FERAL HORSE DISTRIBUTION, HABITAT USE, AND POPULATION DYNAMICS IN THEODORE ROOSEVELT NATIONAL PARK

June 1992

Montana State University
Bozeman, Montana

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Submitted to the:
National Park Service, P.O. Box 25287, Denver, Colorado 80225
in compliance with contract No. PX 1200-9-C818

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INTRODUCTION

Background

During the past eight years the National Park Service has been gathering data on habitat preferences, seasonal movements, and forage preferences of the dominant, large herbivores within Theodore Roosevelt National Park. This information has been collated into a management plan for the protection of the historic, natural, and scenic features for which Theodore Roosevelt National Park was established. One of the Park's historic features is a population of feral horses which has existed in the South Unit since approximately 1900. The presence of horses in the area was noted by Theodore Roosevelt during his ranching days on the Little Missouri River during the 1880's. Because of the historical significance of feral horses in the Little Missouri River region, Park Service management personnel decided to refine the Theodore Roosevelt National Park management plan through incorporation of habitat utilization data for feral horses residing within the Park.

Collection of information on seasonal movements, home range size, habitat preferences, and diets of Theodore Roosevelt National Park's feral horses was basic to the refinement of the Park's management plan. First, this information was to be used in describing the ecological role of the horse within Theodore Roosevelt National Park. Second, comparison of horse diet and habitat utilization patterns with those of elk and bison could indicate whether horses competed directly with these species or whether horses used vegetation types and landforms seldom utilized by the Park's other large ungulates. Finally, quantifying the potential for competition, or lack thereof would fulfill a secondary purpose this investigation; refinement of the optimum carrying capacity model for the Park's ungulate complex.

Description of the ecological role of elk within the Park (Sullivan et al. 1988 and Westfall et al. 1989) led to information which indicated that feral horse diets were similar to that of elk during the spring and to bison diets throughout the year. The implied potential for competition suggests a forage demand level that could have negative effects on both the large herbivore complex and certain vegetation types within Theodore Roosevelt National Park. In the face of potential declines in ecological condition due to the habitat or dietary overlap, the optimum carrying capacity of each of the Park's major ungulate species might have to be held at relatively low levels. However, if feral horses were found to use vegetation types and landforms seldom frequented by either elk or bison, actual competition may be limited and the possibility of environmental degradation lessened. This would allow higher population levels for the Park's large herbivore species.

To describe the potential for actual competition between feral horses, elk, and bison it was necessary to determine horse numbers and those areas within Theodore Roosevelt National Park utilized by horses. The next step was to determine which vegetation and landform types within the respective home ranges were used for foraging, resting, and other social behaviors. Although Ganskopp and Vavra (1986) reported they could not detect a seasonal movement pattern within the home ranges of the feral horses that they studied, the apparent diet similarity between horses and elk during the spring (Sullivan et al. 1988) required that utilization patterns within horse band home ranges be monitored on a seasonal basis. Identification of the size and location of home ranges was important because Waring (1983) reported that home range size is more dependent on resource availability than herd or band size. In the absence of prolonged drought, home range expansion or a shift in its location could signal the onset or intensification of competition. In addition, a measure of home range fidelity and the level of forage utilization within horse home ranges would compliment the data base on the temporal and spatial utilization patterns of elk and bison. Ultimately, this would strengthen the sensitivity of the Park's ecological monitoring effort.

Purpose and Research Objectives

The purpose of this study was to complete the investigation of the interaction between elk, bison, and feral horses within the Park by describing the ecological role of feral horses and to use the information to modify the optimum carrying capacity and forage management model for the Park's ungulate complex. The following research objectives were used to guide this investigation.

1. Identify individual horses and the bands to which they belong in order to establish the location and size of bachelor stallion and harem band home ranges.
2. Determine the seasonal movements of horses within the home ranges identified in Objective One.
3. Identify the landform types utilized by feral horses for feeding, resting, traveling, and other behaviors.
4. Establish seasonal and year-long foraging habits and forage species utilization within the home ranges.
5. Identify the degree of potential competition of feral horses, elk, and bison through comparing seasonal habitat use patterns among the three species.
6. Through the use of Park records on vegetation production within the various habitats used by horses, estimate an annual carrying capacity for feral horses that would facilitate regular public viewing without inducing a decline in ecological condition.

Acknowledgements: The authors wish to acknowledge the efforts of Ms. Elena Hovland to describe social organization of the feral horse population during 1989 and 1990; Ms. Kathy Steven's work on habitat utilization and home range movements during summer 1990 and Mr. Jerry Westfall's continued monitoring of habitat use and home range movements December 1990-March 1991.

Study Area

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

Geology

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

Climate

Climate for Western North Dakota is Continental, characterized by short arid summers (mean July Temperature=22C or 72°F) and long cold winters (mean January Temperature=-11 C or 12°F). Average annual rainfall is about 35.5 centimeters (14 inches) most of which occurs in spring and summer in the form of thunderstorms (Theodore Roosevelt National Park Management Plan and Environmental Assessment, 1984).

Vegetation

Detailed descriptions of vegetation and habitat types in or adjacent to Theodore Roosevelt National Park are given by Nelson (1960), Whitman (1978), Hanson (1980), Girard (1985), and Hirsch (1985). Vegetation in this area is considered to be mixed grass prairie. The combination of mixed grass prairie and the rugged topography of the badlands has resulted in a mosaic of habitat types in Theodore Roosevelt National Park. Norland (1984) used two schemes to describe vegetation in Theodore Roosevelt National Park. A system of physiographic/vegetational classes was developed based on terrain form and vegetational structural characteristics for the Park's South Unit. (Fig.1) The Park was also classified by habitat types. The habitat type system followed Whitman (1978), Hanson et al. (1980), Hirsch (1985), and Girard (1985). Disturbed areas or early stages of succession were classified as mapping units. See Sullivan et al. (1988) for a complete description of physiographic classes, habitat types, and mapping units.

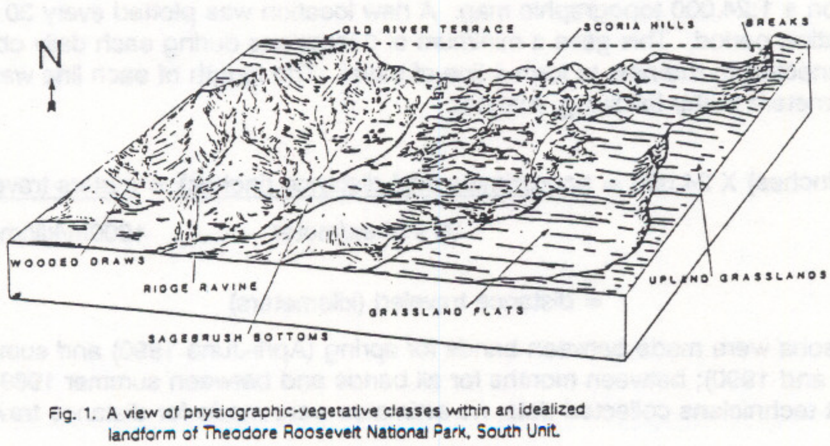

Fig. 1. A view of physiographic-vegetative classes within an idealized landform of Theodore Roosevelt National Park, South Unit.

Land Use

While domestic livestock grazing and mineral development (oil and gas) are principle land uses in the badlands surrounding Theodore Roosevelt National Park, neither use has occurred within the Park since 1947. This country was originally homesteaded in the late 1800's, but the federal government reacquired much of the land following the "dust bowl" years of the 1930's. Land within the Park's boundaries is mostly reacquired farm or rangeland set aside for a state park and recreation demonstration area before the establishment of a national park in 1947.

METHODOLOGY

Horse and Band Identification

During the period from 12 June 1989 until 8 September 1989, harem and bachelor bands were identified. During the period from June 1990 until September 1990 additional band identification was collected. Each group of horses was repeatedly observed with binoculars and/or a spotting scope to identify individuals and determine the sex and age make-up of the bands.

Identification of foals were made in the spring and in the late summer of 1989 and 1990 to determine annual foal survival rate. Foals were not identified in the fall of 1990 and in the winter of 1991 due to changes in field personnel.

Determination of Home Range

Studies involving feral horses have usually reported well defined home ranges for individual bands (Ganskopp and Vavra, 1986). A home range has been defined as the area traversed by an individual or socially cohesive group of animals in the normal activities of foraging, mating, and caring for young (Burt, 1943). To improve the reliability of estimates of home range size and location every effort was made to observe the various bands over a two year period.

During the periods of 12 June 1989 to 8 September 1989 (summer), 3 April 1990 to 28 June 1990 (spring), 2 July 1990 to 6 September 1990 (summer), and 15 January 1991 to 3 April 1991 (winter/spring), the location of each identifiable band was noted on a 1:24,000 topographic map. Efforts were made to locate the identified bands six to eight times during a specific 30 day period during spring, summer, and winter. Home ranges were approximated by connecting the outermost locations of a particular band until a polygon containing all sightings for that seasonal period was constructed. Each home range was further refined by grouping all polygons for each band for spring, summer, and winter.

Monitoring Daily and Seasonal Movements

Distance traveled by individual bands during daylight hours was estimated by plotting each band's location on a 1:24,000 topographic map. A new location was plotted every 30 minutes during the daily observation period. This gave a minimum of 6 locations during each daily observation. Each location was connected to the next to form a line of travel. The length of each line was measured and converted to kilometers in the following manner;

$$\text{map distance (inches)} \times 24{,}000 = \frac{\text{approximate field distance (inches)}}{\text{39 inches/meter}} = \frac{\text{meters traveled}}{\text{1000m/kilometer}}$$

$$= \text{distance traveled (kilometers)}$$

Comparisons were made between bands for spring (April-June 1990) and summer (July-September 1989 and 1990); between months for all bands and between summer 1989 and 1990. Because different technicians collected data, no estimates were made for distance traveled during the winter period. Mean differences in daily movements between bands and for all bands between seasons and between 1989 and 1990 were tested for significance at the p=.05 level with a one-way analysis of variance (ANOVA).

Habitat Use Patterns

The primary method for assessing habitat use was observation. During the observation periods, activity and habitat type used by bands were noted at 5 minute intervals. Horses were observed with 7 X 35 mm binoculars and a 15-60X spotting scope.

The following information was collected at 5-minute intervals during the observation period: 1) the location of the horses (plotted on 1:24,000 topographic maps); 2) the number of stallions, mares, and foals in the band (except for spring and winter 1991); and 3) the activity and habitat use of the band. Activity was classified as grazing, resting, traveling, and other (grooming, breeding, defecating, socializing).

Use of plant communities and cover types were defined as horse-minutes spent in individual physiographic habitat types following the classification system developed for Theodore Roosevelt National Park by Norland (Marlow et al. 1984). Availability of habitats were based on estimates developed by Marlow et al. (1984) and further refined by Norland (1988). The relative quality of habitats used by horses for feeding were assessed on the basis of availability of seasonally preferred forage (Sullivan, 1988; Westfall, 1989) and foraging behavior. Intensity or level of use in habitats and landforms repeatedly used by horses was described through horse minutes per site.

Food Habits and Horse Carrying Capacity

Horse food habits or diet was based on collections of fresh horse feces by Sullivan (1988) and Westfall (1989).

