	8.7	4.8	5.8
Total graminoids	36.3	26.4	12.5	24.8
Forbs				
<u>Achillea millefolium</u>	0.1	0.8	1.0	0.6
<u>Arctium minus</u>		2.0		0.4
<u>Echinacea angustifolia</u>	2.4	1.2	0.6	1.4
<u>Equisetum</u> spp.		0.8		0.2
<u>Erysimum/Lithospermum</u>	0.6	0.4	0.7	0.6
<u>Galium boreale</u>	2.9		0.5	1.3
<u>Gaura coccinea</u>	3.6	1.6	4.2	3.5
<u>Lactuca</u> spp.	1.3	3.2	0.3	1.3
<u>Lysimachia ciliata</u>	0.4			0.2
<u>Melilotus</u> spp.	0.3	0.8		0.3
<u>Monarda fistulosa</u>	3.3	2.8	3.2	3.2
<u>Plantago</u> spp.			0.5	0.2
<u>Potentilla</u> spp.	0.4	1.6		0.5
<u>Psoralea</u> spp.	0.1		0.8	0.4
<u>Ranunculus</u> spp.	0.4			0.2
<u>Ratibida columnifera</u>	1.2	1.6	1.3	1.3
<u>Sanicula marilandica</u>	0.4		2.4	1.1
<u>Sphaeralcea coccinea</u>	4.5	6.0	21.5	11.6
<u>Taraxacum officinale</u>	2.0	0.8	1.4	1.5
<u>Thermopsis rhombifolia</u>	0.7			0.3
<u>Tragopogon dubius</u>		0.4		0.1
Unknown forb leaf	9.8	1.6	7.5	7.2
Unknown forb	4.4			1.8
Total forbs	38.8	25.4	45.9	39.0

Table 57. Continued.

Plant species	Late spring 1988	Early summer 1987	Late summer 1988	Growing season total
Total seed		1.2		0.2
Shrubs				
<u>Amelanchier alnifolia</u>		0.4		0.1
<u>Artemisia frigida</u>	0.3	1.6	4.9	2.4
<u>Atriplex confertifolia</u>	0.6		0.5	0.4
<u>Ceratoides lanata</u>	2.2	18.1	17.5	11.5
<u>Fraxinus pennsylvanica</u>	1.4		0.6	0.8
<u>Juniperus</u> spp.	0.3			0.1
<u>Prunus virginiana</u>	3.5	6.8	4.6	4.6
<u>Rhus trilobata</u>	4.0	4.8	2.1	3.4
<u>Ribes</u> spp.	1.6	1.2	3.5	2.3
<u>Rosa</u> spp.	3.1		2.0	2.0
<u>Shepherdia argentea</u>	4.7		0.5	2.1
<u>Symphoricarpos occidentalis</u>	3.1	14.3	5.0	6.1
<u>Yucca glauca</u>	0.1		0.5	0.2
Total shrubs	24.9	47.0	41.6	36.0

Table 58. Percent vegetative species composition identified in fecal samples of bison during spring 1988 and summer 1988 and during the growing season (spring 1988 and summer 1988).

Plant species	Late spring 1988	Early summer 1987	Growing season total
Graminoids			
<u>Agropyron smithii</u>	19.0	19.5	19.2
<u>Bouteloua gracilis</u>	5.3	2.9	4.1
<u>Bromus inermis</u>	2.3	4.0	3.1
<u>Calamovilfa longifolia</u>	2.9	2.3	2.6
<u>Carex</u> spp.	6.3	11.9	9.1
<u>Distichlis spicata</u>	0.3	0.5	0.4
<u>Elymus</u> spp.	5.6	3.4	4.5
<u>Koeleria pyramidata</u>	10.2	6.9	8.5
<u>Muhlenbergia cuspidata</u>	1.4	2.0	1.7
<u>Oryzopsis micrantha</u>	0.3	1.2	0.8
<u>Poa</u> spp.	28.9	7.2	18.0
<u>Schizachirium scoparium</u>	1.8	2.5	2.2
<u>Stipa comata</u>	2.7	13.8	8.2
<u>Stipa viridula</u>	5.5	0.5	3.0
Total graminoids	92.1	78.4	85.2
Forbs			
<u>Achillea millefolium</u>	0.4	0.2	0.3
<u>Arctium minus</u>	0.4		0.2
<u>Erysimum/Lithospermum</u>	0.1		0.1
<u>Galium boreale</u>	0.8	0.8	0.8
<u>Gaura coccinea</u>		0.3	0.2
<u>Lactuca</u> spp.	0.3	0.4	0.3
<u>Melilotus</u> spp.	2.7	1.3	2.0
<u>Monarda fistulosa</u>	0.6		0.3
<u>Psoralea</u> spp.	0.3		0.1
<u>Ranunculus</u> spp.		0.5	0.2
<u>Ratibida columnifera</u>	0.4		0.2
<u>Sphaeralcea coccinea</u>	0.3	5.0	2.7
<u>Taraxacum officinale</u>		0.7	0.4
<u>Tragopogon dubius</u>	0.5	0.7	0.6
Unknown forb leaf	0.3	1.0	0.6
Unknown forb stem	0.1		0.1
Unknown flower		0.5	0.3
Total forbs	7.1	11.4	9.3

Table 58. Continued.

Plant species	Late spring 1988	Early summer 1987	Growing season total
Shrubs			
<u>Artemisia frigida</u>	0.1	0.6	0.4
<u>Artemisia</u> spp. ^a	0.1	0.1	0.1
<u>Atriplex confertifolia</u>		0.2	0.1
<u>Ceratoides lanata</u>	0.3	7.8	4.0
<u>Fraxinus pennsylvanica</u>		0.2	0.1
<u>Rosa</u> spp.	0.3	1.2	0.7
<u>Shepherdia argentea</u>		0.2	0.1
Total shrubs	0.8	10.2	5.5

^a Includes primarily Artemisia tridentata and A. cana.

