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Pronghorn fawn mortality on the National Bison Range

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PRONGHORN FAWN MORTALITY ON THE
NATIONAL BISON RANGE

By

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ABSTRACT

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Pronghorn Fawn Mortality on the National Bison Range (82 pp.)

Director: Bart W. O'Gara [signature]

Thirty pronghorn fawns (Antilocapra americana) were fitted with radio transmitters, between 16 May and 4 June 1977, to determine the cause and extent of mortality on the National Bison Range in western Montana. Twenty-seven were dead at the end of September, a mortality rate of 90 percent. Two-thirds of the deaths took place in the first 3 weeks of the fawns' lives, with all deaths of fawns born near a coyote denning concentration occurring during that time. Nine carcasses were found with enough evidence to definitely determine the causes of death; 5 were killed by coyotes (Canis latrans), 3 by bobcats (Lynx rufus), and 1 by a golden eagle (Aquila chrysaëtos). Only bits of bone, hair, chewed elastic, and the transmitters were found from 11 fawns; remains of nine were found in the vicinity of coyote dens, and the fawns were undoubtedly consumed by coyotes. The fawns had been seen recently and appeared healthy, giving circumstantial evidence that predation was the fate of the fawns. Dam abandonment may have predisposed three fawns to their deaths. Information concerning deaths of seven fawns was lost due to three transmitter failures and four transmitters dropping from the animals too soon. Fawn survival of the entire pronghorn population was similar to that of the radioed sample.

From the number of denning areas and activities observed, the coyote population on the Bison Range in the summer of 1977 was estimated at 33 or more. Sampling indicated that the small rodent population was low, especially Microtus spp.

Factors involved in the high mortality could be the high number of coyotes on the Range, the low number of alternate coyote prey, the concentration of coyote dens near some fawning areas, and confinement of the pronghorns with experienced predators. Pronghorns are not indigenous to the National Bison Range, but were reproducing rapidly before the coyote population built up.

ACKNOWLEDGEMENTS

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Special thanks go to Dr. Bart O'Gara, my major advisor, for his interest in the project and many helpful suggestions. Other committee members, Drs. Lee Metzgar and Bob Ream, provided assistance during the study's planning stages and the preparation of this manuscript.

Thanks go to the several University of Montana students who volunteered their help during the field season, especially Mark Long and Joel Yesenko who put in long hours of hard work.

I express my gratitude to the Bison Range personnel for their friendly cooperation and for providing housing during part of the study.

Lastly, I thank my parents for sharing with me their appreciation of the natural world, and for giving loving support of whatever I try.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

For a million years, pronghorn antelope roamed the western prairies of North America, from northern Mexico into southern Canada. Yoakum (1968) estimated there were over 35 million pronghorns prior to the arrival of white man, and between 1850 and 1900, the population was reduced to about 20,000 due to uncontrolled hunting and decreased suitable habitat. By the early 1900's, many laymen, wildlife experts, and conservation groups took an active interest in the future of the pronghorn. Refuges were established and antelope hunting was prohibited in most states. With effective law enforcement, habitat restoration, and trapping and transplanting, the pronghorn made a successful comeback from near extinction to number over 430,000 (Yoakum and O'Gara in press).

The National Bison Range (NBR), Moiese, Montana, is one of the national wildlife refuges that now protects the species. Pronghorns, not indigenous to the area, were colonized on the NBR in 1910 in an effort to help preserve them. The 12 animals from Yellowstone National Park increased to 57 in 11 years, but all died in the next 2 years, due to a hard winter, disease, and poachers. A second transplant was tried with nine hand-raised animals from Nevada; all died within a year (Anonymous undated a).

For 25 years, antelope were absent from the NBR. Fifteen were introduced in 1951 in connection with a research project at the University of Montana, and this time the transplant was more successful. By 1962, the pronghorn numbers reached 120. Between 1962 and 1970, the fawn death rate was only 32 percent or less and recruitment into the population was high. Transplanting or cropping of surplus animals became necessary as the herd grew. In 1970, the mortality rate of fawns jumped to 66 percent and has remained high in recent years: 62 percent in 1971, 80 percent in 1972, and 89 percent in 1973 (Anonymous 1956-77); 73 percent in 1974 and 69 percent in 1975 (Reichel 1976); and 93 percent in 1976 (Anonymous 1956-77). As a result, the population remained relatively stable and reductions were not necessary.

A complex of factors (disease, adverse weather, range conditions, and predation) could be involved in the high fawn mortality. Yoakum and O'Gara (in press) discussed several diseases of antelope, but few seem to affect fawns. A few fawns (4% of 370) in an Oregon study died from complications at birth and congenital defects (Yoakum 1957).

In eastern Montana, Martinka (1967) found over 500 carcasses during a severe winter. Malnutrition was the apparent cause and fawns comprised 28 percent of the total deaths. Studies in Idaho (Fichter and Nielson 1964), Utah (Beale and Smith 1970), and New Mexico (Howard et al. 1973), found a positive correlation between pronghorn fawn survival and precipitation during previous years, indicating drought years may also be a limiting factor.

Adequate range condition, related to amounts of precipitation, affects the nutritional level of the dams and can influence neonatal survival. Beale and Smith (1966) and Knowlton (1968) found early fawn losses were less pronounced when green, succulent forage was abundant during spring and summer. Apparently, the dams were in better condition. Verme (1963) showed that white-tailed deer fawns died in proportion to the quality of the doe diet. Limited suitable habitat was considered the major factor controlling pronghorn numbers on the Jornada Experimental Range in New Mexico (Howard et al. 1973). Yoakum (1957) determined that fawn:doe ratios were highest on ranges with the most diversified vegetation composition, production, and interspersion.

The affect predation has on pronghorn numbers has been studied by many researchers. Murie (1940) and Einarsen (1948) concluded that predation rarely limited increases in pronghorn numbers. In some studies, predation was present but was not considered a major limiting factor (Buechner 1950, Compton 1958, Beale and Smith 1966, Howard et al. 1973). Udy (1953) studied the effects of predator control on pronghorn populations in Utah and found fawn survival higher on areas with coyote-control measures than on areas with no control. Yet, he considered poor range condition and competition with livestock greater problems than predation. During 6 years, Arrington and Edwards (1951) encountered a close positive correlation between fawn crops and predator control work done in Arizona.

Coyote predation was thought to be the chief factor limiting antelope in northwestern Texas (Jones 1949), but Larsen (1970) found no conclusive evidence that predation limited the antelope population in New Mexico. Through the use of radiotelemetry, Beale and Smith (1973) found that bobcats were involved in the high fawn mortality that had inhibited pronghorn increase in Utah.

Many predation studies have concluded that the most vulnerable animals were killed (Connolly 1978). The vulnerable were not necessarily the sick, inferior, or surplus animals. Connolly stated that whenever very young animals were the prey it seemed unlikely that weak and unfit individuals would be taken selectively, as any newborn ungulate discovered by a predator would be vulnerable.

Reichel (1976) found, by analyses of coyote scats from the NBR, that pronghorns were an important part of the coyote diet during late May and June, the time when fawns were born. The scat analyses indicated that coyotes consumed carcasses, but could not insure that coyotes killed the fawns. Of seven fawns equipped with radio transmitters during Reichel's study, only one death could be definitely attributed to coyote predation. Four were "coyote involved" with over 95 percent of each carcass consumed. Weak calf syndrome was suspected in the other two deaths.