Methods used in calculating feral horse carrying capacity in TRNP were the same as those used by Marlow et al. (1984) for bison in TRNP and by Sullivan et al. (1988) and Westfall (1989) for elk in TRNP. In all cases the following formula was used.

$$\frac{TAPj \times AUFj}{PDj \times Yl} = \text{No. of Horses/Year}$$

Where:

j = the value for the species or plant type under consideration

TAP = Total Annual Production for each species or plant type for an average year

AUF = Allowable Use Factor - (the amount of plant material which can be grazed without affecting plant survival)

Yl = the amount of forage consumed by an average animal throughout the growing season

PD = percent of the animal's diet the plant species of interest contributes during the growing season

Estimates of carrying capacity were based on plant species that comprised >3% of the growing season diet. Total annual production for common graminoids, forbs, and shrubs have been calculated for habitat types in TRNP by other researchers. These values are given in Marlow et al. (1984), Sullivan et al. (1988), and Westfall (1989).

An allowable use factor (AUF) of 0.5 (50% utilization) is used for most livestock grazing schemes (Sampson, 1952, Bell 1973). Because maintenance of the Park vegetation rather than maximization of animal numbers was the primary objective of the carrying capacity estimate, a conservative AUF of .35 was used (Kipple, 1964). Because the assigned AUF is conservative and diet values were for the growing season only, no attempt was made to account for variable forage production due to drought. The overall health and vigor of preferred forages should be maintained by limiting horse, elk and bison numbers to a level that will not remove excessive plant material during the critical growing season.

The growing season forage intake of an average feral horse in TRNP was determined by calculating the weight of an average horse in the park and estimating how much forage a horse of this size would consume (Westfall, 1989). In developing an estimate of horse intake it was assumed the average mature horse would weigh 442 kg (972 lbs). This weight was multiplied by 2.5% to arrive at an average daily intake. Average daily intake was multiplied by 180 days to represent horse intake over the vegetative growing season.

Carrying capacity was calculated for primary (physiographic classes used more than availability) and secondary (physiographic classic used in proportion to their availability) foraging areas. Those classes used less than their apparent availability to the horses were not included in the calculations. Percent of time spent in either physiographic classes or habitat types during each season were compared with the percent of that type or class available in the southeastern and eastern portions of the Park (Sullivan, 1988). Differences in availability and use of physiographic classes were tested using Bonferroni's inequality test (Byer's et al 1984) at the p=.05 significance level. Total production for forage items was calculated by multiplying production/ha times the area for each habitat type or mapping unit within the southeast and eastern part of Theodore Roosevelt National Park. These values were then summed for production on primary and secondary ranges divided by daily horse intake.

RESULTS AND DISCUSSION

Horse and Band Identification

The number of bands and the total feral horse population in TRNP increased during the study (Tables 1 and 2). Results from summer 1989 field observations indicated that there were 8 bands and unattached individuals totaling about 72 horses. During spring 1990 two additional bands were identified and the minimum estimate of horses had increased to a total of 90. Low estimates in summer 1990 coupled with seasonal changes in band distribution indicates summer counts are probably the least accurate measure of horse populations in the Park. During the course of this study horses converged on the Boicourt Springs - Limbo Flats area during late May and June, this made viewing relatively easy and all bands could generally be seen. However, as the summer progressed, some bands or subgroups of larger bands appeared to disperse into the drainage of upper Paddock Creek. The winter of 1991 census suggested continued dispersal and fragmentation of bands throughout the January to March period. Consequently, the most consistent estimates of feral horse numbers were made during the May to June period when the bands were using the Boicourt Springs-Limbo Flats area.

The feral horses in TRNP were herded into a capture corral in the fall of 1991 for the purpose of reducing the herd size. At this time there were 15 bands comprised of 112 horses. This increase of 21 horses was probably due to the 1991 crop of 22 foals (Appendix A). Despite observations from the summer of 1990 that foal mortality appeared to be highest during the first 4-6 weeks of life (5 foals died during the summer of 1990), there may have been as much as a 56% increase in the number of feral horses in TRNP. The actual increase may be lower because the 1989 count may have underestimated the horse population. The low mortality among adult horses indicates that increase an horse numbers can occur even with the level of observed foal mortality. Consequently, unchecked horse population growth could have a significant impact on the vegetation community and ultimately other herbivore populations.

Table 1. Size of feral horse bands in TRNP during field observation in 1989 and 1990.

Band	Summer 89	Spring 90	Summer 90
Brookman	17	15	14
Painted	10	10	10
Target	12	17	14
Blue Roan/Arab	6	5	5
Red Roan	9	8	8
Iron Grey	3	7	7
Bad Black	6	10	11
Boys Club	7	13	9
Painted Canyon Son	1	2	a
Little Roan	1	3	a
Total	72	90	78

[a]These small bands were not relocated after June, 1990

Table 2. Size of feral horse bands in TRNP during field observations in 1991[a]

Band	Winter 91
1	15
2	4
3	8
4	6
4A	3
5	11
6	2
7	11
9	2
10	5
11	5
12	12
13	4
14	3
Total	91

[a]Identification of bands was modified due to a change in field personnel

Home Range and Seasonal Movement

Feral horses in TRNP did not exhibit distinctly separate home ranges. The use patterns displayed in Figures 2, 3, and 4 represent multi-band occupation of the same locations. These ranges are much smaller than those used by feral horses in southeastern Oregon (Ganskopp and Vavra, 1986). Aggressive behavior leading to displacement of one band by another was uncommon away from watering points. Horses ranged east of a line anchored on the Boicourt Springs to the north and the Badlands Scenic Overlook to the south. This eastern third of the Park produced all of the band sightings from July 1989 to March 1991. Size of multi-band ranges was greatest during the winter period (Figure 4) and least extensive during the summer (Figure 3). The limited size of areas used by horse bands during June through September of both years coincide with reliable water sources at Boicourt, Sheep Butte, and Southeast Corner Springs. Constriction of use areas during the summer was also reflected in the distance horses traveled during daylight hours.

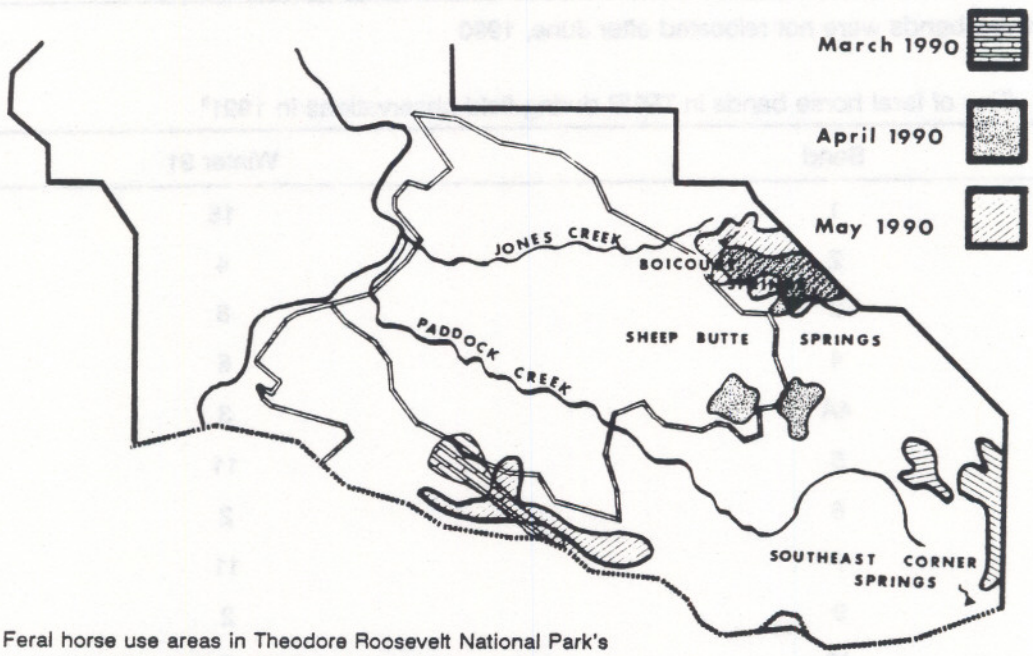

Fig. 2. Feral horse use areas in Theodore Roosevelt National Park's south unit during March, April and May 1990.

In July and August of 1989 horses traveled about 1.3 km (.9 miles) and 1.8 km (1 mile) daily (Figure 5). However, the same bands traveled slightly less in July 1990 and significantly less ($p<.01$) in August 1990 (Figure 5). Comparison of daily travel from April 1990 to September 1990 indicates that horses moved less during July and August than the spring (Figure 6). This matches the concentration of use by all bands in a few, small home range areas during summer months (Figure 3).

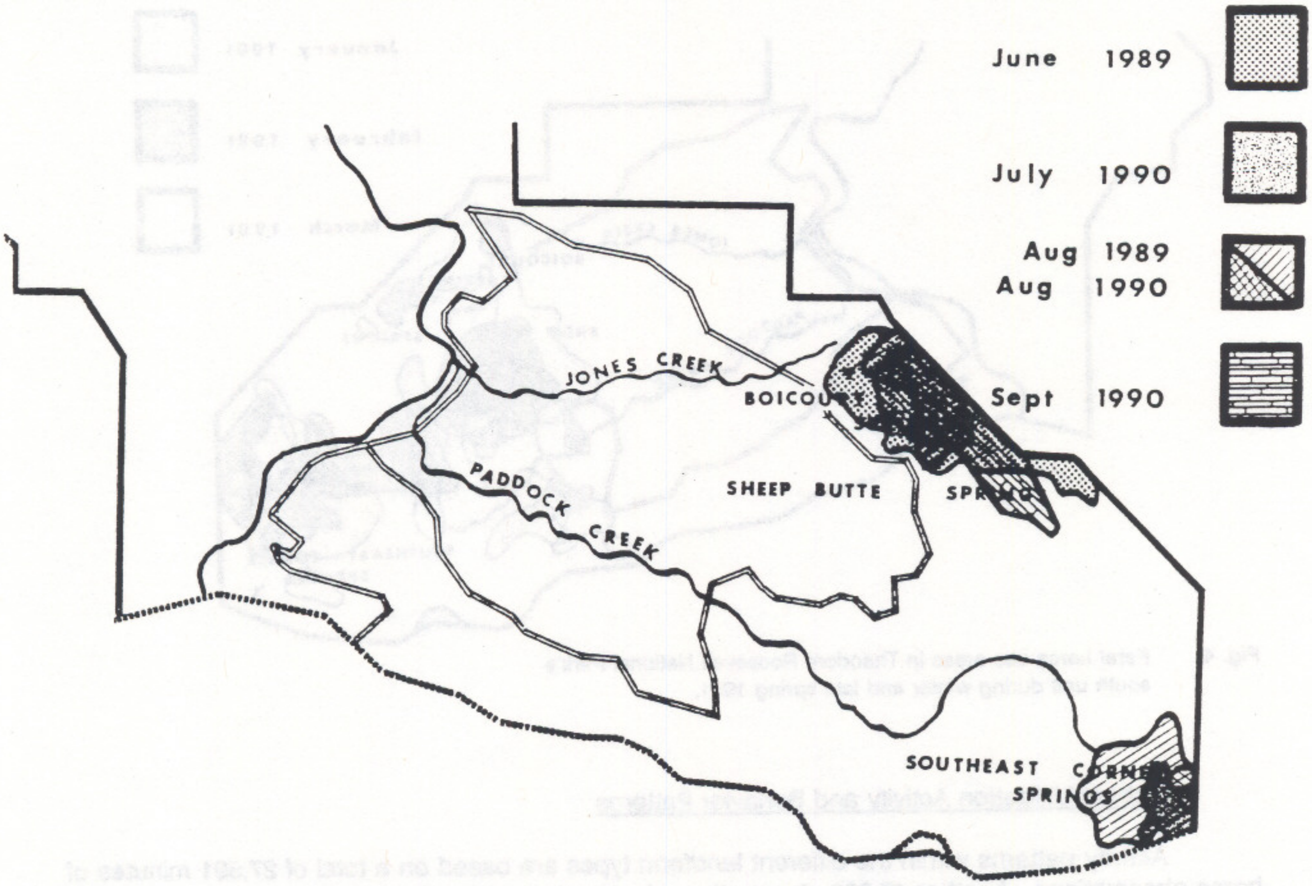

Fig. 3. Feral horse use areas in Theodore Roosevelt National Park's south unit during the summers of 1989 and 1990.