Table 59. Percent vegetative species composition identified in fecal samples of feral horses during spring 1988 and summer 1988 and during the growing season (spring 1988 and summer 1988).

Plant species	Late spring 1988	Early summer 1987	Growing season total
<u>Graminoids</u>			
<u>Agropyron smithii</u>	21.5	17.3	19.4
<u>Bouteloua gracilis</u>	1.7	1.5	1.6
<u>Bromus inermis</u>	3.4	3.3	3.3
<u>Calamovilfa longifolia</u>	0.6	0.3	0.4
<u>Carex</u> spp.	29.1	15.7	22.4
<u>Distichlis spicata</u>	0.7	0.3	0.5
<u>Elymus</u> spp.	0.2		0.1
<u>Koeleria pyramidata</u>	9.9	14.0	12.0
<u>Oryzopsis micrantha</u>		0.9	0.5
<u>Poa</u> spp.	14.0	8.5	11.3
<u>Schizachirium scoparium</u>	1.8	1.4	1.6
<u>Stipa comata</u>	10.2	21.8	16.0
<u>Stipa viridula</u>	4.5	0.5	2.5
Total graminoids	97.5	85.3	91.4
<u>Forbs</u>			
<u>Lactuca</u> spp.	0.2		0.1
<u>Sphaeralcea coccinea</u>	1.1	4.4	2.7
Unknown forb leaf		0.3	0.1
Total forbs	1.3	4.7	3.0
<u>Browse</u>			
<u>Ceratoides lanata</u>	1.2	10.0	5.6
<u>Shepherdia argentea</u>	0.1		0.1
Total shrubs	1.3	10.0	5.6

Table 60. Percent vegetative species composition identified in fecal samples of mule deer during spring 1988 and summer 1988 and during the growing season (spring 1988 and summer 1988).

Plant species	Late spring 1988	Early summer 1987	Growing season total
Graminoids			
<u>Agropyron smithii</u>	0.2	1.7	1.0
<u>Carex</u> spp.		0.7	0.4
<u>Elymus</u> spp.	0.4	0.4	0.4
<u>Poa</u> spp.	0.2		0.1
<u>Stipa comata</u>	0.4		0.2
<u>Stipa viridula</u>	0.4	0.4	0.4
Total graminoids	1.5	3.3	2.4
Forbs			
<u>Achillea millefolium</u>	2.6	0.7	1.6
<u>Aster</u> spp.		2.1	1.0
<u>Astragalus</u> spp.	2.6		1.3
<u>Echinacea angustifolia</u>		1.8	0.9
<u>Erysimum/Lithospermum</u>	2.8	0.4	1.6
<u>Galium boreale</u>	2.3		1.2
<u>Gaura coccinea</u>	3.0		1.5
<u>Lactuca</u> spp.	0.3	1.1	0.7
<u>Linum</u> spp.	2.5	0.7	1.6
<u>Lysimachia ciliata</u>	0.4		0.2
<u>Melilotus</u> spp.	2.1		1.0
<u>Monarda fistulosa</u>	1.4		0.7
<u>Penstemon</u> spp.		0.9	0.4
<u>Ranunculus</u> spp.	0.7		0.4
<u>Ratibida columnifera</u>	2.8	3.2	3.0
<u>Sanicula marilandica</u>	0.9	1.5	1.2
<u>Sphaeralcea coccinea</u>		1.1	0.5
<u>Thermopsis rhombifolia</u>	2.0	0.1	1.0
<u>Tragopogon dubius</u>		0.9	0.4
<u>Vicia</u> spp.	3.1	1.5	2.3
Unknown forb leaf		0.2	0.1
Total forbs	29.3	16.1	22.7
Shrubs			
<u>Amelanchier alnifolia</u>		5.7	2.9
<u>Artemisia frigida</u>	3.2	0.5	1.9
<u>Artemisia</u> spp. ^a	0.1	8.7	4.4

Table 60. Continued.

Plant species	Late spring 1988	Early summer 1987	Growing season total
Shrubs (Continued)			
<u>Fraxinus pennsylvanica</u>		3.0	1.5
<u>Prunus virginiana</u>	5.6	9.5	7.5
<u>Rhus trilobata</u>	5.7	7.0	6.3
<u>Ribes</u> spp.	2.1	5.2	3.7
<u>Rosa</u> spp.	0.7	4.9	2.8
<u>Shepherdia argentea</u>	44.9	11.5	28.2
<u>Symphoricarpos occidentalis</u>	4.9	13.0	8.9
<u>Toxicodendron radicans</u>	2.2	5.9	4.0
Total shrubs	69.2	74.9	72.1

^a Includes primarily Artemisia tridentata and A. cana.

Table 61. Percent vegetative species composition identified in fecal samples of white-tailed deer during spring 1988 and summer 1988 and during the growing season (spring 1988 and summer 1988).

Plant species	Late spring 1988	Early summer 1987	Growing season total
Graminoids			
<u>Agropyron smithii</u>	1.1	1.1	1.1
<u>Carex</u> spp.		0.3	0.2
<u>Elymus</u> spp.	2.5	1.0	1.7
<u>Poa</u> spp.	6.4		3.2
Total graminoids	10.0	2.4	6.2
Forbs			
<u>Achillea millefolium</u>	1.1		0.5
<u>Anemone</u> spp.	1.3		0.7
<u>Antennaria</u> spp.	0.2		0.1
<u>Arabis</u> spp.	0.2		0.1
<u>Astragalus</u> spp.	1.3		0.7
<u>Campanula rotundifolia</u>	0.7		0.3
<u>Cystopteris fragilis</u>	0.3		0.2
<u>Erysimum/Lithospermum</u>		0.3	0.2
<u>Galium boreale</u>	1.2	0.2	0.7
<u>Gaura coccinea</u>	2.5		1.3
<u>Lactuca</u> spp.	1.5	0.1	0.8
<u>Melilotus</u> spp.	1.2	0.2	0.7
<u>Monarda fistulosa</u>	3.1	1.8	2.5
<u>Oxalis stricta</u>	2.5		1.3
<u>Psoralea</u> spp.	0.8		0.4
<u>Ranunculus</u> spp.	4.1		2.1
<u>Sanicula marilandica</u>	1.6	2.2	1.9
<u>Smilacena stellata</u>	0.5		0.3
<u>Taraxacum officinale</u>	0.3	1.0	0.7
<u>Thermopsis rhombifolia</u>	0.3		0.2
<u>Vicia</u> spp.	0.7		0.3
Unknown forb leaf	23.8	3.1	13.4
Unknown forb	0.8		0.4
Total forbs	50.0	8.8	29.4
Shrubs			
<u>Artemisia frigida</u>	0.9		0.5
<u>Artemisia</u> spp. ^a	0.2		0.1

Table 61. Continued.