My research, an extension of Reichel's (1976) study, was conducted on the NBR from April through September 1977. Objectives were to:

1) examine the causes and degree of pronghorn fawn mortality on the NBR;
2) determine the density of coyotes; and
3) determine the relative densities of alternate coyote prey.

CHAPTER II

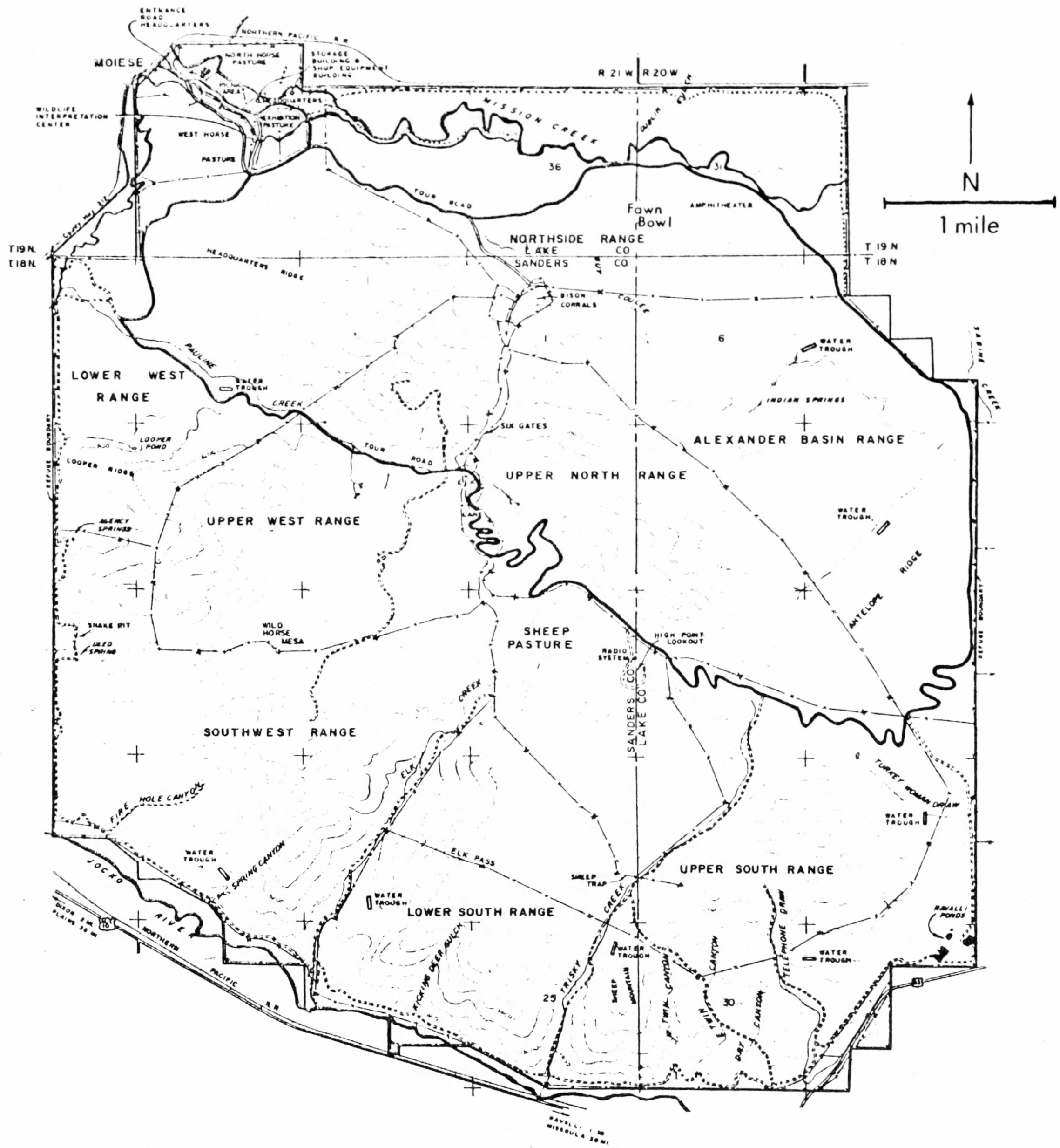
STUDY AREA

The NBR (Fig. 1) is located in western Montana at the southern end of the Flathead Valley, with elevations ranging from about 788 to 1,489 m above sea level. Over 7,700 ha, the Range is completely enclosed with a 2.4 m tall woven-wire fence that confines the animals. My study was concentrated on the eastern half of the Range, where most pronghorn does were located.

Two separate herds of bison (Bison bison) are managed through a deferred-rotation grazing program, with movements restricted to two of eight pastures every 3 months. The fences are built with the top wire about 1.2 m high and the bottom wire about 0.4 m above the ground so that the other ungulate species on the Range, pronghorns, elk (Cervus elaphus), white-tailed deer (Odocoileus virginianus), mule deer (O. hemionus), bighorn sheep (Ovis canadensis), and mountain goats (Oreamnos americanus), are relatively free to roam over the entire Range.

Grasslands with low ridges and small basins predominate the northern half of the Range. Much of the southern half is steep and rocky, with dissecting small canyons, except for the southeast corner

Fig. 1. The National Bison Range, Montana.


MOIESE
NORTHERN PACIFIC R.R.
NORTH HORSE PASTURE
STORAGE BUILDING & SHOP EQUIPMENT BUILDING
HEADQUARTERS
EXHIBITION PASTURE
WILDLIFE INTERPRETATION CENTER
WEST HORSE PASTURE
R 21 W
R 20 W
MISSION CREEK
36
31
N
1 mile
Fawn Bowl
AMPHITHEATER
TOUR ROAD
NORTHSIDE RANGE
LAKE CO
SANDERS CO
T19N.
T18N.
T 19 N
T 18 N
HEADQUARTERS RIDGE
BISON CORRALS
1
6
WATER TROUGH
LOWER WEST RANGE
PAULINE CREEK
INDIAN SPRINGS
SIX GATES
ALEXANDER BASIN RANGE
LOOPER POND
LOOPER RIDGE
UPPER NORTH RANGE
AGENCY SPRINGS
UPPER WEST RANGE
ANTELOPE RIDGE
SNAKE PIT
WILD HORSE MESA
SHEEP PASTURE
HIGH POINT LOOKOUT
RADIO SYSTEM
REFUGE BOUNDARY
SOUTHWEST RANGE
SANDERS CO
LAKE CO
FIRE HOLE CANYON
TURKEY WOMAN DRAW
ELK CREEK
ELK PASS
SHEEP TRAP
UPPER SOUTH RANGE
SPRING CANYON
JOCKO RIVER
LOWER SOUTH RANGE
TELEPHONE DRAW
RAVALLI PONDS
NORTHERN PACIFIC R.R.
KICKING DEER GULCH
TRISKY CREEK
SHEEP MOUNTAIN
TWIN CANYON
DRY CANYON
25
30
RAVALLI 1 MI
MISSOULA 38 MI