There was not a significant difference (p=.91) between individual bands in daily travel for any period other than spring 1990. The Iron Grey brand traveled less than the other seven bands (1.0 km vs. 1.5 km) [.6 miles vs. 1 mile] during the time from early April to late June 1990.

The limited distribution of horses within TRNP is in sharp contrast to the more widespread use patterns noted for elk (Sullivan, 1988; Westfall, 1989) and bison (Marlow et al., 1984). Although other factors, such as human disturbance, may contribute to the small home range size, the close affinity to springs during July, August, and September coupled with limited daily travel during the same period suggests that the availability of higher quality water has a pronounced effect on habitat utilization by horses. Observations of dispersal and band fragmentation during the winter and spring when snow and melt-water runoff provide additional sources of high quality water further strengthens this argument.

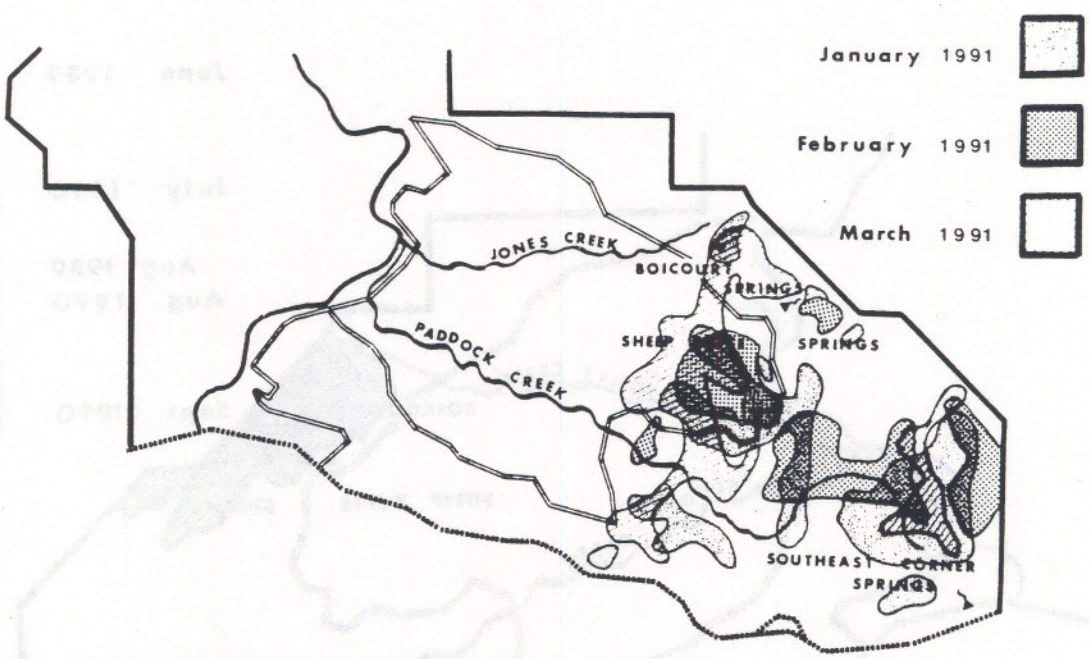

Fig. 4. Feral horse use areas in Theodore Roosevelt National Park's south unit during winter and late spring 1991.

Habitat Utilization Activity and Behavior Patterns

Activity patterns within the different landform types are based on a total of 27,591 minutes of horse observations. Another 48,000 observation minutes deal with individual horse activities and social behavior and will not be reported here.

Grazing and resting were dominant diurnal activities (Table 3). Recorded horse minutes indicated that horses spent 55% of their time grazing and 32% of their time resting. Ten percent of the recorded horse minutes showed the horses traveling while other behaviors such as grooming, breeding, socializing, and defecating only accounted for approximately 2% of the activity budget. Grazing was predominated during late afternoon, accounting for nearly 3 out of every 4 recorded minutes. Grazing also accounted for the majority of recorded minutes during the early morning. Time spent resting peaked during the late morning while time spent traveling and other activities remained fairly constant throughout the day.

Table 3. Daily activity of feral horses in Theodore Roosevelt National Park 1989-1991.

Time[a]	Grazing		Resting		Traveling		Other	
	mins.	%	mins.	%	mins.	%	mins.	%
Early AM	6751	54.8	3905	31.7	1361	11.0	306	2.5
Late AM	3285	47.8	2740	39.9	684	9.9	166	2.4
Early PM	3152	56.6	1715	30.8	486	8.8	212	3.8
Late PM	2009	71.0	419	14.8	353	12.5	47	1.7
Daily	15197	55.1	8779	31.8	2884	10.5	731	2.6

[a] Early AM 5:00-9:30, Late AM 9:35-12:00, Early PM 12:05-14:30, Late PM 14:35-17:00.

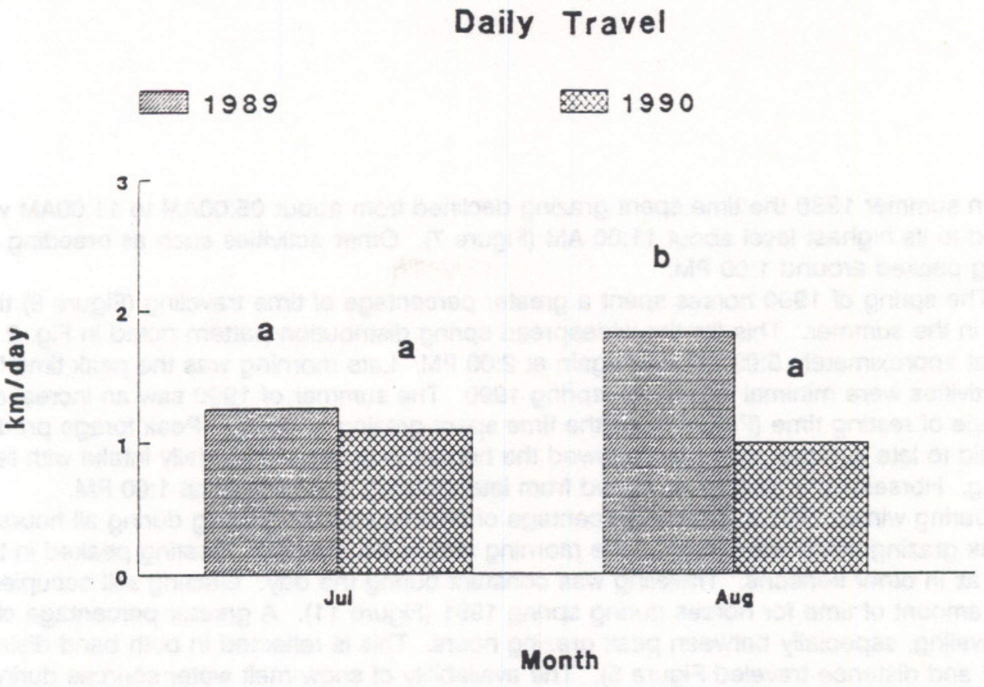

Fig. 5. Average distance (kilometer per day) feral horse bands moved on a daily basis during July and August of 1989 and 1990. Bars with different superscripts are statistically different at the p=.05 level. Values represent the mean of all bands.

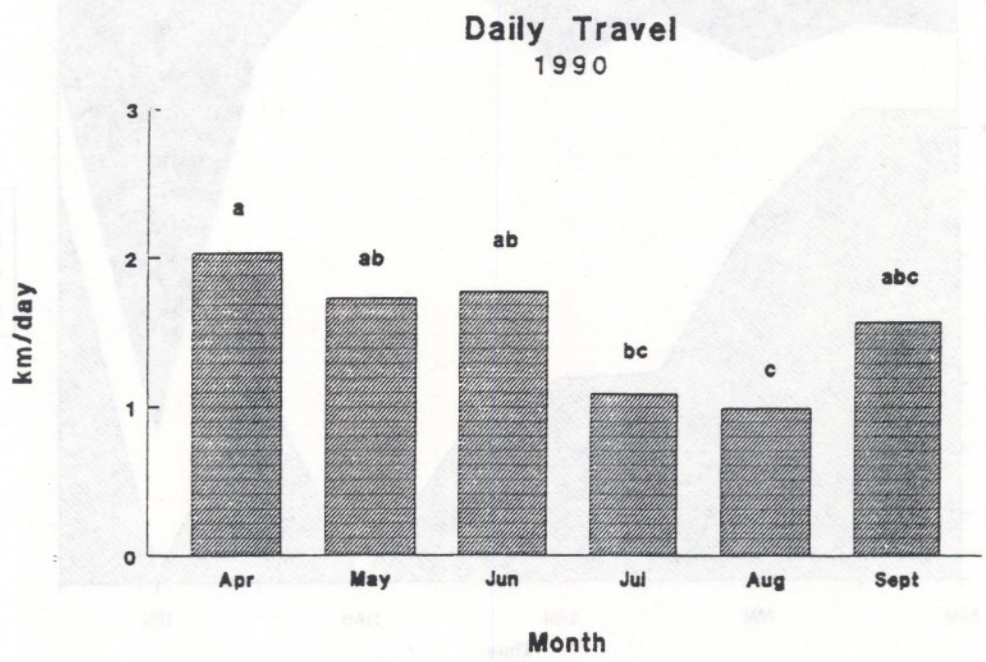

Fig. 6. Average distance (kilometers per day) feral horse bands moved on a daily basis during the spring and summer of 1990. Bars with different superscripts are statistically different at the p=.05 level. Bars with the same letters are not different. Values represent the mean of all bands.

In summer 1989 the time spent grazing declined from about 05:00AM to 11:00AM while resting increased to its highest level about 11:00 AM (Figure 7). Other activities such as breeding and grooming peaked around 1:00 PM.

The spring of 1990 horses spent a greater percentage of time traveling (Figure 8) than they did later in the summer. This fits the widespread spring distribution pattern noted in Fig. 2. Traveling peaked at approximately 5:00 AM and again at 2:00 PM. Late morning was the peak time for resting. Other activities were minimal during the spring 1990. The summer of 1990 saw an increase in the percentage of resting time (Figure 9) as the time spent grazing declined. Peak forage production during mid to late summer may have allowed the horses to achieve their daily intake with fewer hours of grazing. Horses' time resting increased from late morning and peaked at 1:00 PM.

During winter 1991 a greater percentage of time was spent grazing during all hours (Figure 10). Peak grazing times were early in the morning and in the evening. Resting peaked in the late morning as in other seasons. Traveling was constant during the day. Grazing still occupied the greatest amount of time for horses during spring 1991 (Figure 11). A greater percentage of time was spent traveling, especially between peak grazing hours. This is reflected in both band distribution (Figure 2 and distance traveled Figure 5). The availability of snow-melt water sources during warm periods and newly emerged vegetation in late March my have encouraged horses to be more selective in their grazing locations. Greater selectivity is one factor that would require horses to travel more and cover larger areas.