Plant species	Late spring 1988	Early summer 1987	Growing season total
Shrubs (Continued)			
<u>Fraxinus pennsylvanica</u>	2.3	4.1	3.2
<u>Populus</u> spp.	1.9		0.9
<u>Prunus virginiana</u>	0.9	51.3	26.1
<u>Rhus trilobata</u>	3.9	11.2	7.5
<u>Ribes</u> spp.	2.4		1.2
<u>Rosa</u> spp.	4.8	4.1	4.5
<u>Salix</u> spp.	1.5		0.8
<u>Shepherdia argentea</u>	9.9	3.0	6.4
<u>Symphoricarpos occidentalis</u>	5.4		2.7
<u>Toxicodendron radicans</u>	6.1	14.0	10.1
Total shrubs	40.1	87.6	63.8

^a Includes primarily Artemisia tridentata and A. cana.

APPENDIX E

Percent composition, hecterage and vegetative production of Habitat
Types (HTs), Mapping Units (MUs), and Complexes in the Upland
Grassland Physiographic Type for the South Unit of
Theodore Roosevelt National Park.

Table 62. Percent composition and hecterage of Habitat Types (HTs), Mapping Units (MUs), and Complexes in the Upland Grassland Physiographic Type (PT) for the South Unit of Theodore Roosevelt National Park.

HT/MU/and Complex	Hectares	Percent composition
1. AGSM/STVI	513.5	50.8
2. AGSM/STCO	77.2	7.6
3. STCO/BOGR	192.3	19.0
4. SCSC	25.7	2.5
5. ARTR/ATCO	0.7	0.1
6. Hardwood Draws	0.3	tr ^a
7. Brush	2.6	0.3
8. Introduced Grass	155.7	15.4
9. Unvegetated Areas	42.6	4.2

^a tr = <0.05%

^b Description of PTs, HTs, MUs, and Complexes and definition of acronyms in Appendix A, Tables 40 and 41.

Table 63. Vegetative production (kg/ha) for Habitat Types (HTs), Mapping Units (MUs), and Complexes within the Upland Grassland Physiographic Type (PT). Production figures are from Marlow et al. 1984, Norland 1988^a and Sullivan 1988.

Plant species	HT/MU/Complex			
	AGSM/ STVI	AGSM/ STCO	STCO/ BOGR	SCSC
<u>Agropyron smithii</u>	757	555	191	
<u>Bouteloua curtipendula</u>				64
<u>Bouteloua gracilis</u>	252	369	286	129
<u>Calamovilfa longifolia</u>			286	129
<u>Carex</u> spp.	84	92	191	129
<u>Koeleria pyramidata</u>	34	93	95	64
<u>Muhlenbergia cuspidata</u>				64
<u>Poa</u> spp.	87	25	22	
<u>Schizachirium scoparium</u>				259
<u>Sporobolus cryptandrus</u>			22	
<u>Stipa comata</u>		184	476	194
<u>Stipa viridula</u>	84	92		
Other grasses	210	112	50	64
Forbs	84	185	191	64
<u>Ceratoides lanata</u>	11			28
<u>Rhus trilobata</u>				56
Other shrubs	73	93	95	45
Total	1726	1800	1905	1289

Table 63. Continued.

Plant species	ARTR/ ATCO	HT/MU/Complex		Introduced Grass
		Hardwood Draws	Brush	
<u>Agropyron caninum</u>			104	
<u>Agropyron cristatum</u>				841
<u>Agropyron smithii</u>			20	
<u>Agropyron</u> spp.	84			
<u>Bouteloua curtipendula</u>			11	
<u>Bouteloua gracilis</u>	56		68	
<u>Bromus inermis</u>				280
<u>Calamovilfa longifolia</u>			167	
<u>Carex</u> spp.	28		148	
<u>Distichlis spicata</u>	22			
<u>Elymus canadensis</u>			10	
<u>Koeleria pyramidata</u>			10	
<u>Muhlenbergia cuspidata</u>	28		9	
<u>Muhlenbergia racemosa</u>			26	
<u>Oryzopsis micrantha</u>			20	
<u>Poa pratensis</u>			159	
<u>Poa</u> spp.			19	
<u>Schizachirium scoparium</u>			34	
<u>Stipa comata</u>	28		54	
<u>Stipa spartea</u>			11	
<u>Stipa viridula</u>			21	
Other grasses	39		8	
Forbs	112		39	112
<u>Amelanchier alnifolia</u>		94		
<u>Atriplex confertifolia</u>	56			
<u>Atriplex nuttallii</u>	17			
<u>Artemisia cana</u>	45		3	
<u>Artemisia tridentata</u>	140			
<u>Ceratoides lanata</u>	17			
<u>Chrysothamnus nauseosus</u>	45			
<u>Fraxinus pennsylvanica</u>		559	1	
<u>Juniperus horizontalis</u>			12	
<u>Prunus virginiana</u>		386	82	
<u>Ribes setosum</u>			2	
<u>Ribes odoratum</u>			9	
<u>Rosa</u> spp.		35	1	
<u>Rhus trilobata</u>			10	
<u>Symphoricarpos occidentalis</u>	45	912	856	
Other shrubs	45			
Total	807	1986	1904	1233

APPENDIX F

Transect summaries of 1988 for 24 vegetation transec's established
in woodland and shrubland communities in TRNP.