which is a flat area about $\frac{1}{2}$ km^2, encompassing the three small Ravalli Ponds. The 6,435 ha of grasslands on the Range consist largely of Palouse Prairie vegetation with bluebunch wheatgrass (Agropyron spicatum) as the principle species. Other major grasses are Idaho fescue (Festuca idahoensis) and rough fescue (F. scabrella). Swales and drainage courses contain snowberry (Symphoricarpos occidentalis), hawthorn (Crataegus douglasii), and wild rose (Rosa spp.). Rocky outcrops and stoney areas support scattered stands of chokecherry (Prunus demissa), serviceberry (Amelanchier alnifolia), and mockorange (Philadelphus lewisii). Major forbs include balsamroot (Balsamorrhiza sagittata), yarrow (Achillea lanulosa), and aster (Aster falcatus). The forested portion of the Range, found at the higher elevations, is predominately Douglas-fir (Pseudotsuga menziesii) on northern exposures and ponderosa pine (Pinus ponderosa) on southern exposures. Rocky Mountain maple (Acer glabrum) is commonly found as an understory species in the forest types. Ninebark (Physocarpus malvaceus) is abundant at the margins of the Douglas-fir type (Morris and Schwartz 1957).

The climate at the NBR is generally mild. Winter temperatures rarely fall below -20°C, and summer temperatures seldom exceed 38°C. The 25-year average of annual precipitation, accumulated from September to August, the ecological year of the pronghorn (Fichter and Nielson 1962), is 32.19 cm, but was only 18.52 cm in 1976-77 (Table 1) (Anonymous undated b, NBR Records).

Table 1. September 1976-August 1977 monthly precipitation in centimeters and the 1950-1975 monthly means as recorded at Headquarters, National Bison Range. Months are arranged by ecological year.

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
25-year mean	2.64	2.39	2.06	2.08	2.51	1.45	1.75	2.64	4.10	5.36	2.34	2.87	32.19
'76-'77	1.35	1.32	0.99	1.40	1.93	0.05	1.78	0.00	3.96	1.88	2.36	1.50	18.52

CHAPTER III

METHODS AND MATERIALS

Pronghorns

Fawn Mortality

Observers situated at high vantage points used binoculars and spotting scopes to scan areas for does. In past years, most fawning occurred in the northeast section of the Range (NE) in the Fawn Bowl and Alexander Basin (Kitchen 1974, Haderlie pers. comm.). A large group of does moved to the southeast section (SE) during May 1977 and fawned there, so observations were concentrated in both eastern areas. A pregnant doe near parturition left her group and indicated impending birth by frequently standing and lying, raising her tail, humping her back, and self-licking of the belly and flank areas. Postparturient does were watched until they fed their fawns.

When a fawn was located, its surroundings were carefully noted. Newborn fawns were not handled until 4 hours had elapsed, allowing a mother-young imprinting period (Autenrieth and Fichter 1975). After approaching slowly and quietly, a salmon net 0.8 m in diameter was gently placed over the animal. The net was unnecessary for fawns under 3 days old, but was used in all cases to assure capture. A rag tied over the fawn's eyes kept the animal quiet as it was handled. Working quickly, the fawn was sexed, aged, weighed, eartagged, checked for general condition, and the length and girth were measured. Fawns were aged by the condition of the pelage and the umbilical cord, and by their response to capture using Bromley's (1977) criteria. Fawns 1 day old or less made no or only feeble attempts to escape, had damp umbilical cords, and the hair on their backs was often in small clumps, apparently stuck together by dried amniotic fluid. Fawns from 1 to 3 days of age were easily caught, but struggled vigorously when handled, often bleating. Their umbilical cords were gone or hardened. Fawns from 3 to 7 days of age were difficult to catch with the net, leaping up as the net was placed over them.

Each fawn was fitted with a radio transmitter which had a temperature-activated switch designed to change pulse rate by a factor of 2 or 3 times slower when the animal died and cooled down (Wildlife Materials Inc., Carbondale, IL). Eight of the 28 transmitters used had a 0.28 milliampere drain with a 3.2-4.8 km range, powered by a 3 volt, 1,100 mah lithium battery. The total package, including transmitter, battery, antenna and acrylic, weighed about 70 g, or 1.9 percent of the body weight of a 3.6 km fawn. The other 20 transmitters had a 0.7-0.9 ma drain with a 6.4-9.7 km range, powered by a 3 volt, 3,900 mah lithium battery. The total package weighed about

130 g, or 3.6 percent of a 3.6 kg fawn. A small patch of hair, about 2 by 4 cm, was clipped close to the skin between the scapulae to remove the insulating effect the hair might have on the temperature-activated switch. A dab of cattle-back-tag cement was used to keep the transmitter from shifting. Two pieces of 1.27 cm wide elastic were stapled, one around the neck and one around the chest, to attach the package to the fawn. As the fawn grew, the elastic stretched, the staples pulled out, and the radio package fell off.

I located fawns as often as possible using a hand-held, 3-element Yagi antenna and an AVM receiver. Data collected from live fawns included date and time sighted, location, activity, and condition. Dead fawns were photographed, examined, and collected with notations on date, location, approximate time of death, tracks or signs of predators, and carcass description (see datum forms in Appendix A). All carcasses were later necropsied to determine cause of death. Characteristic patterns of attacking and feeding on prey species, as described by O'Gara (1978), were used to ascertain what predator had killed or fed on a fawn.

Pronghorn Population

Pregnant does were located and censused in early May. Over 95 percent of the does on the NBR had twins during O'Gara's (1968) study, so an estimate of fawns born was derived by multiplying the number of pregnant does by 1.9.

Doe and fawn counts were conducted during August and September to determine fawn mortality for the whole NBR pronghorn population.

Coyote Population

Coyote control has not been practiced on the NBR since 1962, although some coyotes are killed on lands adjacent to the Range by private and government trappers.