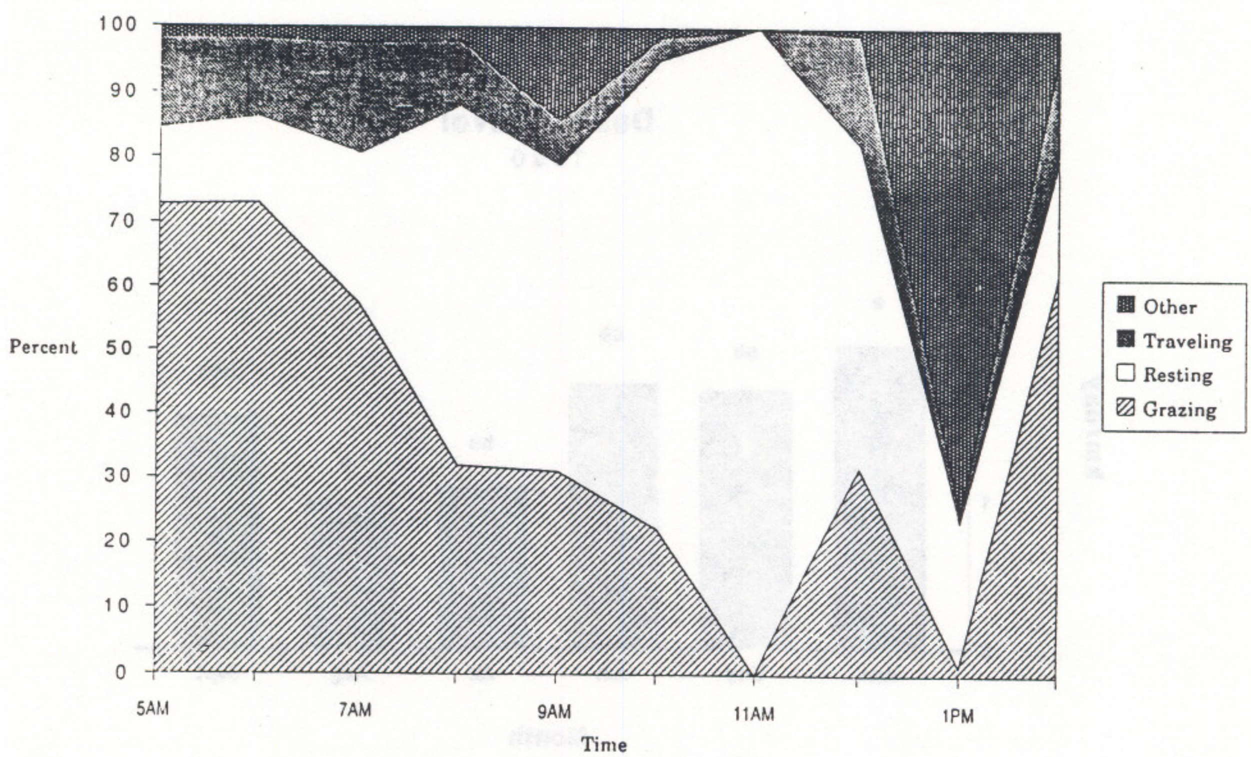

Fig. 7. Percent of horse minutes spent grazing, resting, traveling, and other in TRNP in summer of 1989.

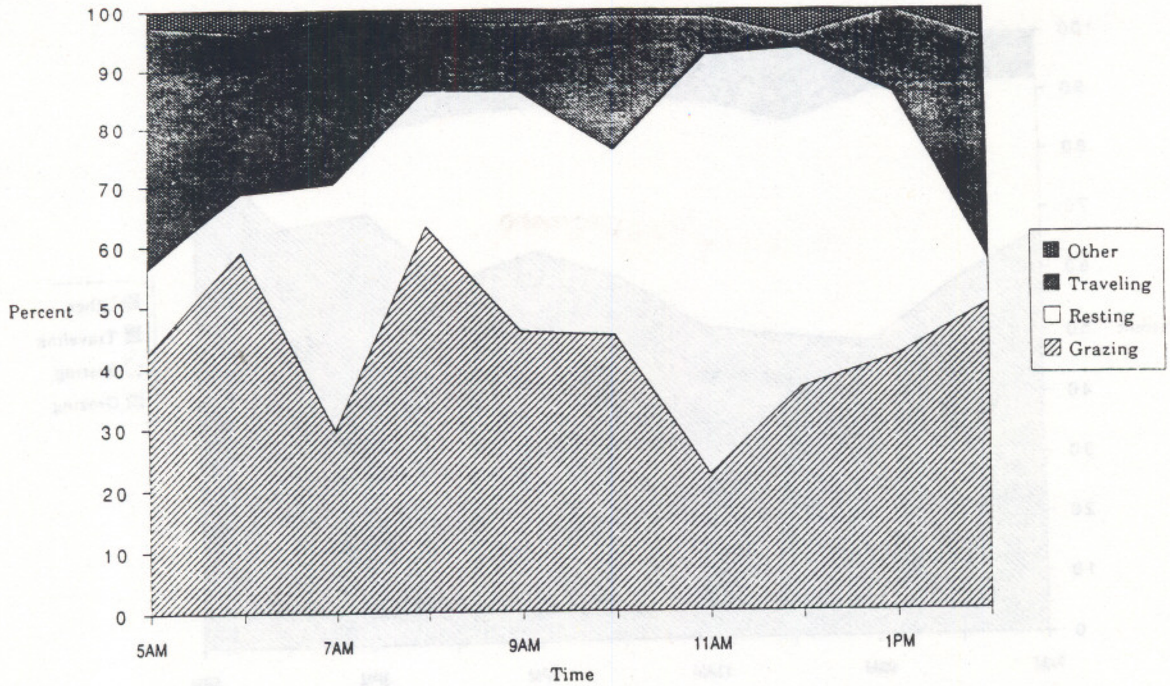

Fig. 8. Percent of horse minutes spent grazing, resting, traveling, and other in TRNP in spring of 1990.

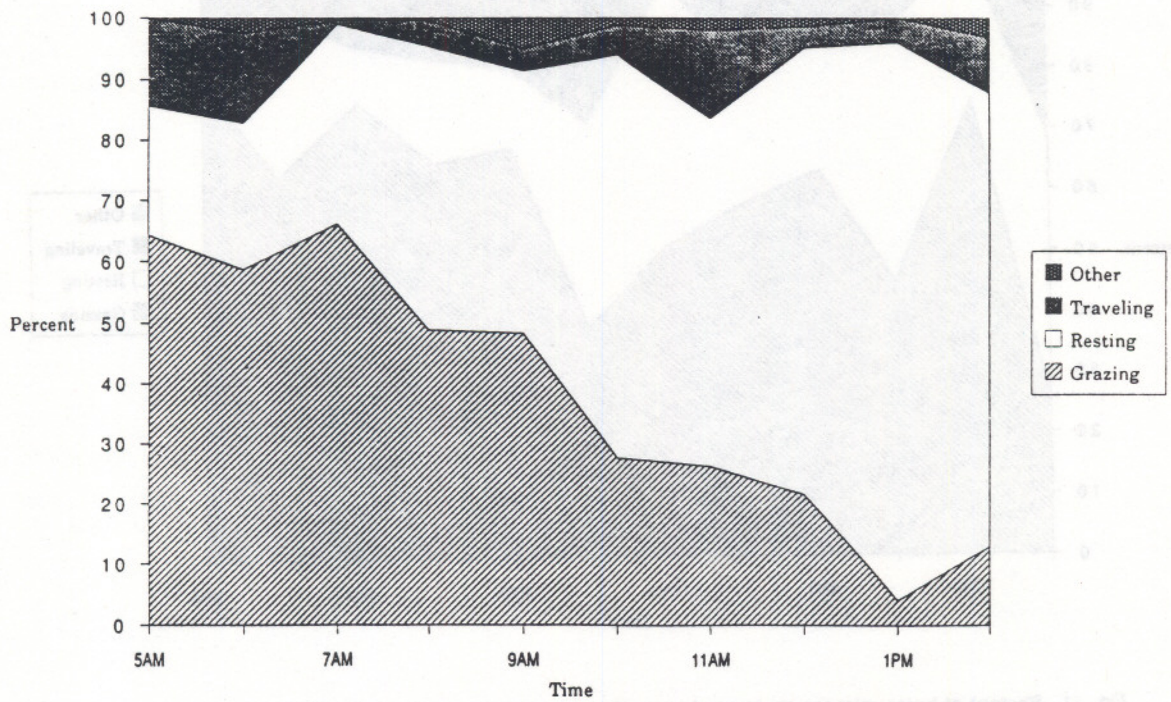

Fig. 9. Percent of horse minutes spent grazing, resting, traveling, and other in TRNP in summer of 1990.

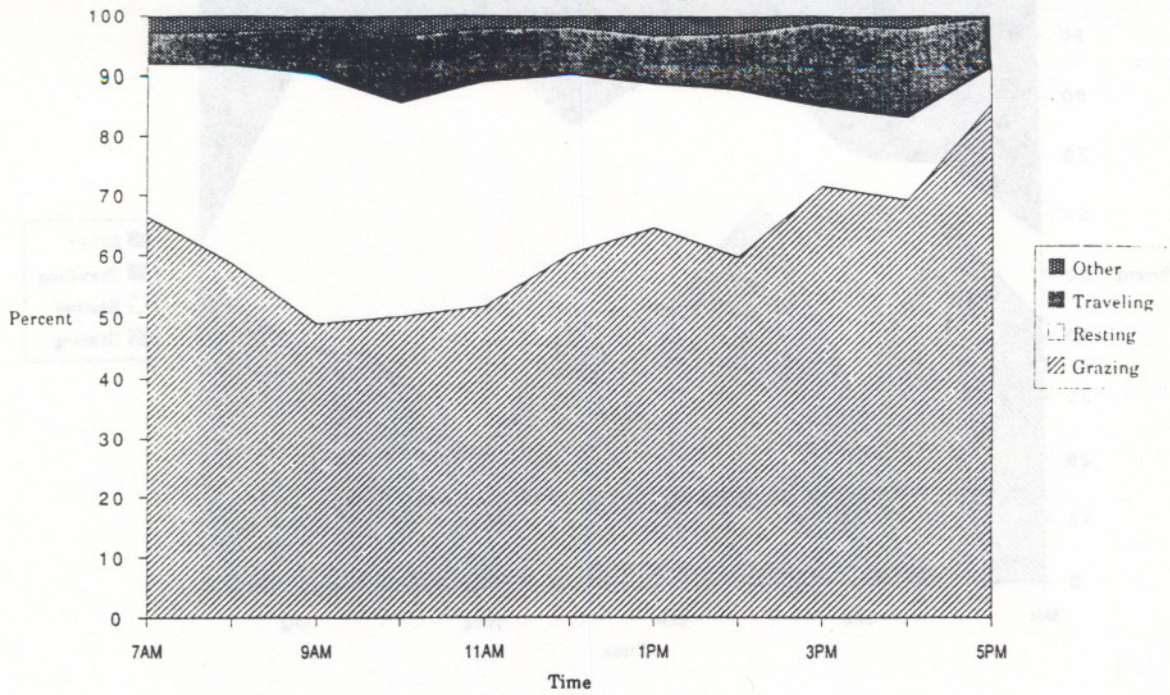

Fig. 10. Percent of horse minutes spent grazing, resting, traveling, and other in TRNP in winter of 1991.