Table 64. Type (Hardwood, Juniper, Cottonwood, or Shrubland), location (area and UTM), and character (aspect and elevation) of marked transects in woodland and shrubland habitats in TRNP.

No.	Area description	UTM	Aspect	Elevation
Hardwood draws				
1	Sec 32, 200 m SW of SE Corner Spring	6274/51949	N	2750'
2	Sec 32, 600 m W of SE Corner Spring	6268/51951	NE	2750'
3	Sec 31, 700 m NW of Olsen Well	6256/51955	NE	2700'
4	Sec 9, 1000 m NNW of Radio Tower (follow plateau)	6107/52017	N	2600'
5	Sec 14, 600 m E of scenic pullout (Johnson Plat., N of road)	6128/51992	NE	2450'
6	Sec 22, 1.5 km N of Park entrance, 150 m W of entrance road (left side of rd. before making curve towards the Interstate)	6122/51984	N	2350'
7	Sec 20, 1.4 km S of Horse Corral	6277/51982	N	2750'
8	Sec 20, 1.3 km SSW of Horse Corral	6273/51983	N	2700'
9	Sec 20, 1 km SW of Horse Corral	6267/51988	N	2700'
13	Sec 11, 1.2 km W of Sheep Butte Spr., 250 m NE of Loop Rd.	6223/52017	NE	2650'
14	Sec 29, 500 m W of Bison Corral, <50 S of maintenance rd.	6136/52076	N	2350'

Table 64. Continued.

No.	Location	UTM	Aspect	Elevation
(Hardwood draws cont.)				
15	Sec 1, 300 m SSW of W parking area for Jones Cr. Trail, 100 m E of River Rd.	6150/52024	NE	2350'
Juniper draws				
10	Sec 20, 1.1 km SW of Horse Corral	6268/51988	NE	2650'
11	Sec 3, 400 m W of Boicourt Spr., 250 m N of Loop Rd.	6216/52031	NW	2600'
12	Sec 30, 1.5 km NW of Olsen Well	6252/51963	NE	2600'
16	Sec 13, 400 m NE of Scoria Point, 100 m SW of Loop Rd.	6151/53991	NE	2500'
17	Sec 19, 1.5 km SW of Horse Corral, 400 m W of Transect 24	6267/51985	N	2650'
18	Sec 23, 400 m N of top of Buck Hill, <50 m S of old Buck Hill Rd.	6226/51984	N	2650'
Cottonwood forests				
19	Sec 10, 200 m NE of motor-home loop of Cottonwood Campground	6121/52013	Flat	2250'
20	Sec 1, Beef Corral area, 1.2 km NW of W parking area for Jones Cr., 100 m W of River Rd.	6148/52036	Flat	2250'
21	Sec 11, 300 m W of Peaceful Valley Ranch buildings	6137/52019	Flat	2250'

Table 64. Continued.

No.	Location	UTM	Aspect	Elevation
Shrubland				
22	Sec 31, 900 m NW of Olsen Well, 200 m NW of Transect 3	6255/51955	NE	2700'
23	Sec 17, 800 m W of Horse Corral	6271/51994	N	2650'
24	Sec 20, 1.2 km SW of Horse Corral, 300 m E of Transect 17	7272/51985	N	2700'

Table 65. Species names (scientific and common) for plants identified with 4-letter acronyms. Names follow the TRNP plant list.

GRAMINOIDS

Agcr	- <u>Agropyron cristatum</u> (Crested wheatgrass)
Agsm	- <u>Agropyron smithii</u> (Western wheatgrass)
Agtr	- <u>Agropyron trachycaulum</u> (Slender wheatgrass)
Agr sp	- <u>Agropyron</u> spp. (Wheatgrass species)
Scsc	- <u>Schizachirium scoparium</u> (Little bluestem)
Brin	- <u>Bromus inermis</u> (Smooth brome)
Cael	- <u>Carex eleocharis</u> (Neddleleaf sedge)
Calo	- <u>Calamovilfa longifolia</u> (Prairie sandreed)
Casp	- <u>Carex sprengei</u> (Fox sedge)
Car sp	- <u>Carex</u> spp. (Sedge species)
Disp	- <u>Distichlis spicata</u> (Saltgrasses)
Elvi	- <u>Elymus virginicus</u> (Virginia wild-rye)
Kopy	- <u>Koeleria pyramidata</u> (Prairie junegrass)
Mucu	- <u>Muhlenbergia cuspidata</u> (Plains muhly)
Mura	- <u>Muhlenbergia racemosa</u> (Mat muhly)
Ormi	- <u>Oryzopsis micrantha</u> (Little ricegrass)
Popr	- <u>Poa pratensis</u> (Kentucky bluegrass)
Poa sp	- <u>Poa</u> spp. (Poa species)
Stvi	- <u>Stipa viridula</u> (Green needlegrass)

FORBS/HALF-SHRUBS

Acmi	- <u>Achillea millefolium</u> (Yarrow)
Arlu	- <u>Artemisia ludoviciana</u> (Cudweed or Louisiana sagewort)
Armi	- <u>Arctium minus</u> (Burdock)
Ama sp	- <u>Amaranthus</u> spp. (Pigweed species)
Anpa	- <u>Anemone patens</u> (Pasque flower)
Asc sp	- <u>Asclepias</u> spp. (Milkweed species)
Cer sp	- <u>Cerastium</u> spp. (Chickweed species)
Chhy	- <u>Chenopodium hybridum</u> (Maple-leaved goosefoot)
Che sp	- <u>Chenopodium</u> spp. (Goosefoot species)
Ciar	- <u>Cirsium arvense</u> (Canada thistle)
Clli	- <u>Clematis ligusticifolia</u> (Western virgin's bower)
Cyfr	- <u>Cystopteris fragilis</u> (Bladder-fern)
Cru sp	- Cruciferae (Unknown mustard species)
Ditr	- <u>Disporum trachycarpum</u> (Fairbells)
Eues	- <u>Euphorbia esula</u> (Leafy spurge)
Frvi	- <u>Fragaria virginiana</u> (Wild strawberry)
Gaap	- <u>Galium aparine</u> (Goosegrass)
Gabo	- <u>Galium boreale</u> (Northern bedstraw)
Getr	- <u>Geum triflorum</u> (Prairie smoke)
Hade	- <u>Hackelia deflexa</u> (Wood stickseed)

Table 65. Continued.