Population Indices

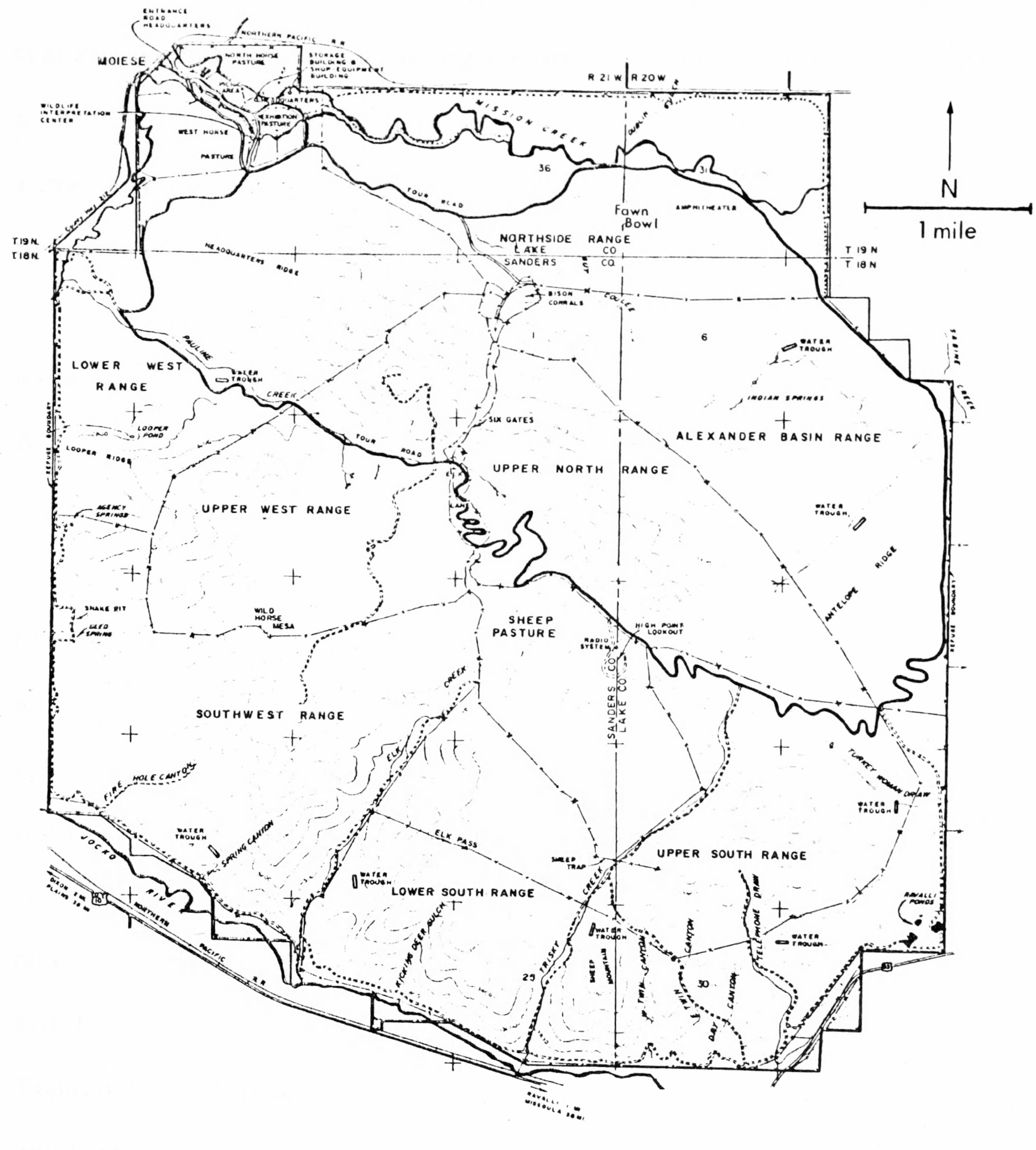
A standardized scent station line was run in July and September to obtain an index of relative coyote abundance (Linhart and Knowlton 1975). The route used by Reichel (1976) was followed to standardize the index on the Range for better comparison of population trends between years (Fig. 2). The Denver Wildlife Research Laboratory provided the materials, identical to those used in the annual western predator survey of the U.S. Fish and Wildlife Service.

An estimate of the coyote population was also obtained by direct observation of coyotes and pups at dens.

Toe-Clipping for Track Identification

It may be possible to determine a single coyote's response to the scent station line by identification of an individual from its tracks.

Fig. 2. Location (heavy black line) of the standardized scent station line on the NBR during 1975 and 1977.



ENTRANCE ROAD
HEADQUARTERS
NORTHERN PACIFIC R.R.
MOIESE
NORTH HORSE PASTURE
STORAGE BUILDING & SHOP EQUIPMENT BUILDING
WILDLIFE INTERPRETATION CENTER
HEADQUARTERS
EXHIBITION PASTURE
WEST HORSE PASTURE
R 21 W
R 20 W
MISSION CREEK
36
31
N
1 mile
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AMPHITHEATER
TOUR ROAD
T19N.
T18N.
NORTHSIDE RANGE
LAKE CO.
SANDERS CO.
T 19 N
T 18 N
HEADQUARTERS RIDGE
BISON CORRALS
6
WATER TROUGH
LOWER WEST RANGE
PAULINE CREEK
INDIAN SPRINGS
SIX GATES
ALEXANDER BASIN RANGE
LOOPER POND
LOOPER RIDGE
UPPER NORTH RANGE
REFUGE BOUNDARY
UPPER WEST RANGE
AGENCY SPRINGS
ANTELOPE RIDGE
SNAKE PIT
WILD HORSE MESA
SHEEP PASTURE
HIGH POINT LOOKOUT
RADIO SYSTEM
SANDERS CO.
LAKE CO.
SOUTHWEST RANGE
ELK CREEK
FIRE HOLE CANYON
TURKEY WOMAN DRAW
ELK PASS
SPRING CANYON
JOCKO RIVER
SHEEP TRAP
UPPER SOUTH RANGE
LOWER SOUTH RANGE
TRISKY CREEK
RAVALLI PONDS
NORTHERN PACIFIC R.R.
KICKING DEER GULCH
SHEEP MOUNTAIN
TWIN CANYON
YELLOWSTONE DRAW
DRY CANYON
29
30

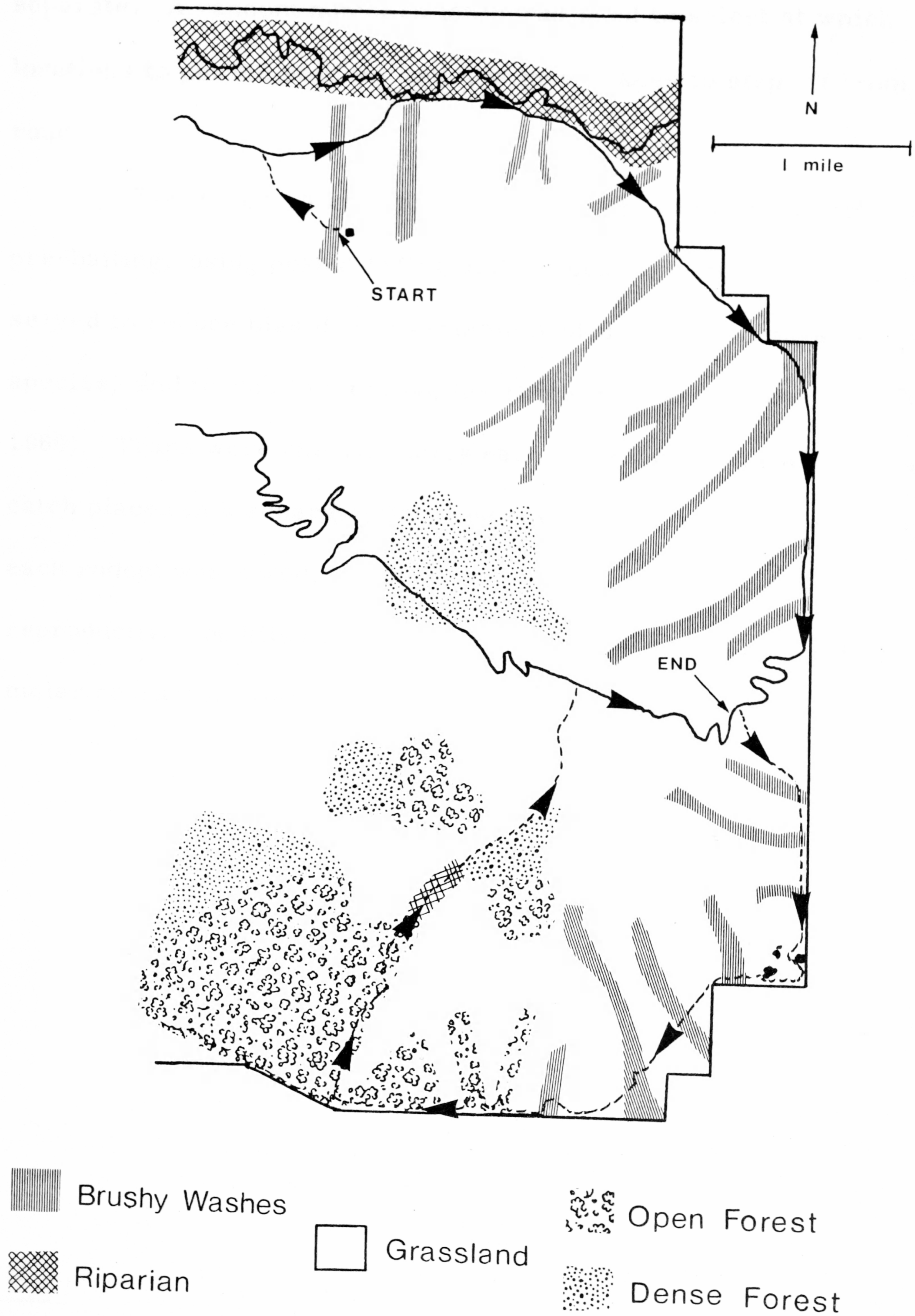
In late June, coyotes were trapped using No. 3 steel traps, each having a tranquilizer tab (Balser 1965) wired to one of the padded, offset jaws. With the help of a government trapper, J. Lewis, nine traps were set near dens, using coyote urine and putrid food scents as bait. After 8 days of little success, the traps were moved to runways that coyotes had dug under the peripheral fence. No bait or scent was used at these sets.