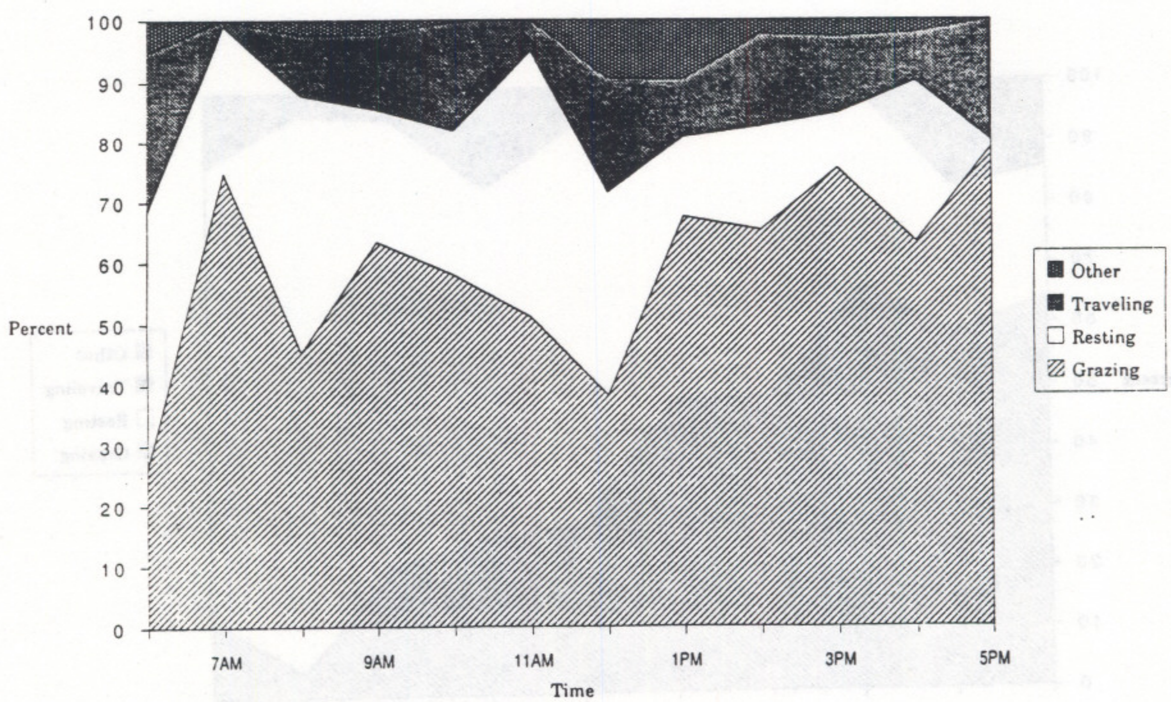

Fig. 11. Percent of horse minutes spent grazing, resting, traveling, and other in TRNP in spring of 1991.

Habitat Use

The percent of horse minutes spent in each physiographic class for all seasons and for habitat types during winter and spring 1991 was calculated for all horses. Diurnal habitat use was calculated from direct observations of feral horses. The preferred habitat type was the Agropyron smithii - Stipa viridula HT with the rolling scoria complex being the second most preferred HT (Table 4). Upland grasslands and grasslands flats were the most preferred landform types (Table 5).

Table 4. Percent diurnal habitat use of feral horses and percent available in Theodore Roosevelt National Park for winter and spring 1991.

Habitat Type	Percent Park Covered	Horse Minutes	Percent Use
Artemisia cana[a]	5	791	4.4
Bare ground	tr	141	.8
Artemisia tridentata - Boureloua	1	352	2.0*
Hardwood draws	2	16	.1*
Schizachyrium scoparium - Juniperus horizontalis	2	59	.3*
Schizachyrium scoparium	5	1206	6.7*
Prairie Dog Town	1	59	.3
Rolling scoria complex	11	3124	17.4*
Artemisia tridentata - Atriplex confertifolia	2	129	.7*
Stipa comata - Bouteloua gracilis	2	121	.7*
Steep scoria complex	15	637	3.5*
Agropyron smithii - Stipa viridula	17	10800	60.1*
Agropyron smithii - Stipa comata	2	540	3.0

[a]Common plant names are given in Table 26 of Appendix E.
* Indicates a difference between use and availability at the 0.5 level of significance.

Table 5. Percent diurnal landform use by feral horses compared to the percent of that landform available in Theodore Roosevelt National Park 1989-1991 for all seasons (including two summers and two springs).

Physiographic Class	Percent Park Covered	Horse Minutes	Percent Use
Breaks	24	1153	4.2*
Grassland flats	14	8700	31.5*
Prairie dog town	1	557	2.0
Ridge & ravine	14	250	.9*
Sagebrush bottoms	5	1049	3.8*
Scoria Hills	33	4228	15.3*
Upland grasslands	7	11654	42.2*

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

Diurnal habitat use for all seasons was compared with availability of habitat types and physiographic classes on the east side of the Little Missouri River (Tables 4 and 5). Differences between availability and use were significant ($p<.05$) for both habitat types and physiographic classes. Most habitat types and physiographic classes were utilized disproportionately relative to availability. For example, upland grasslands comprised only 7% of the land area within the Park but experienced 42% of the day time horse use (Table 5). This could be an artifact of the fidelity of feral horses to the southeastern and eastern portions of the Park's South Unit.

Feral horse proportional use of habitat types and physiographic classes when analyzed separately for grazing, resting, and traveling were approximately the same as total horse use of habitat types and physiographic classes. A detailed breakdown of these activities and the related landforms can be found in Appendix B.

Seasonal Habitat Use

Use of physiographic classes was determined for summer 1989, spring 1990, summer 1990, winter 1991, and spring 1991. The starting and ending dates for each season, the number of days the horses were observed, and the number of feral horse minutes recorded are shown in Table 6. Habitat type was only recorded during winter and spring 1991. The percentages of feral horse minutes spent grazing, resting, and traveling during each season are given in Appendix C for habitat types and physiographic classes.

Table 6. The number of days feral horses were under observation and the total minutes of observation for each season of the study.

Season	Starting Date	Ending Date	Observations Days	Observations Minutes
Summer 1989	June 19	August 31	45	4171
Summer 1990	June 16	September 6	29	2365
Spring 1990	April 3	June 15	36	3080
Spring 1991	March 15	April 22	10	2933
Winter 1991	January 8	March 15	42	15042
Total			162	27591

A relatively small number of physiographic classes were utilized in summer 1989 when horses were concentrated in the southeastern corner of the South Unit (Table 7). Over three-quarters of the horse minutes in summer 1989 were spent in the upland grasslands physiographic class. The grassland flats physiographic class accounted for the majority of the remaining horse minutes.

Table 7. Percent of diurnal feral horse minutes observed in physiographic classes for two summers (1989 and 1990), two springs (1990 and 1991), and one winter (1991). The number of horse minutes recorded during each season are shown in parentheses.

	Season				
Physiographic Class	Sum. 89 (4171)	Spr. 90 (3080)	Sum. 90 (2365)	Win. 91 (15042)	Spr. 91 (2933)
Breaks	0.0	0.0	0.0	2.7	25.4
Grassland flats	17.6	51.7	36.6	32.6	20.7
Prairie dog town	0.0	4.6	17.6	0.0	0.0
Ridge & ravine	1.8	0	0.0	1.2	0.0
Sagebrush bottoms	3.3	16.3	1.5	2.5	0.0
Scoria hills	0.0	11.2	0.0	19.4	32.8
Upland grasslands	77.3	16.2	44.3	41.6	21.1

The number of physiographic classes utilized by horses increased in spring of 1990. Horses began to utilize the scoria hills and prairie dog town physiographic classes and were not sighted in the ridges and ravine class. This probably reflects the greatest home range extension of horses and may be due to the closure of the Loop Road during this period as well as the availability of higher quality water from snow melt. Grassland flats replaced upland grasslands as the most heavily used class.

In summer 1990 there was a decrease in the number of physiographic classes utilized. As was the case in summer 1989, feral horses did not utilize the scoria hills landform. Upland grasslands was the most heavily used physiographic class again during the summer. However, it was not as heavily utilized in summer 1990 as it was in summer 1989. Horses continued to heavily utilize the upland grasslands and grassland flats landforms during winter 1991. As was noted in spring 1990, the horses crossed the Loop Road and utilized the scoria hills physiographic class extensively.

Spring 1991 saw the first extensive use of the breaks physiographic class by feral horses. In addition, horses continued to utilize upland grasslands and grassland flats. Scoria hills replaced upland grasslands and grassland flats as the most heavily used landforms. Exclusive of the shift towards the scoria hills landform in spring 1991, the similarities in use patterns noted during summer 1989 and 1990 and spring 1990 and 1991 suggests we encountered the full spectrum of feral horse use patterns in the South Unit.

Observation of habitat type use in winter and spring 1991 (Table 8) indicated that a small number of habitat types were used during the winter. The most heavily used habitat types were Agropyron smithii - Stipa viridula HT and rolling scoria complex. In the spring there was an increase in the number of habitat types used by horses. The Artemisia tridentata - Bouteloua gracilis HT and Schizachyrium scoparium HT saw increased use as well as continued use of the Agropyron smithii - Stipa viridula HT (Table 8) and rolling scoria complex.

Table 8. Percent diurnal habitat use by feral horses in Theodore Roosevelt National Park for winter and spring 1991. Total observation minutes recorded per season is in parentheses.

Habitat Type	Winter 91 (15042)	Spring 91 (2933)
Artemisia cana	5.3	0
Bare ground	0.8	0.6
Artemisia tridentata - Bouteloua gracilis	0.1	11.5
Hardwood draws	0.1	0
Schizachyrium scoparium - Juniperus horizontalis	0.1	1.5
Schizachyrium scoparium	5.5	12.9
Prairie dog town	0	2.0
Rolling scoria complex	15.1	29.1
Artemisia tridentata - Atriplex confertifolia	0.5	2.1
Stipa comata - Bouteloua gracilis	0.3	2.4
Steep scoria complex	4.0	1.1
Agropyron smithii - Stipa viridula	66.1	29.3
Agropyron smithii - Stipa comata	2.1	7.8

Upland grasslands and grassland flats were heavily used for feeding during all seasons. Upland grasslands were most often used for grazing during the summer and winter while grassland flats had greater use for grazing during the spring. During spring and winter the scoria hills landform was also used extensively for feeding.

The Agropyron smithii - Stipa viridula HT within both physiographic types was used most often for grazing, especially during the winter. The rolling scoria complex also contained two other types, Artemisia tridentata - Bouteloua gracilis HT and Schizachyrium scoparium HT which experienced increased grazing use during the spring. Use of habitat types and physiographic classes by season for the different times of day can be found in Appendix D.

Herbivore Competition for Habitat Use

Greatest similarity in the use of physiographic classes occurred between feral horses and elk (Table 9). Both of these ungulates utilized grassland flats and scoria hills as primary and secondary ranges respectively. Elk and horses differed in their most preferred physiographic class with elk preferring the breaks landform while horses favored the upland grassland class. This difference may exist because elk seek hiding cover (breaks) while horses rely on eyesight and open terrain to avoid enemies. Bison, elk, and horses all preferred the scoria hills physiographic class as secondary range. Bison utilized the grassland flats at a level similar to elk but slightly less than horses. Bison appeared to used the South Unit more uniformly than elk and horses.

Table 9. Percent diurnal use of physiographic classes by large herbivores in Theodore Roosevelt National Park. The number of minutes collected for elk, bison, and feral hoses are in parentheses. Horse, elk, and bison observations are from this study, Sullivan et al (1988) and Westfall (1989).

Physiographic Class	Feral Horses (27591)			Elk (104813)		Bison (298016)	
	1991	1989	1988	1989	1988	1989	1988
Breaks	4	5	3	40	40	3	3
Grassland flats	32	31	29	9	30	13	8
Prairie dog town	2	0	1	<1	1	25	18
Ridge & ravine	1	2	6	2	6	14	6
Sagebrush bottoms	4	2	1	1	1	12	9
Scoria hills	15	17	5	21	9	14	10
Upland grasslands	42	44	54	27	14	17	7

The close agreement between observations carried out form 1989 to 1991 suggests that the multiple observers used in this study did not overtly bias data collection on habitat use.