(FORBS/HALF-SHRUBS continued)

Hebo	- <u>Hedysarum boreale</u> (Sweet vetch)
Heri	- <u>Heuchera richardsonii</u> (Alum root)
Heu sp	- <u>Heuchera</u> spp. (Alum root species)
Lile	- <u>Linum lewisii</u> (Lewis' wild flax)
Lyci	- <u>Lysimachia ciliata</u> (Fringed Loosestrife)
Meof	- <u>Melilotus officinalis</u> (Yellow sweetclover, may include a small amount of <u>M. alba</u>)
Mofi	- <u>Monarda fistulosa</u> (Wild bergamot)
Oxst	- <u>Oxalis stricta</u> (Upright yellow wood sorrel)
Pain	- <u>Parthenocissus inserta</u> (Virginia creeper)
Smhe	- <u>Smilax herbacea</u> (Carrion flower)
Smst	- <u>Smilacina stellata</u> (False Solomon's seal)
Sol sp	- <u>Solidago</u> spp. (Goldenrod species)
Taof	- <u>Taraxacum officinale</u> (Common dandelion)
Thrh	- <u>Thermopsis rhombifolia</u> (Golden pea)
Thve	- <u>Thalictrum venulosum</u> (Early meadowrue)
Tora	- <u>Toxicodendron radicans</u> (Poison ivy)
Vio sp	- <u>Viola</u> spp. (Violet species)

SHRUBS/TREES

Amal	- <u>Amelanchier alnifolia</u> (Serviceberry, Juneberry)
Arca	- <u>Artemisia cana</u> (Silver sagebrush)
Artr	- <u>Artemisia tridentata</u> (Big sagebrush)
Cela	- <u>Ceratoides lanata</u> (Winterfat)
Chna	- <u>Chrysothamnus nauseosus</u> (Rubber rabbitbrush)
Cro	- <u>Crataegus rotundifolia</u> (Round-leaved hawthorn)
Frpe	- <u>Fraxinus pennsylvanica</u> (Green ash)
Juco	- <u>Juniperus communis</u> (Dwarf juniper)
Juho	- <u>Juniperus horizontalis</u> (Creeping juniper)
Jusc	- <u>Juniperus scopulorum</u> (Rocky Mountain juniper)
Jun sp	- <u>Juniperus</u> spp. (Juniper species)
Pode	- <u>Populus deltoides</u> (Plains cottonwood)
Pofr	- <u>Potentilla fruticosa</u> (Shrubby cinquefoil)
Pram	- <u>Prunus americana</u> (Wild plum)
Prvi	- <u>Prunus virginiana</u> (Chokecherry)
Riod	- <u>Ribes odoratum</u> (Golden currant)
Rise	- <u>Ribes setosum</u> (Bristly gooseberry)
Rhtr	- <u>Rhus trilobata</u> (Skunkbush sumac)
Ros sp	- <u>Rosa</u> spp. (Rose species)
Save	- <u>Sarcobatus vermiculatus</u> (Greasewood)
Shar	- <u>Shepherdia argentea</u> (Silver buffaloberry)
Syoc	- <u>Symphoricarpos occidentalis</u> (Snowberry, includes a small amount of <u>S. alba</u>)
Ulam	- <u>Ulmus americana</u> (American elm)

Table 66. Mean canopy coverage (%) for the ground stratum in 20 plots (25x51 cm) measured on 12 20-m transects in hardwood stands in the South Unit of Theodore Roosevelt National Park, 1988. Standard deviations are given in parentheses.

Category ^a	Transects ^b with elk sign in 1985-88				Transects with elk sign in 1985-86 or 1988				Transects with no elk sign			
	1	3	8	9	2	7	13	15	4	5	6	14
Bare	5 (9)	10 (13)	3 (5)	19 (16)	5 (6)	7 (9)	1 (1)	12 (6)	7 (10)	6 (10)	5 (9)	4 (6)
Litter	90 (14)	88 (16)	95 (5)	76 (19)	91 (7)	93 (9)	98 (0)	88 (5)	88 (16)	89 (15)	91 (9)	92 (7)
Elk pellets	1 (3)	t ^c	t ^c	1 (3)								
Deer pellets				t	t						t	
GRAMINOIDS												
Agtr		2 (8)	t		t							
Brin								t		5 (7)		t
Car sp	5 (12)				t		29 (12)	t				2 (5)
Casp		7 (7)	5 (12)		8 (10)	9 (10)			2 (5)	9 (15)		t
Elvi	1 (3)		t	t	t			2 (3)				5 (7)
Popr	2 (8)	1 (3)	t		1 (3)		1 (3)	t	t	t		1 (3)
Ormi	1 (3)	4 (6)	2 (5)	15 (15)	4 (9)		1 (3)	12 (11)	10 (12)	t		9 (14)
FORBS												
Acmi	t	t	t	t	t				t			
Ar1u					t				t			
Armi		t										
Chhy												
C11i									1 (3)			t
Cru sp											1 (3)	
Ditr	t					1 (3)						
Frgl	4 (6)		9 (7)	5 (6)	1 (3)	t			6 (7)	t		
Gaas									1 (3)			
Gabo	3 (4)	3 (5)	3 (5)	t	4 (6)	t	3 (6)	7 (6)	6 (6)	7 (7)	3 (5)	5 (6)
Hade									t			
Heri			t		t							
Lyci	4 (6)	t	5 (7)		5 (12)		t		1 (3)	t		

Table 66. Continued.