The three captured coyotes were anesthetized with 1 cc Ketaset, then sexed, weighed, measured, and eartagged (Appendix A). One half cubic centimeter of additional Ketaset was administered when necessary to keep the animal anesthetized.

Each of two coyotes had one toe removed. The surgical procedure, performed by a former Veterinarian's Assistant, D. Pond, approximated the technique described by Lumb (1965) for amputating toes of dogs. A teardrop-shaped incision was made encircling the toe to be removed. The skin was reflected slightly, the tendons overlying the joint severed, the joint between the second and third phalanges disarticulated, and the toe and pad removed. Three stitches secured the skin over the stump. Two topical antibodies, Topazone and Furacin, were applied to the wound, and $1\frac{1}{2}$ cc of combiotic (penicillin and streptomycin) were injected to help combat infection.

In a Nebraska study (Andelt 1976), toe removal did not

Fig. 3. Habitat types of the eastern portion of the NBR. The arrows mark the route of the small rodent trapline.


N
1 mile
START
END
Brushy Washes
Riparian
Grassland
Open Forest
Dense Forest

into 100 m intervals and each mark numbered, keeping habitats separate. A random numbers table was used to select at which locations to put the stations and how many paces to step off from the road.

Trapping was conducted for 4 nights, following 2 nights of pre-baiting, using peanut butter and oatmeal as bait. Pre-baiting served to reduce bias due to variable probability of capture between species, and tended to increase the removal rate (Babinska and Bock 1969). Traps were checked early each morning, with each station's catch placed in a separate, labelled envelope. Later the same day, each rodent was sexed, weighed, measured, and inspected for reproductive condition (Appendix A). Species were identified by molar characteristics following the key by Hoffmann and Pattie (1968).

CHAPTER IV

RESULTS

Pronghorns

Fawn Mortality

Thirty pronghorn fawns, 16 males and 14 females, were fitted with radio transmitters between 16 May and 4 June 1977 (Table 3). For fawns 1 day old or less, the average weight, total length, and girth were 3.7 kg, 64.8 cm, and 37.9 cm, respectively, with no significant differences between males and females (Table 2).

Table 2. Means and standard deviations of weights, lengths, and girths for pronghorn fawns from birth to 7 days of age.

	Weight (kg)	Length (cm)	Girth (cm)
1 day old or less: (N = 15)	$\bar{x}$ = 3.7 s = 0.54	$\bar{x}$ = 64.8 s = 4.12	$\bar{x}$ = 37.9 s = 2.36
2-3 days old: (N = 11)	$\bar{x}$ = 3.8 s = 0.32	$\bar{x}$ = 66.6 s = 2.82	$\bar{x}$ = 38.6 s = 1.30
4-5 days old: (N = 3)	$\bar{x}$ = 4.7 s = 0.17	$\bar{x}$ = 71.7 s = 2.08	$\bar{x}$ = 42.7 s = 0.58
6-7 days old: (N = 1)	x = 5.8	x = 74	x = 43

Table 3. Physical characteristics of 30 fawns captured in 1977 on the National Bison Range.

Fawn No.	Sex	Twin No.	Date of Capture	Estimated Age	Weight (kg)	Length-Girth (cm)
1	♂	. . .	16 May	1 day	3.9	61-39
2	♂	. . .	21 May	2 days	4.2	64-39
3	♀	4	21 May	1 day	3.9	59-38
4	♀	3	22 May	2 days	3.7	71-38
5	♀	. . .	23 May	2 days	3.9	62-41
6	♀	7	24 May	4 hrs.	3.7	72-42
7	♂	6	24 May	4 hrs.	3.9	67-39
8	♂	9	24 May	6 hrs.	4.3	70-40
9	♂	8	24 May	6 hrs.	3.2	62-38
10	♂	11	24 May	4 hrs.	4.2	63-38
11	♂	10	25 May	16 hrs.	4.3	71-39
12	♂	13	25 May	2 days	3.4	69-37
13	♂	12	25 May	2 days	4.1	67-39
14	♀	15	25 May	8 hrs.	4.1	70-39
15	♀	14	25 May	12 hrs.	2.7	62-32
16	♂	. . .	25 May	8 hrs.	4.1	64-38
17	♂	. . .	25 May	5 hrs.	2.7	63-34
18	♂	. . .	27 May	1 day	3.9	64-39
19	♀	. . .	27 May	2 days	3.6	65-38
20	♀	. . .	28 May	1 day	3.1	63-37
21	♀	22	29 May	3 days	4.3	69-39
22	♀	21	29 May	3 days	3.5	64-36
23	♂	. . .	30 May	3 days	4.1	69-40
24	♂	25	30 May	2 days	3.9	66-39
25	♀	24	30 May	2 days	3.4	67-38
26	♀	. . .	2 June	4 days	4.6	70-42
27*	♀	. . .	2 June	4 days	4.9	74-43
28	♂	. . .	2 June	5 days	4.5	71-43
29	♀	. . .	2 June	8 hrs.	3.4	61-37
30	♀	. . .	4 June	6-7 days	5.8	74-43