Similarity in habitat use by elk and horse in TRNP could impact plant species and communities preferred by both ungulates. Because both species prefer habitat types found within the grassland flats and upland grasslands, high populations of elk and feral horses could lead to rapid changes in plant communities. This also suggests that several drought years during periods of moderate population levels for either species could also lead to undesirable shifts in floristic composition.

Carrying Capacity

Because of the consistent and relatively intense use of upland and grassland flat physiographic classes by feral horses with TRNP, the carrying capacity estimates for this ungulate species are based on total annual forage production in only the portions of these classes within the eastern, northeastern, and southeastern sectors of the Park's south unit (Sullivan et al., 1988). Actual values used were derived largely from the Agropyron smithii-Stipa viridula and rolling scoria habitat types falling within the primary use physiographic classes, upland grasslands and grassland flats, and secondary use area, the scoria hills physiographic class. Forage production estimates did not include all of the potential forage from all the preferred primary and secondary classes within the south unit because horse use was restricted to the eastern third of the park. The initial calculation of horse carrying capacity is shown in Table 10. Even though the figures suggest the potential for relatively high horse numbers (2,175 head based on Bouteloua gracilis production) this information must be interpreted with caution.

Carrying capacity estimates derived from Bouteloua gracilis, Schizachyrium scoparium, and Muhlenbergia cuspidata production levels are inflated because of the low proportion of the horses' diet that these species contribute; 40 kg (88 lbs) intake, 60 kg (132 lbs) intake, and 20 kg (44 lbs) intake respectively. When the high production levels of each graminoid species are divided by such low intake levels it appears that the eastern third of the Park could support substantial horse numbers. What these estimates of carrying capacity actually indicate is that neither of these three grass species is likely to be overgrazed by horses. The grasses and grass-like species which are likely to be most negatively effected by horse use are the ones which make up a relatively large component of the horse diets throughout the plant growing season.

Table 10. Initial feral horse carrying capacity of Theodore Roosevelt National Park's South Unit.

Forage Species[a]	TAP[b]	AUF	PD	Intake	Horses per year
Agropyron cristatum	39,153	.35	.06	1988	115
Agropyron smithii	537,045	.35	.16	1988	590
Bouteloua gracilis	247,189	.35	.02	1988	2175
Carex ssp	41,685	.35	.15	1988	49
Muhlenbergia cuspidata	11,360	.35	.01	1988	200
Poa ssp	46	.35	.01	1988	1
Schizachyrium scoparium	57,364	.35	.03	1988	336
Stipa comata	97,007	.35	.19	1988	89
Stipa virdula	57,241	.35	.07	1988	144

[a]Common plant names can be found in Table 26 Appendix E

[b]TAP=total annual production (kg). AUF=allowable use to accommodate both plant vigor and grazing by elk and bison PD=percent of horse diet made up by this species, Intake (kg)=volume of forage consumed by one feral horse weighing 442 kg during a six month period when forage species are actively growing.

Agropyron smithii (0.16 x 1988 kg = 318 kg intake), Carex ssp. (298 kg intake), Poa ssp. (278 kg intake), and Stipa comata (378 kg intake) are preferred by horses and importantly, bison as well as elk (Westfall, 1989). Because these graminoids make up a substantial portion of horse diets the carrying capacity estimates developed from their respective forage production values are more biologically accurate. Estimates from Table 10 suggest there could be as many as 590 horses (Agropyron smithii) to as few as 49 (Carex ssp). However, should horse numbers be allowed to increase to the upper bound set by Agropyron smithii there is a very real likelihood that Carex ssp., Poa ssp., Stipa comata, Stipa viridula, and even Schizachyrium scoparium would be overgrazed in the vegetative community of the Park's eastern third. The probability of a decline in vegetative diversity is even greater when the cumulative impacts of bison and elk use of the same forage species are considered. Even though Westfall (1989) refined the forage allocation model used in earlier studies of the Park's large herbivores (Marlow et al., 1984; Sullivan et al., 1988), to include horse and bison use when determining optimum elk numbers, horses exhibit several habitat use patterns that make a reciprocal calculation extremely complex.

Marlow et al. (1984) reported a wide-spread distribution of bison within the entire south unit of TRNP. Sullivan et al. (1988) reported a restricted but potentially expanding area of elk influence and Westfall (1989) confirmed that elk range covered more of the preferred habitat than previously recorded. Observation and mapping of horse use indicated that horses used a small portion of the habitat available to them and concentrated their use in a few localities. Horse use also appeared to be much more restricted by the availability of water from springs than the use patterns of either bison or elk. This restricted use pattern makes forage allocation to other herbivores in the immediate vicinity of the Boicourt, Sheep Butte, and Southeast Corner Springs rather academic. Horses will probably graze all of the forage assumed to be useable under the concepts of "allowable use" (Kipple, 1964; Bell, 1973) and the conservative approach of allocating the entire years's forage from on growing season consumption may still not account for all of the grazing use forage species experience. Grazing by elk and bison occupying the same areas will probably be additive and lead eventually to overgrazing. Consequently, carrying capacity estimates for horses must be based on those forages with the greatest likelihood of being overgrazed.

Because the most limiting forage species for horse carrying capacity are Carex ssp., Poa ssp., and Stipa comata (Table 10), a long term average of 49 head would be necessary to assure a minimal impact on the vegetative diversity of the Park's eastern third. While the lower bound of this long term average should be dictated by viewing opportunities and genetic diversity within the horses themselves, the upper bound should not exceed the potential set by Stipa comata productivity for periods longer than about two years. Horse numbers greater than 90 head for two or more years would begin a process of declining health and vigor in Carex and Poa species. Another supporting argument for feral horse population of 49-50 individuals is that it appears to be in balance with the optimal elk population suggested by Westfall (1989).

SUMMARY AND RECOMMENDATIONS

Horse numbers in the South Unit of TRNP prior to October 1991 were approximately 90 head (lowest count 72, highest count 112). Reproductive success has been high even though foal survival rate appears low. The majority of foal mortality occurs in the first 4 to 6 weeks of life. There after long term survival is quite high and the total population can increase steadily.

This population did not display distinct home ranges nor was habitat use segregated by band. The composition of bands was constant with little exchange of members among bands. During the late spring and summer horse bands were concentrated in the southeastern part of the Park near the Boicourt, Sheep Butte, and Southeast Corner Springs. Bands or fragments of bands crossed the Loop Road and utilized the scoria hills physiographic class along Paddock Creek only during the winter and the early spring. In February and March 1991 several bands moved westward along the interstate boundary to a point roughly south of the Badland Turnout on the Loop Road. However, by April 1991 all horse sightings were again to the eastward as they had been in April 1990.

Feral horses utilized a limited variety of habitat types. Only when the horses crossed the Loop Road did their utilization of different habitat types increase and this use was concentrated in a mosaic of types comprising the rolling scoria complex. As spring progressed, horse use generally shifted back to the southeast corner of the Park. Upland grasslands were heavily utilized during the first summer for grazing and resting. Some use of the grassland flats was also noted during the first summer. These two physiographic classes provided horses with forage and easy access to water. Horses did not rely on woody draws for cover as do elk (Sullivan et al., 1988;Westfall, 1989). This may also explain why horses restrict their movements to remote portions of the Park until visitor use declines, e.g. winter use of the scoria hills physiographic class.

Horse use of upland grasslands decreased in the early spring and a corresponding increase in use of grassland flats and scoria hills occurred. This pattern occurred in both spring 1990 and spring 1991. Decreased use of upland grassland during early spring may be due to mares moving into secluded micro-topographic sites of the scoria hills complex to foal.

As in summer 1989 upland grasslands were the preferred physiographic class for feral horses in July, August, and September 1990. However; the utilization of upland grasslands in summer 1990 was not as extensive as it was in summer 1989. Grassland flats were also heavily utilized during summer 1990. These two physiographic classes accounted for 80% of horse observation minutes in summer 1990. Prairie dog towns were utilized during the second summer whereas they had not been utilized at all during the first summer of observations.

During the winter horses continued to utilize upland grasslands and grassland flats. Additionally, horses used scoria hills as they did during the early spring of 1990. The spring of 1991 saw increased use of scoria hills and a decrease in the use of upland grasslands and grassland flats. Feral horse use of breaks was also quite heavy during spring 1991. This was the first season of observations that the horses favored the breaks physiographic class to such an extent.

The distance horses traveled varied seasonally with the greatest movements occurring in April and May. During July, August, and September horses moved very little, and stayed close to permanent springs in the southeast and Boicourt-Limbo Flats areas.

Both elk and horses used similar habitats during the period of study. The overlap was especially pronounced for the grassland flats and scoria hills physiographic classes. Calculations based on habitat use and forage production indicate that approximately 50 to 90 horses could be maintained in the South Unit of TRNP without causing serious overgrazing of most preferred graminoid species. A horse population in excess of 90 individuals for more than two years could lead to a serious decline in some forage species. Grass species in danger of over utilization through combined horse and elk use would be <u>Carex</u> ssp., <u>Poa</u> ssp., and <u>Stipa</u> <u>comata</u> but the greatest likelihood of overgrazing would be for preferred forages plants around the springs.

Observation data indicate a minimum horse population of 72 individuals during the study period with a mare:stallion ratio of 1:1. This population was at its upper limits in light of the affinity the horses have for the Boicourt, Sheep Butte, and Southeast Corner springs. They remain in this general area throughout the year with minimal movement across the Loop Road into the Scoria Hills along upper Paddock Creek. This shift occurs only in the winter and early spring and does little to alleviate the grazing pressure on preferred forages during the spring and summer. This suggests that horse numbers will have to be more closely controlled than either bison or elk.

An effective means of controlling horse grazing impact adjacent to the springs would be to develop the water supply at each spring and then fence the development. Water could be piped to a dish tank a short distance away. By installing a control valve in the spring development the water then could be shut-off requiring the horses to move to another locality for grazing. Reduced grazing around the spring would facilitate forage species recovery. Development of wells or seeps within the Loop Road or along the Interstate south of the Badlands Overlook would enable Park Managers to move some of the horses into new habitat and allow range recovery in the southeast and Boicourt-Limbo Flats localities. The apparent affinity horses have for water sources other than Paddock Creek means this non-intrusive management strategy is quite likely to be successful. The level or degree to which water developments will be useful will depend upon proper placement of the new spring developments and wells. Developments should be placed in the immediate vicinity of the preferred physiographic classes, e.g. upland grasslands. A well or spring development in close proximity to less preferred types such as breaks or scoria hills complex would hold few horses in the immediate area and negate any possible range improvements. A secondary benefit of spring enclosure would be the protection of riparian plant species from concentrated horse and bison grazing.

Feral horses represent a unique feature within the ecological community of Theodore Roosevelt National Park. They are a popular, highly visible grazing species that are well adapted to the Park's environment. Although there were several instances of mounted visitors chasing feral bands, failure of this harassment to move horses out of preferred physiographic classes and continued population increases indicates this activity has minimal impact.

Horses appear to be second in hierarchal dominance within TRNP's large ungulate community, acquiescing only to bison. Horses do not appear to colonize or exploit new areas within the Park. Consequently, they are likely to overgraze preferred habitat types and physiographic classes in areas they habitually use. The strong association between horse use areas and springs can be used to manage horse grazing for maintenance of both the Park's vegetative community and subordinate grazing species such as elk. Problems with feral horses can be minimized by maintaining the population with the 50 to 90 head carrying capacity of the eastern third of Theodore Roosevelt National Park.

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APPENDIX A

Table 11. Feral horses in TRNP at time of fall 1991 reduction in population size.