Category ^a	Transects ^b with elk sign in 1985-88				Transects with elk sign in 1985-86 or 1988				Transects with no elk sign			
	1	3	8	9	2	7	13	15	4	5	6	14
FORBS (cont.)												
Mofi					t			1 (3)			1 (3)	t
Oxst		t		t				t			t	t
Pain	t	t		t					2 (8)			
Smhe		t									t	t
Smst		t										2 (3)
Sol sp		t			t	t		t				
Taof	t	1 (1)	t	1 (1)	1 (1)				t		t	t
Thrh			1 (3)									
Thve	1 (3)				t			1 (3)		t		2 (5)
Tora	2 (5)		1 (3)		2 (5)				1 (3)			
Vio sp			1 (3)						t			
Unknown		t		t					t			
SHRUBS												
Ana1	1 (1)		t		t		2 (5)	1 (3)				
Frpe	1 (3)						2 (5)	1 (3)	4 (10)			1 (3)
Juco											t	
Jusc				2 (5)				2 (5)				
Prvi	7 (7)	10 (14)	8 (10)	5 (7)	9 (12)	10 (13)	6 (7)	6 (7)	12 (13)	16 (11)	1 (1)	4 (6)
Rhtr								4 (7)			4 (10)	
Riod												
Rise	t				t					t	2 (5)	
Ros sp			2 (5)		t		1 (3)		1 (3)		t	
Syoc	11 (11)	1 (3)	4 (7)	11 (9)	13 (13)	t	2 (5)	7 (7)	8 (12)	t	10 (12)	2 (5)
OTHER												
Moss		t	t	1 (3)			t	1 (1)		1 (3)		
Fungus							t			t		

^a Definitions for species acronyms are given in Table 65.^b Locations of transects are noted in Fig. 11.^c t = <0.5%.

Table 67. Number of shrub stems by height class counted in 7 1-m² plots on 12 20-m transects in hardwood draws for the South Unit of Theodore Roosevelt National Park, 1988. Median estimated use (1 = no observed use, 2 = 1-10%, 3 = 10-50%, 4 = >50%) is given in parentheses.

Category ^a	Transects ^b used 1985-88					Transects used 1985-86 or 1988					Transects - no elk use observed				
	1	3	8	9	2	7	13	15	4	5	6	14			
<50 cm															
Ana1	6 (3)	9 (3)	9 (2)		15 (3)		12 (2)	1 (2)	7 (1)	5 (1)	1 (1)				
Crro	1 (2)														
Frpe	3 (1)	3 (2)	1 (1)				21 (1)	6 (1)	16 (1)	17 (2)	4 (1)	3 (2)			
Juco										2 (1)					
Jusc								1 (1)							
Prvi	40 (2)	94 (3)	70 (2)	61 (2)	86 (2)	55 (1)	75 (2)	39 (2)	49 (1)	296 (1)	22 (1)	39 (2)			
Rhtr								8 (2)			9 (1)				
Riod	2 (3)										2 (1)				
Rise					6 (2)		4 (1)			5 (1)	19 (1)				
Ros sp	1 (3)		11 (2)		2 (2)		1 (1)		1 (1)	2 (2)	1 (3)				
Syoc	100 (2)	6 (1)	62 (2)	109 (2)	101 (2)	4 (2)	44 (1)	72 (2)	17 (1)	5 (1)	87 (1)	34 (1)			
Ulam						3 (1)									
50-100 cm															
Ana1	2 (3)	2 (3)	2 (2)		8 (2)		5 (2)	1 (2)			4 (2)				
Frpe	1 (2)	1 (3)		3 (3)			3 (1)	2 (2)		5 (2)	2 (1)				
Prvi	18 (2)	32 (3)	14 (2)	9 (2)	34 (2)	15 (2)	4 (2)	48 (2)	3 (1)	7 (1)		9 (2)			
Rhtr								5 (1)			4 (1)				
Riod				1 (3)											
Syoc	10 (3)		1 (1)		29 (1)			1 (1)			21 (2)	1 (3)			
100-200 cm															
Ana1	6 (2)	3 (2)	5 (3)		5 (3)		2 (2)		1 (1)						
Frpe				1 (1)		1 (2)	1 (1)	2 (2)	1 (1)		4 (1)				
Prvi	7 (1)	7 (2)	7 (2)	4 (2)	17 (2)	12 (1)	1 (2)	17 (2)	16 (1)	4 (1)		4 (1)			
Rhtr								4 (2)			1 (1)				
Riod	9 (1)			1 (2)											

^a Definitions for species acronyms are given in Table 65.

^b Locations of transects are noted in Fig. 11.

Table 68. Continued.

Category ^a	Transects ^b used by elk in 1985-88				Transects used by elk in 1985-86 or 1988					Transects with minor or no use in 1985-88			
	1	3	8	9	2	7	13	15	4	5	6	14	
Riob													
	6										1		
	6										1		
	50										0		
Ulam													
		1				5							
		1				5							
		0				60							
						1							
						1							
						0							

^a Species acronyms are defined in Table 65.^b Transect locations are identified in Fig. 11.

Table 69. Mean canopy coverage (%) for the ground stratum of 20 plots (25x51 cm) measured on 6 20-m transects in juniper stands of the South Unit of Theodore Roosevelt National Park, 1988. Standard deviations are given in parentheses.

Category ^a	Transects ^b with elk sign in 1988				Transects with no elk sign in 1988	
	10	11	12	18	16	17
Bare	12 (18)	3 (5)	2 (8)	5 (9)	2 (8)	10 (16)
Litter	73 (26)	65 (23)	30 (16)	45 (19)	37 (9)	34 (14)
Elk pellets	t ^c	t	t	t		
Deer pellets					t	
Graminoids						
Agtr		1 (1)	t	3 (6)		1 (3)
Cael			t	14 (14)		
Casp		13 (14)	t	1 (3)		
Car sp			t		17 (15)	
Elvi		t				
Ormi	20 (12)	11 (7)	9 (7)	8 (7)	4 (6)	7 (10)
Forbs						
Acmi		1 (1)		1 (3)		t
Ama sp	t					
Anpa		t	1 (3)	t		
Asc sp			t			
Cer sp				t		
Ciar	3 (5)					
Cyfr		1 (1)		1 (1)		t
Ditr						t
Gabo	t	1 (1)	2 (4)	t	t	t
Getr				t		
Hade		t				
Hebo			t			
Heri		t				t
Pain		t				
Smst				1 (3)		
Sol sp	t	1 (3)	2 (5)	1 (3)		t
Taof	t	1 (1)		t		
Vio sp		t	t	t		
Unknown	t	t		t		t

Table 69. Continued.