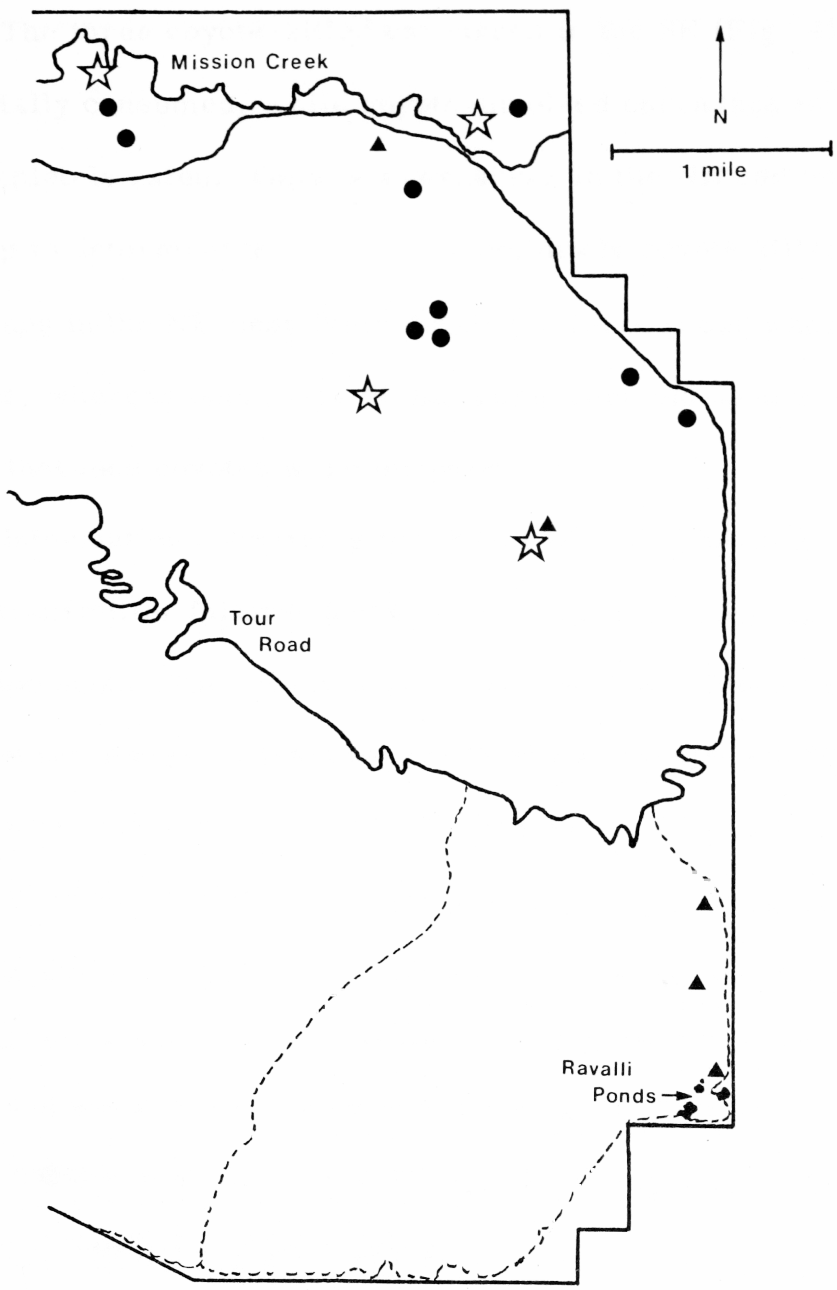
*Had a dislocated leg with lacerations.

All fawns appeared healthy and normal when handled, except for one (No. 27) whose left front leg was dislocated at the proximal end of the cannon bone with the skin over the joint lacerated. Eight pairs of the captured fawns were twins; others could have been twins but did not live long enough for me to see them feeding from the same doe (Table 3).

By the end of September, 27 of the 30 radio-equipped fawns were dead, a 90 percent mortality. Nine carcasses were found with enough evidence (hemorrhage and wound patterns) to determine the cause of death; five were killed by coyotes, three were killed by bobcats, and one was punctured by a golden eagle. The eagle kill had only a few talon-inflicted wounds in the right flank, with little bleeding and no organs being punctured. The 24-day-old fawn presumably died from the infection that was evident at necropsy. The mother probably frightened the eagle away before it could complete the kill. Two of the fawns killed by bobcats were found cached near Mission Creek; the other was cached about 6.5 km away at the top of Telephone Draw. Because of the distance between the caches, two bobcats were probably involved.

Only bits of bone, hair, chewed elastic, and the transmitters were found from 11 fawns. Nine of these remains were in the vicinity of coyote dens (Fig. 4), and the fawns were undoubtedly consumed by coyotes. The fawns had recently been seen and appeared healthy.

Fig. 4. The eastern portion of the National Bison Range with four coyote dens (stars), five coyote kills (solid triangles), and nine coyote-involved deaths (solid circles) shown.


Mission Creek
N
1 mile
Tour
Road
Ravalli
Ponds

These deaths were labelled "coyote involved" in Tables 4 and 5.

The three coyote-killed carcasses in the SE (Fig. 4) were only partially consumed, while coyote-involved carcasses in the NE were completely eaten. Only two carcasses in the NE had enough remaining to determine that they were definitely coyote kills. Coyotes feeding pups in the NE near their denning areas utilized whole carcasses, whereas only parts of the fawns were fed upon in the SE, implying that lone coyotes were involved.

Information concerning the deaths of seven fawns was lost due to three transmitter failures and four transmitters dropping from the animals too soon. The transmitter from Fawn No. 18 was found in the SE part of the Range 3 days after the fawn was seen appearing listless and suffering from a shoulder injury. The cause of death is unknown.

Two-thirds of the total mortality took place within the first 3 weeks of the fawns' lives, with all deaths of fawns born in the NE occurring during that time. Two fawns born in the SE moved to Alexander Basin and died there; one moved at 35 days of age and died 5 days later, the other moved at 33 days of age and died 2 days later. Both were "coyote-involved" deaths.

Three of the four fawns dying in the first week of life on the SE part of the Range (Fawns Nos. 15, 17, 18) were never seen with a doe after they were captured. Only a scratched transmitter and chewed elastic were found 1 day after handling Fawn No. 18. I was

Table 4. Fate of 14 fawns born in the NE and two fawns that moved to Alexander Basin from the SE.

Fawn No.	Days Surviving	Cause of Death	Remains
1	15+	Unknown	Transmitter failure--signal lost
2	3	Coyote	Head, neck, forelegs
3	10	Bobcat	Head, neck, left foreleg
4	11	Coyote involved	Transmitter
6	19	Coyote involved	Transmitter
7	9	Coyote involved	Transmitter
20	120+	Alive on 20 September	
21	10	Bobcat	Head and neck
22	10	Coyote involved	Transmitter
23	16	Coyote	Head, neck, forelegs
24	5	Coyote involved	Transmitter
25	13	Coyote involved	Transmitter*
26	4+	Unknown	Transmitter failure--signal lost
29	6	Coyote involved	Transmitter
Moved to Alexander Basin from SE:			
12	40	Coyote involved	Transmitter
28	35	Coyote involved	Transmitter

*A NBR employee saw the head with the eartag in the vicinity of a coyote den, but did not retrieve it; hence, a necropsy could not be performed.

Table 5. Fate of 16 fawns born in the SE.