ID	Horse	Sex	Age
A1	Brookman stallion	M	11
A2	BLM stallion	M	12
A3	Baldface black mare	F	11
A4	Crop ear white mare	F	13
A5	White/gray griggs mare	F	10
A6	White griggs mare	F	14
A7	Fat grey mare	F	17
A8	Bay stud, star & snip	M	1
A9	Medicine hat stud	M	1
A10	Blue/White pinto stud	M	1
A11	Baldface sorrel filly	F	<1
A12	Buckskin roan stud	M	<1
A13	Yellow/white stud	M	<1
AA1	Grey/white pinto	M	6
AA2	Blue mare, small star	F	6
AA3	Blue/white pinto filly	F	<1
B1	Pnted Cnyn grey stallion	M	12
B2	Blue mare, star	F	11
B3	Baldface black mare	F	15
B4	Bay mare, satar	F	4
B5	Baldface grey stud	M	2
B6	Red/grey mare, baldface	F	2
B7	Brown stud, small star	M	1
B8	Roan filly	F	1
B9	Brown filly	F	1
B10	Red roan filly,star	F	<1
B11	Brown filly, star and snip	F	<1
B12	Sorrel strip face stud	M	<1
B13	Sorrel stallion	M	9
B14	Blue stud, big star	M	4
C1	Blue roan stallion	M	8
C2	Black mare, small star	F	11
C3	Bay/white pinto mare	F	7
C4	Sorrel/white pinto mare	F	6
C5	Baldface sorrel mare	F	6
C6	Blue mare, small star	F	5
C7	Blue stud	M	1
C8	Brown stud	M	1
C9	Blue filly	F	1
C10	Blue stud	M	<1

table continues

Table 11 continued

ID	Horse	Sex	Age
C11	Blue stud, big star	M	<1
C12	Blue or red roan stud	M	<1
C13	Blue filly	F	<1
C14	Black stud	M	<1
D1	Stripface blue roan stud	M	8
D2	Arab stallion	M	11
D3	Starface sorrel mare	F	4
D4	Baldface sorrel stud	M	1
D5	Brown filly, small star	F	1
D6	Red roan filly	F	<1
E1	Red roan stallion	M	6
E2	Blue/white mare	F	10
E3	Baldface grey mare	F	8
E4	Bay mare, star	F	4
E5	Bay mare, small star	F	2
E6	Dark grey mare	F	3
E7	Baldface blue stud	M	2
E8	Blue/white filly	F	1
E9	Grey stud	M	1
E10	Baldface grey filly	F	<1
E11	Red roan stud	M	<1
E12	Bay filly, small star	F	<1
F1	Big grey stallion	M	7
F2	Baldface blue/white mare	F	3
F3	Baldface buckskin mare	F	2
F4	Bay mare	F	unknown
F5	Baldface bay mare	F	3
F6	Bay filly, star & snip	F	1
F7	Black stud, star & snip	M	<1
F8	Solid blue filly	F	<1
G1	Black stallion	M	8
G2	Red roan mare	F	11
G3	Buckskin mare, star/snip	F	5
G4	Blue/grey mare, star	F	4
G5	Bay mare, big star	F	4
G6	Baldface red roan stud	M	2
G7	Red roan filly	F	1
G8	Buckskin stud	M	1
G9	Black filly, star	F	1
G10	Blue road stud	M	2
G11	Bay or roan filly	F	<1

table continues

Table 11 continued

ID	Horse	Sex	Age
GG1	Brown stud, star	M	5
GG2	Baldface brown mare	F	4
GG3	Dark stud	M	<1
H1	Blue/white pinto stud	M	3
H2	Baldface bay stud	M	2
H3	Blue stud	M	2
H4	Blue stud	M	4
H5	Drk buckskin stud	M	4
H6	Black stud, long snip	M	3
H7	Black stud, star/snip	M	3
H8	Bay stud, star/snip	M	3
H9	Baldface grey stud	M	3
H10	Lght buckskin stud	M	4
H11	Solid black stud	M	unknown
I1	White stallion	M	7
I2	Blue mare, star/snip	F	6
J1	Red roan stallion	M	6
J2	Brown mare, star/snip	F	3
J3	Bay/white mare	F	2
J4	Blue stud, star	M	1
K1	Sorrel/white pinto stud	M	5
K2	Little grey mare	F	12
K3	Black filly	F	1
K4	Bay stallion, star/snip	M	6
L1	Sorrel/white pinto stud	M	4
L2	Dark grey mare, star	F	3
L3	Sorrel stud	M	<1
M1	Bay/white pinto stallion	M	4
M2	Brown mare, white feet	F	3
M3	Stripface black/grey filly	F	1
M4	Stripface sorrel	?	<1

APPENDIX B

Table 12. Percent diurnal habitat use by feral horses for grazing in TRNP for winter and spring 1991.

Habitat Type	Horse Minutes	Percent
Artemisia cana	475	4.5
Bare ground	66	0.6
Artemisia tridentata - Bouteloua gracilis	266	2.5
Hardwood draws	0	0.0
Andropogon scoparius - Juniperus horizontalis	34	0.3
Andropogon scoparius	735	7.0
Prairie dog town	43	0.4
Rolling scoria complex	1675	15.8
Artemisia tridentata - Atriplex confertifolia	64	0.6
Stipa comata - Bouteloua gracilis	90	0.8
Steep scoria complex	346	3.3
Agropyron smithii - Stipa viridula	6446	61.0
Agropyron smithii - Stipa comata	329	3.1

Table 13. Percent diurnal landform use by feral horses for grazing in TRNP 1989-1991 for all seasons (including two summers and two springs).

Physiographic Class	Horse Minutes	Percent
Breaks	595	3.9
Grassland flats	4677	30.8
Prairie dog town	129	0.9
Ridge & ravine	167	1.1
Sagebrush bottoms	594	3.9
Scoria hills	2230	14.7
Upland grasslands	6805	44.8

Table 14. Percent diurnal habitat use by feral horses for resting in TRNP for winter and spring 1991.

Habitat Type	Horse Minutes	Percent
Artemisia cana	211	4.0
Bare ground	35	0.7
Artemisia tridentata - Bouteloua gracilis	51	1.0
Hardwood draws	9	0.2
Andropogon scoparius - Juniperus horizontalis	2	0.0
Andropogon scoparius	388	7.3
Prairie dog town	16	0.3
Rolling scoria complex	1075	20.3
Artemisia tridentata - Atriplex confertifolia	57	1.1
Stipa comata - Bouteloua gracilis	4	0.1
Steep scoria complex	208	3.9
Agropyron smithii - Stipa viridula	3087	58.2
Agropyron smithii - Stipa comata	158	3.0

Table 15. Percent diurnal landform use by feral horses for resting in TRNP 1989-1991 for all seasons (including two summers and two springs).

Physiographic Class	Horse Minutes	Percent
Breaks	439	5.0
Grassland flats	2738	31.2
Prairie dog town	360	4.1
Ridge & ravine	58	0.7
Sagebrush bottoms	295	3.4
Scoria hills	1479	16.8
Upland grasslands	3410	38.8

Table 16. Percent diurnal habitat use by feral horses for traveling in TRNP for winter and spring 1991.

Habitat Type	Horse Minutes	Percent
Artemisia cana	97	5.8
Bare ground	32	1.9
Artemisia tridentata - Bouteloua gracilis	34	2.0
Hardwood draws	7	0.4
Andropogon scoparius - Juniperus horizontalis	23	1.4
Andropogon scoparius	52	3.11
Prairie dog town	0	0
Rolling scoria complex	300	17.9
Artemisia tridentata - Atriplex confertifolia	8	0.5
Stipa comata - Bouteloua gracilis	26	1.6
Steep scoria complex	64	3.8
Agropyron smithii - Stipa viridula	977	58.4
Agropyron smithii - Stipa comata	53	3.2

Table 17. Percent diurnal habitat use by feral horses for traveling in TRNP 1989-1991 for all seasons (including two summers and two springs).

Physiographic Class	Horse Minutes	Percent
Breaks	92	3.2
Grassland flats	979	34.0
Prairie dog town	44	1.5
Ridge & ravine	23	0.8
Sagebrush bottoms	138	4.8
Scoria hills	419	14.5
Upland grasslands	1189	41.2

APPENDIX C

Table 18. Percent of feral horse minutes spent grazing in each habitat type for winter and spring 1991 in TRNP.

Habitat Type	Winter 91	Spring91
Artemisia cana	5.4	0.0
Bare ground	0.7	0.4
Artemisia tridentata - Bouteloua gracilis	0.1	14.5
Hardwood draws	0.0	0.0
Schizachyrium scoparium-Juniperus horizontalis	0.2	1.1
Schizachyrium scoparium	6.2	10.6
Prairie dog town	0.0	2.4
Rolling scoria complex	13.7	26.5
Artemisia tridentata - Atriplex confertifolia	0.6	0.6
Stipa comata - Bouteloua gracilis	0.3	3.6
Steep scoria complex	3.7	1.1
Agropyron smithii - Stipa viridula	67.2	31.0
Agropyron smithii - Stipa comata	2.0	8.3

Table 19. Percent of feral horse minutes spent grazing in physiographic classes for two summers (89 & 90), two springs (90 & 91), and one winter (91).

	Season				
Physiographic Class	Sum. 89	Spr. 90	Sum. 90	Win. 91	Spr. 91
Breaks	0.0	0.0	0.0	2.0	23.5
Grassland flats	13.7	54.2	42.2	31.7	21.1
Prairie dog town	0.0	2.2	10.5	0.0	0.0
Ridge & ravine	2.2	0	0.0	1.3	0.0
Sagebrush bottoms	3.9	16.5	0.6	2.8	0.0
Scoria hills	0.0	8.4	0.0	17.7	30.6
Upland grasslands	80.2	18.8	47.8	44.6	24.8

Table 20. Percent of feral horse minutes spent resting in each habitat type for winter and spring 1991 in TRNP.

Habitat Type	Winter 91	Spring91
Artemisia cana	4.6	0.0
Bare ground	0.7	0.7
Artemisia tridentata - Bouteloua gracilis	0.1	6.6
Hardwood draws	0.2	0.0
Schizachyrium scoparium-Juniperus horizontalis	0.0	0.3
Schizachyrium scoparium	5.2	20.7
Prairie dog town	0.0	2.2
Rolling scoria complex	18.1	33.9
Artemisia tridentata - Atriplex confertifolia	0.2	6.5
Stipa comata - Bouteloua gracilis	0.0	0.6
Steep scoria complex	4.4	1.1
Agropyron smithii - Stipa viridula	63.8	23.3
Agropyron smithii - Stipa comata	2.8	4.2

Table 21. Percent of feral horse minutes spent resting in physiographic classes for two summers (89 & 90), two springs (90 & 91), and one winter (91).

Physiographic Class	Season				
	Sum. 89	Spr. 90	Sum. 90	Win. 91	Spr. 91
Breaks	0.0	0.0	0.0	4.4	32.8
Grassland flats	18.2	46.5	31.5	33.5	18.1
Prairie dog town	0.0	9.0	22.2	0.0	0.0
Ridge & ravine	0.5	0.0	0.0	1.1	0.0
Sagebrush bottoms	2.4	14.9	2.0	2.1	0.0
Scoria hills	0.0	19.3	0.0	22.6	35.3
Upland grasslands	78.8	10.3	44.3	36.4	13.9

Table 22. Percent of feral horse minutes spent traveling in each habitat type for winter and spring 1991 in TRNP.