Category ^a	Transects ^b with elk sign in 1988				Transects with no elk sign in 1988	
	10	11	12	18	16	17
Shrubs						
Artr						t
Frpe					t	
Juco				2 (8)	6 (14)	
Jusc		t	t	1 (3)	2 (5)	
Prvi		4 (9)		6 (12)	7 (12)	
Rhtr		t	2 (5)	t		t
Rise				t		
Ros sp			t			t
Syoc	2 (5)		2 (3)	2 (5)	t	t
Other						
Moss	13 (22)	47 (36)	65 (34)	69 (21)	81 (18)	65 (25)

^a Definitions for species acronyms are given in Table 65.

^b Locations of transects are noted in Fig. 11.

^c t = <0.5%.

Table 70. Number of shrub stems counted by height class in 7 1-m² plots for 6 20-m transects in juniper stands of the South Unit of Theodore Roosevelt National Park, 1988. Median estimated use (1 = no observed use, 2 = 1-10%, 3 = 10-50%, 4 = >50%) is given in parentheses.

Category ^a	Transects ^b with elk sign in 1988				Transects with no elk sign in 1988	
	10	11	12	18	16	17
<u><50 cm</u>						
Amal	1 (1)					
Chna				2 (3)		
Frpe				2 (2)	1 (1)	
Juco			9 (1)	42 (1)	14 (1)	
Jusc			12 (1)			
Pofr					1 (1)	
Prvi	7 (2)	27 (2)		31 (2)	29 (2)	
Rhtr	1 (1)		1 (1)	5 (2)		
Rise				2 (2)		
Ros sp			5 (2)			
Syoc	21 (2)	5 (1)	29 (2)	54 (2)	25 (2)	18 (1)
<u>50-100 cm</u>						
Frpe	1 (4)	1 (2)			1 (1)	
Juco					1 (1)	
Pofr					1 (1)	
Prvi	4 (3)	6 (2)		3 (1)	7 (2)	
Rhtr				1 (2)	1 (1)	
Syoc						
<u>100-200 cm</u>						
Prvi					5 (1)	

^a Definitions for species acronyms are given in Table 65.

^b Locations of transects are noted in Fig. 11.

Table 71. Numbers of saplings (>2m in height and dbh <10cm) and trees (>2m in height and >10cm dbh) counted in 60m² plots in 6 juniper stands in the South Unit of Theodore Roosevelt National Park, 1988. Numbers of plants with browse available to ungulates (N avail) and percent of those plants browsed (% use) are given in the table.

Category ^a		Transects ^b with elk sign present in 1988				Transects with no elk sign in 1988	
		10	11	12	18	16	17
Frpe	Sapling N	3	9		5		
	N avail	2	7		3		
	% use	100	14		67		
	Tree N		2				
	N avail		2				
	% use		50				
Jusc	Sapling N	7	2	22	18	14	22
	N avail	3	0	12	14	7	8
	% use	0		33	21	0	25
	Tree N	6	4	7	1	6	7
	N avail	2	1	3	1	0	4
	% use	0	0	67	0		25
Prvi	Sapling N					4	
	N avail					4	
	% use					50	

^a Species acronyms are defined in Table 65.

^b Transect locations are identified in Fig. 11.

Table 72. Mean canopy coverage (%) in 20 plots (20x50 cm in 1986, and 25x51 cm in 1988) measured on 3 20-m transects in cottonwood forests of the South Unit of Theodore Roosevelt National Park, 1986 and 1988. Standard deviations are given in parentheses.

Category ^a	Transects - 1986 ^b			Transects - 1988		
	19	20	21	19	20	21
Bare	t ^c	3 (9)	t	12 (17)	6 (14)	8 (7)
Litter	94 (6)	93 (15)	98 (t)	87 (16)	92 (14)	92 (7)
Deer pellets	1 (1)	t	t	2 (5)	1 (3)	2 (5)
<u>Graminoids</u>						
Agtr	1 (1)	t		t	t	
Brin				t	t	t
Calo					2 (5)	6 (10)
Car sp				1 (3)	1 (3)	
Elvi	t	t	3 (8)	t	1 (1)	
Mura				t	1 (3)	t
Ormi				1 (3)		
Popr	1 (1)			7 (7)	t	
Poa sp					t	
Stvi					2 (5)	
Unknown	t	t			t	
<u>Forbs</u>						
Armi			t			
Arlu		2 (8)				
Che sp	t	t				
Clli	1 (3)			t		
Eues			18 (15)	t	2 (5)	26 (13)
Frvi						
Gabo		t			t	
Lyci			t			
Meof	2 (3)	7 (16)	22 (22)	t	t	
Pain						t
Smst	1 (1)	1 (1)	1 (1)		t	
Sol sp	t	t	2 (8)	t	t	1 (3)
Taof	t	t	t	t		
Thve		t	t		1 (3)	
Tora	1 (3)		t		1 (3)	t
Vio sp	t					
Unknown	4 (9)	t	t	t		t

Table 72. Continued.

Category ^a	Transects - 1986 ^b			Transects - 1988		
	19	20	21	19	20	21
<u>Shrubs</u>						
Frpe			1 (3)	1 (3)	t	
Jusc	t	t	1 (1)	t	t	t
Prvi		t			t	1 (3)
Rhtr					1 (3)	
Rise	2 (5)			t		
Ros sp			1 (3)			
Syoc	7 (10)	1 (1)	5 (7)	4 (5)	2 (5)	6 (7)

^a Definitions for species acronyms are given in Table 65.