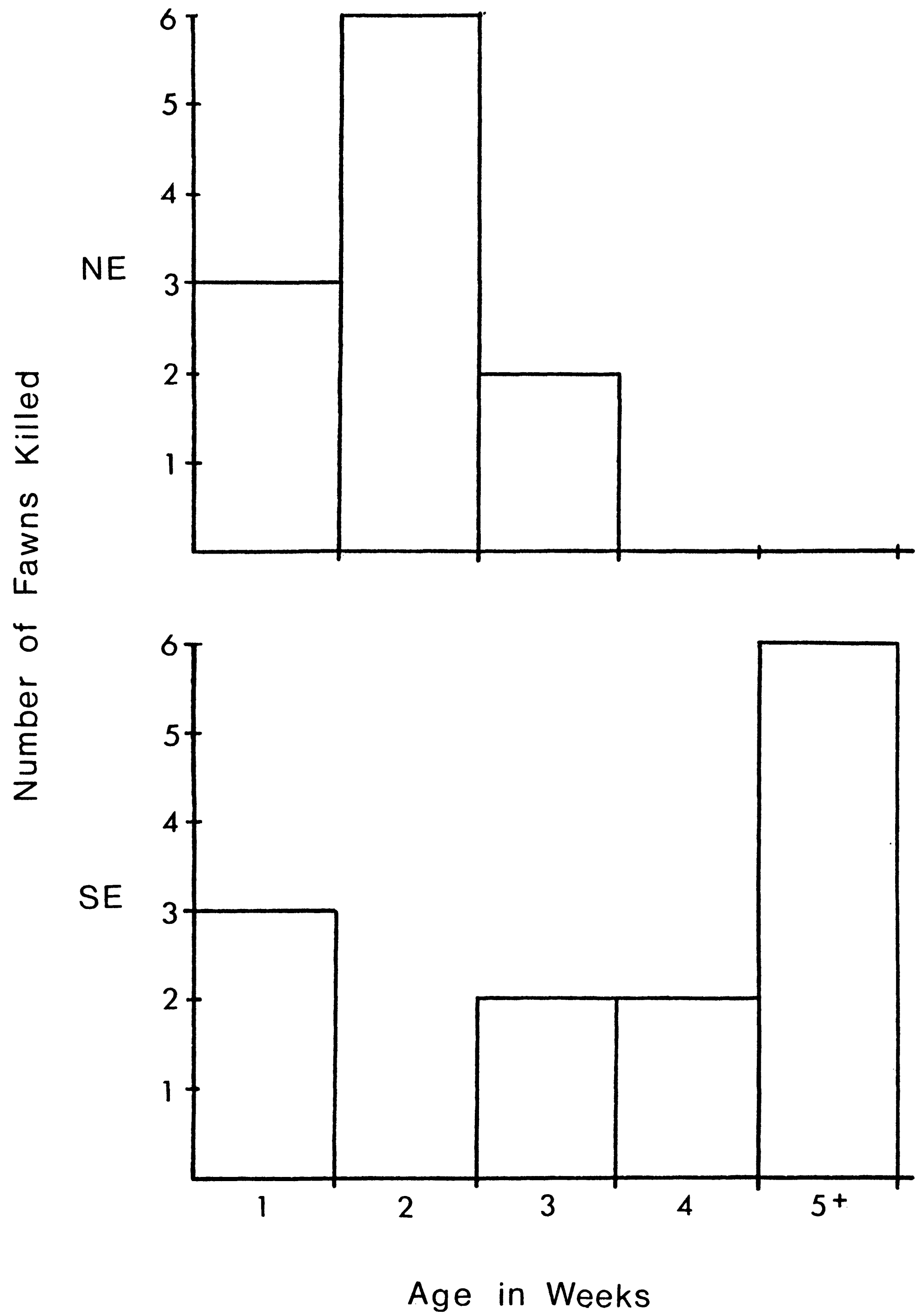
Fawn No.	Days Surviving	Cause of Death	Remains
5	43+	Unknown	Dropped transmitter 1 July, last seen 5 July
8	120+	Alive on 20 September	
9	20	Coyote	Head, neck, forelegs
10	51+	Unknown	Dropped transmitter 14 June, last seen 14 July
11	24	Unknown	Transmitter
12	40	Coyote involved	Transmitter
13	120+	Alive on 20 September	
14	36+	Unknown	Dropped transmitter 19 June, last seen 30 June
15*	2	Coyote	Whole carcass
16	5	Bobcat	Head, neck, forelegs
17*	4+	Unknown	Transmitter failure--signal lost
18*	1	Unknown	Transmitter
19	24	Eagle	Whole carcass
27	17	Coyote	Head, neck, forelegs
28	35	Coyote involved	Transmitter
30	29+	Unknown	Dropped transmitter 1 July, last seen 3 July

*Never seen with a doe after handling.

unable to locate the signal of Fawn No. 17 after 4 days, so its fate is unknown. No. 15, the smallest fawn caught, died 2 days after handling. Hemorrhage patterns indicated that a coyote had inflicted the wounds. Whether the fawns were accepted by their mothers is unknown; possibly, rejection predisposed the three fawns to their deaths. Fawn No. 16 was taken by a bobcat at 5 days of age. All other SE deaths occurred when the fawns were over 2 weeks old (Fig. 5). A Kolmogrov-Smirnov two-sample test showed that fawns born in the NE died at significantly earlier ages than those born in the SE ($T = 0.69$, $p < 0.005$).

The fawns which dropped their transmitters too early were assumed dead when they were not seen while censusing the pronghorn population on the Range in August and September. Does and fawns ranging in the SE started moving to the NE during the first part of July, and it seems highly possible that the fawns were killed by coyotes when they arrived in Alexander Basin. Consequently, fawns born in the SE that later moved to the NE died at older ages than fawns already near the coyote dens. Few pronghorns were seen using the SE part of the Range after mid-July.

Two of the three radio-tagged fawns that survived (Nos. 8 and 13) were above the average weight, girth, and length. Fawn No. 20, one of the smaller fawns, was the only fawn that survived in the NE. Size evidently did not predetermine who would survive, and any


NE
SE
Number of Fawns Killed
1
2
3
4
5
6
1
2
3
4
5+
Age in Weeks

fawn encountered by a coyote or bobcat was susceptible to predation.

Pronghorn Population

Fifty pregnant does were seen during each of the two censuses of the pronghorn population on the Range in early May; an estimated 95 fawns were born. Ten fawns were counted during the last census on 20 September, resulting in a fawn:doe ratio of 20:100.

Coyote Population

Scent Station Indices

The indices of scent station lines from 1974, 1975, and 1977 indicate an increase in the coyote population on the NBR (Table 6).

Table 6. Coyote scent station line indices from the NBR.*

	July	September
1974**	41	63
1975**	55	...
1977	80	132

$$^{*}\text{Index} = \frac{\text{total coyote visits}}{\text{total operative station-nights}} \times 1{,}000$$

**1974 and 1975 indices from Reichel (1976).

The increases in the indices between July and September are probably due to increased movement of pups and adults on the Range as the pups became more independent.

Toe-Clipping

Two coyotes each had a toe amputated. The third coyote captured had a previously injured right front leg which made her tracks recognizable and removal of a toe was unnecessary. The physical characteristics of the three captured coyotes are shown in Appendix B.