Habitat Type	Winter 91	Spring91
Artemisia cana	7.3	0.0
Bare ground	2.0	1.5
Artemisia tridentata - Bouteloua gracilis	0.6	7.8
Hardwood draws	0.5	0.0
Schizachyrium scoparium-Juniperus horizontalis	0.0	6.9
Schizachyrium scoparium	2.5	5.7
Prairie dog town	0.0	0.0
Rolling scoria complex	15.3	28.7
Artemisia tridentata - Atriplex confertifolia	0.4	0.9
Stipa comata - Bouteloua gracilis	1.8	0.6
Steep scoria complex	4.4	1.5
Agropyron smithii - Stipa viridula	64.4	34.3
Agropyron smithii - Stipa comata	0.9	12.2

Table 23. Percent of feral horse minutes spent traveling in physiographic classes for two summers (89 & 90), two springs (90 & 91), and one winter (91).

Physiographic Class	Season				
	Sum. 89	Spr. 90	Sum. 90	Win. 91	Spr. 91
Breaks	0.0	0.0	0.0	1.9	20.0
Grassland flats	11.4	53.4	52.2	34.8	24.2
Prairie dog town	0.0	3.5	14.3	0.0	0.0
Ridge & ravine	2.9	0.0	0.0	0.5	0.0
Sagebrush bottoms	2.5	16.7	2.8	2.5	0.0
Scoria hills	0.0	4.7	0.0	20.8	34.9
Upland grasslands	83.2	21.1	30.8	39.5	20.9

APPENDIX D

Table 24. Percent of feral horse grazing minutes spent in habitat types each season for early morning (EM), late morning (LM), early afternoon (EA), and late afternoon (LA). Total feral horse minutes recorded per season is in parentheses.

Habitat Type	Winter 91 (15042)				Spring 91 (2933)			
	EM	LM	EA	LA	EM	LM	EA	LA
Artemisia cana	8.2	2.2	5.7	6.0	0	0	0	0
Bare ground	0.1	0.9	0.8	2.2	0	1.9	2.2	0
Artemisia tridentata - Bouteloua gracilis	0	0.3	0	0	0	6.6	18.2	24.1
Hardwood draws	0.4	0.0	0	0	0	0	0	0
Schizachyrium scoparium-Juniperus horizontalis	0	0	0	0.8	0.1	10.3	0	0
Schizachyrium scoparium	6.6	8.0	1.9	4.8	28.9	11.9	0	0
Prairie dog town	0	0	0	0	2.6	0	5.4	0.8
Rolling scoria complex	10.2	16.0	16.3	20.4	37.4	0	50.4	23.3
Artemisia tridentata - Atriplex confertifolia	1.8	0	0	0	0	14.1	0	0
Stipa comata - Bouteloua gracilis	0.4	0.2	0.3	0.6	0	0	0	7.3
Steep scoria complex	1.3	2.4	4.8	12.4	0	0	5.8	0.9
Agropyron smithii - Stipa viridula	67.5	67.7	68.7	52.9	14.0	48.2	18.0	43.5
Agropyron smithii - Stipa comata	3.5	2.3	1.6	0	17.0	7.0	0	0

Table 25. Percent of feral horse minutes spent in grassland flats (GF), breaks (BR), ridge and ravines (RR), prairie dog town (PDT), upland grasslands (UG), scoria hills (SH), and sagebrush bottoms (SB) classes each season for four time periods. Total feral horse minutes recorded per season is in parentheses.

Time Period	Physiographic Classes						
	BR	GF	PD	RR	SB	SH	UG
Summer 89 (4171)							
Early morning	0.0	14.0	0.0	2.4	4.3	0.0	79.3
Late morning	0.0	30.7	0.0	0.0	0.0	0.0	69.3
Afternoon	0.0	1.4	0.0	0.0	0.0	0.0	98.6
Evening							
Daily	0.0	17.6	0.0	1.8	3.3	0.0	77.3
Spring 90 (3080)							
Early morning	0.0	54.9	4.1	0.0	17.9	9.8	13.4
Late morning	0.0	31.0	0.0	0.0	0.0	31.0	38.1
Afternoon	0.0	41.2	17.2	0.0	20.7	0.0	20.7
Evening							
Daily	0.0	51.7	4.6	0.0	16.3	11.2	16.2
Summer 90 (2365)							
Early morning	0.0	45.3	16.4	0.0	3.0	0.0	35.4
Late morning	0.0	39.4	0.0	0.0	0.0	0.0	60.6
Afternoon	0.0	0.0	63.8	0.0	0.0	0.0	36.2
Evening							
Daily	0.0	36.6	17.6	0.0	1.5	0.0	44.3
Winter 91 (15042)							
Early morning	6.2	34.7	0.0	1.4	6.5	11.5	39.7
Late morning	3.2	36.3	0.0	0.3	1.7	18.4	40.2
Afternoon	0.0	29.9	0.0	0.0	0.0	22.1	48.1
Evening	0.2	24.6	0.0	5.5	1.8	33.1	34.9
Daily	2.7	32.6	0.0	1.2	2.5	19.4	41.6
Spring 91 (2933)							
Early morning	29.0	8.5	0.0	0.0	0.0	37.4	25.1
Late morning	36.3	38.9	0.0	0.0	0.0	0.0	24.8
Afternoon	7.5	23.4	0.0	0.0	0.0	0.0	69.1
Evening	24.1	25.7	0.0	0.0	0.0	26.4	23.9
Daily	25.4	20.7	0.0	0.0	0.0	32.8	21.1

APPENDIX E

Table 26. Species names (scientific and common) for plants identified in text.

GRAMINOIDS

Agropyron cristatum (Crested wheatgrass)
Agropyron smithii (Western wheatgrass)
Boutelous gracilis (Blue grama)
Carex spp. (Sedge species)
Muhlenbergia cuspidata (Plains muhly)
Oryzopsis micrantha (Little ricegrass)
Poa spp. (Blue grasses species)
Schizachyrium scorparium (Little bluestem)
Stipa viridula (Green needlegrass)
Stipa comata (Needleandthread grass)

SHRUBS/TREES

Artemisia tridentata (Big sagebrush)
Artiplex confertifolia (Shadscale saltbush)
Juniperus horizontalis (Creeping juniper)

Table 14. Percent diurnal habitat use by feral horses for resting in TRNP for winter and spring 1991.

Habitat Type	Horse Minutes	Percent
Artemisia cana	211	4.0
Bare ground	35	0.7
Artemisia tridentata - Bouteloua gracilis	51	1.0
Hardwood draws	9	0.2
Andropogon scoparius - Juniperus horizontalis	2	0.0
Andropogon scoparius	388	7.3
Prairie dog town	16	0.3
Rolling scoria complex	1075	20.3
Artemisia tridentata - Atriplex confertifolia	57	1.1
Stipa comata - Bouteloua gracilis	4	0.1
Steep scoria complex	208	3.9
Agropyron smithii - Stipa viridula	3087	58.2
Agropyron smithii - Stipa comata	158	3.0

Table 15. Percent diurnal landform use by feral horses for resting in TRNP 1989-1991 for all seasons (including two summers and two springs).

Physiographic Class	Horse Minutes	Percent
Breaks	439	5.0
Grassland flats	2738	31.2
Prairie dog town	360	4.1
Ridge & ravine	58	0.7
Sagebrush bottoms	295	3.4
Scoria hills	1479	16.8
Upland grasslands	3410	38.8

APPENDIX C

Table 20. Percent of feral horse minutes spent resting in each habitat type for winter and spring 1991 in TRNP.

Habitat Type	Winter 91	Spring91
Artemisia cana	4.6	0.0
Bare ground	0.7	0.7
Artemisia tridentata - Bouteloua gracilis	0.1	6.6
Hardwood draws	0.2	0.0
Schizachyrium scoparium-Juniperus horizontalis	0.0	0.3
Schizachyrium scoparium	5.2	20.7
Prairie dog town	0.0	2.2
Rolling scoria complex	18.1	33.9
Artemisia tridentata - Atriplex confertifolia	0.2	6.5
Stipa comata - Bouteloua gracilis	0.0	0.6
Steep scoria complex	4.4	1.1
Agropyron smithii - Stipa viridula	63.8	23.3
Agropyron smithii - Stipa comata	2.8	4.2

Table 21. Percent of feral horse minutes spent resting in physiographic classes for two summers (89 & 90), two springs (90 & 91), and one winter (91).

	Season				
Physiographic Class	Sum. 89	Spr. 90	Sum. 90	Win. 91	Spr. 91
Breaks	0.0	0.0	0.0	4.4	32.8
Grassland flats	18.2	46.5	31.5	33.5	18.1
Prairie dog town	0.0	9.0	22.2	0.0	0.0
Ridge & ravine	0.5	0.0	0.0	1.1	0.0
Sagebrush bottoms	2.4	14.9	2.0	2.1	0.0
Scoria hills	0.0	19.3	0.0	22.6	35.3
Upland grasslands	78.8	10.3	44.3	36.4	13.9

APPENDIX D

Table 25. Percent of feral horse minutes spent in grassland flats (GF),

APPENDIX D

Table 25. Percent of feral horse minutes spent in grassland flats (GF), breaks (BR), ridge and ravines (RR), prairie dog town (PDT), upland grasslands (UG), scoria hills (SH), and sagebrush bottoms (SB) classes each season for four time periods. Total feral horse minutes recorded per season is in parentheses.

	Physiographic Classes						
Time Period	BR	GF	PD	RR	SB	SH	UG
Summer 89 (4171)							
Early morning	0.0	14.0	0.0	2.4	4.3	0.0	79.3
Late morning	0.0	30.7	0.0	0.0	0.0	0.0	69.3
Afternoon	0.0	1.4	0.0	0.0	0.0	0.0	98.6
Evening							
Daily	0.0	17.6	0.0	1.8	3.3	0.0	77.3
Spring 90 (3080)							
Early morning	0.0	54.9	4.1	0.0	17.9	9.8	13.4
Late morning	0.0	31.0	0.0	0.0	0.0	31.0	38.1
Afternoon	0.0	41.2	17.2	0.0	20.7	0.0	20.7
Evening							
Daily	0.0	51.7	4.6	0.0	16.3	11.2	16.2
Summer 90 (2365)							
Early morning	0.0	45.3	16.4	0.0	3.0	0.0	35.4
Late morning	0.0	39.4	0.0	0.0	0.0	0.0	60.6
Afternoon	0.0	0.0	63.8	0.0	0.0	0.0	36.2
Evening							
Daily	0.0	36.6	17.6	0.0	1.5	0.0	44.3
Winter 91 (15042)							
Early morning	6.2	34.7	0.0	1.4	6.5	11.5	39.7
Late morning	3.2	36.3	0.0	0.3	1.7	18.4	40.2
Afternoon	0.0	29.9	0.0	0.0	0.0	22.1	48.1
Evening	0.2	24.6	0.0	5.5	1.8	33.1	34.9
Daily	2.7	32.6	0.0	1.2	2.5	19.4	41.6
Spring 91 (2933)							
Early morning	29.0	8.5	0.0	0.0	0.0	37.4	25.1
Late morning	36.3	38.9	0.0	0.0	0.0	0.0	24.8
Afternoon	7.5	23.4	0.0	0.0	0.0	0.0	69.1
Evening	24.1	25.7	0.0	0.0	0.0	26.4	23.9
Daily	25.4	20.7	0.0	0.0	0.0	32.8	21.1

Table 26. Species names (scientific and common) for plants identified in text.

GRAMINOIDS

Agropyron cristatum (Crested wheatgrass)
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Schizachyrium scorparium (Little bluestem)
Stipa viridula (Green needlegrass)
Stipa comata (Needleandthread grass)

SHRUBS/TREES

Artemisia tridentata (Big sagebrush)
Artiplex confertifolia (Shadscale saltbush)
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