^b Locations of transects are noted in Fig. 11.

^c t = <0.5%.

Table 73. Number of shrub stems counted by height class in 7 1-m² plots on 3 20-m transects in cottonwood forests in the South Unit of Theodore Roosevelt National Park, 1986 and 1988. Median estimated browse use (1 = no observed use, 2 = 1-10%, 3 = 10-50%, 4 = >50%) is given in parentheses.

Category ^a	Transects - 1986 ^b			Transects - 1988		
	19	20	21	19	20	21
<u><50 cm</u>						
Frpe	2 (1)			5 (3)	3 (1)	2 (1)
Jusc	1 (1)	1 (1)	4 (1)	1 (1)		2 (1)
Prvi	15 (2)	7 (1)	6 (1)	4 (1)		
Rhtr		4 (1)			2 (2)	
Riod		1 (1)				
Rise	10 (1)			4 (1)		
Ros sp			6 (1)			2 (1)
Syoc	141 (2)	45 (2)	82 (1)	128 (3)	27 (3)	50 (1)
<u>50-100 cm</u>						
Rhtr			3 (1)			
Syoc	3 (2)		3 (1)	3 (3)		
<u>100-200 cm</u>						
Jusc					1 (1)	
Rhtr			4 (1)		2 (1)	

^a Definitions for species acronyms are given in Table 65.

^b Locations of transects are noted in Fig. 11.

Table 74. Numbers of saplings (>2m in height and dbh <10cm) and trees (>2m in height and >10cm dbh) counted in 60m² plots in cottonwood forest for 1986 and 1988. Numbers of plants with browse available to ungulates (N avail) and percent of those plants browsed (% use) are given in the table.

Category ^a		Transects 1986 ^b			Transects 1988		
		19	20	21	19	20	21
Frpe	Sapling N	1					
	N avail	1					
	% use	0					
Pode	Tree N	4	3	4	4	3	4
	N avail	0	0	0	0	0	0
	% use						
Jusc	Sapling N	6	7	9	9	7	8
	N avail	6	7	9	6	7	8
	% use	0	0	0	0	57	0
	Tree N	8	6	2	6	6	2
	N avail	5	3	2	4	4	2
	% use	0	0	0	0	0	0
Rhtr	Sapling N				1		
	N avail				1		
	% use				0		

^a Species acronyms are defined in Table 65.

^b Transect locations are identified in Fig. 11.

Table 75. Mean basal coverage of 30 microplots (2x5cm) measured on 3 30-m shrub transects within the range of elk in the South Unit of Theodore Roosevelt National Park, 1986 and 1988. Standard deviations are given in parentheses.

Category ^a	Transects - 1986 ^b			Transects - 1988		
	22	23	24	22	23	24
Bare	5 (19)	41 (41)	5 (14)	14 (16)	11 (15)	t ^c
Litter	88 (21)	62 (37)	46 (40)	48 (16)	49 (15)	51 (24)
<u>Pellets</u>						
Elk			6 (21)		1 (5)	t
Deer	1 (3)	1 (3)	1 (4)			t
<u>Graminoids</u>						
Agr sp		2 (5)	t		1 (3)	t
Calo	1 (3)			1 (3)		t
Car sp		4 (17)	3 (10)	1 (5)	1 (5)	t
Disp			t			
Kopy					t	
Mucu		2 (11)			1 (5)	1 (3)
Popr		1 (3)	t	1 (3)		
Poa sp						
Scsc	3 (10)			8 (12)		
Stvi		t				
<u>Forbs</u>						
Acmi		t	t			
Gabo	t			t		
Hebo		t			t	
Heu sp	t					
Lile					t	
Smst	t					
Sol sp	t		t		1 (3)	1 (3)
Tora				1 (3)		
Unknown					1 (5)	t
<u>Shrubs</u>						
Juco		t				
Juho			8 (25)			6 (20)
Ros sp			t			
Syoc	t		1 (3)	t	t	
<u>Other</u>						
Moss	1 (4)	6 (21)	26 (38)		8 (14)	30 (32)
Lichen			1 (7)			

^a Definitions for species acronyms are given in Table 65.

^b Locations of transects are noted in Fig. 11.

^c t < 0.5%

Table 76. Shrub intercept (in centimeters) along 30-m lines measured for ecotonal shrubland sites in the South Unit of Theodore Roosevelt National Park, 1986 and 1988.

Species ^a	Transects ^b 1986			Transects 1988		
	22	23	24	22	23	24
Amal	45			27		
Arca	35	258	68	52	236	182
Artr						18
Chna					45	
Cela		36			84	
Juco	245	202		340	183	
Juho			615			1023
Jusc	594	150	390	495	206	248
Pofr			151	15		158
Prvi				8		
Rhtr	24	311	615	10	592	408
Ros sp			27	6		6
Save			22			6
Shar			45			78
Syoc	57	288	220	166	386	276

^a Species acronyms are defined in Table 65.

^b Transect locations are noted in Fig. 11.

Table 77. Numbers of Junipers (Juniperus communis and J. scopulorum) in 3 size classes and total canopy coverage (m²) by size class in 300-m² plots in ecotonal shrubland in the South Unit of Theodore Roosevelt National Park, 1986 and 1988.

Category	Transects ^a - 1986			Transects - 1988		
	22	23	24	22	23	24
<u>50-100cm</u>						
Number	0	5	6	5	4	3
Canopy coverage		1.7	1.2	2.4	1.5	1.7
<u>100-200cm</u>						
Number	8	11	17	4	7	18
Canopy coverage	11.1	21.3	21.3	5.1	10.7	25.5
<u>>200cm</u>						
Number	3	NM ^b	NM	7	17	9
Canopy coverage	48.6			56.7	89.6	57.4

^a Locations of transects are given in Fig. 11.

^b Not measured.