Unfortunately, the tracks of the marked coyotes were never seen at a scent station, so no conclusions can be drawn regarding individual coyote response to the line.

Coyote Observations

Four coyote denning areas were located in the NE; none were found in the SE, but coyotes were seen using the area. Coyotes denned in the West Horse Pasture and the Pauline Drainage, both in the northwestern part of the Range. K. Livesey (pers. comm.) found a denning area in the Elk Creek Drainage in the southwestern portion of the Range. Therefore, at least seven denning areas were located on the NBR during the study. Four adults used one of the NE denning sites, and a minimum of two adults used the other sites, resulting in a total of 16 adults. One den had five pups; other dens were conservatively estimated to have two pups each, adding to 17 pups. Consequently, there were 33 or more coyotes on the NBR during the summer of 1977. Reichel (1976) estimated from direct observations that a minimum of 29 coyote adults and pups were on the Range during the summer of 1975.

Coyotes were seen many times hunting in the NE, especially in Alexander Basin and south of Mission Creek. On nine different occasions, does were seen striking, snorting, and stamping at coyotes which approached closely.

Rodent Population

The number of rodents captured per 1,000 trap nights for 1977 are shown in Table 7. The six species were not trapped in equal numbers in the five habitats. *Peromyscus maniculatus* was the most abundant species, with significantly more trapped in the grassland habitat. The greatest number of *Microtus montanus* were trapped in grasslands; *M. pennsylvanicus* was caught in riparian habitat only. *Sorex vagrans* was trapped most frequently in riparian habitat, with *Zapus princeps* found in brushy washes and riparian habitat, and *Eutamias amoenus* in open and dense forests.

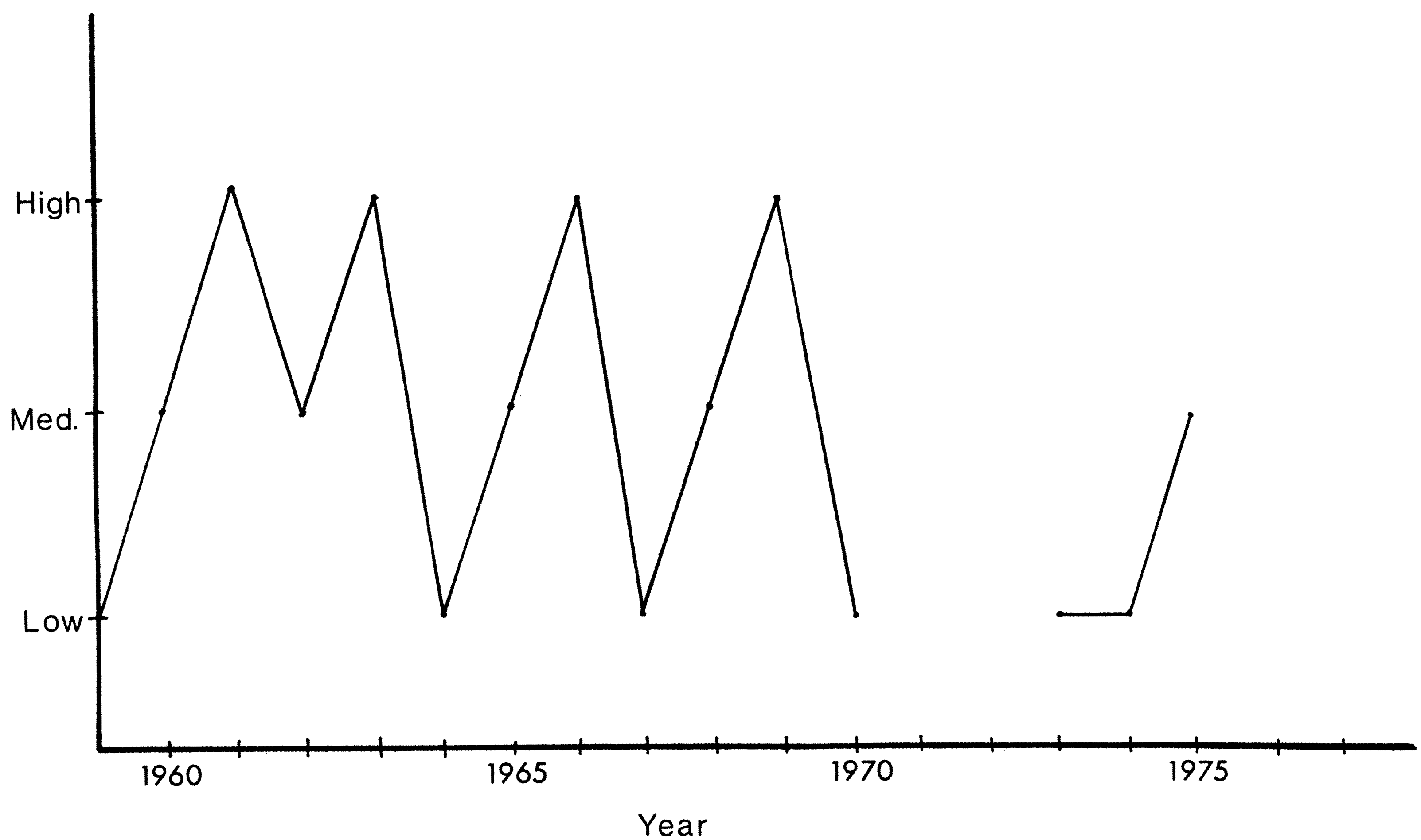
Many species of microtine rodents exhibit cyclic population fluctuations. Extrinsic agents of control, such as food supply, predators, or disease may influence the populations, but intrinsic agents, such as behavior and genetics, are thought by some to be the chief causes of the cycles (Krebs et al. 1973). For over 20 years, Range personnel have rated the annual microtine populations as high,

Table 7. Small rodent captures per 1,000 trap nights for five habitats (G = grassland, BW = brushy washes, R = riparian, OF = open forest, and DF = dense forests).

	G	BW	R	OF	DF	Total
Peromyscus maniculatus	172.92	95.83	79.17	47.92	33.33	429.17
Microtus montanus	8.33	...	6.25	2.08	...	16.66
Microtus pennsylvanicus	...	...	8.33	...	...	8.33
Sorex vagrans	1.04	6.25	25.00	...	...	32.29
Zapus princeps	...	4.17	2.08	...	...	6.25
Eutamias amoenus	...	...	...	4.17	4.17	8.34

medium, or low from general observations on the NBR (Anonymous 1956-77). Fig. 6 illustrates the cyclic population with peaks every 3 to 4 years.

The mean body measurements, weights, and reproductive condition of the small rodents are listed in Appendices C, D, and E, respectively.



High
Med.
Low
1960
1965
1970
1975
Year

CHAPTER V

DISCUSSION

Factors Limiting Pronghorn Fawn Survival

Fawn mortality is found throughout the range of the pronghorn, but rarely to the extent that I found on the NBR. The 90 percent mortality resulted in a September fawn:adult doe ratio of 20:100, which is unusually low compared to late summer ratios from other areas. Beale and Smith (1973) reported an average of 91 fawns per 100 adult does during a 5-year period in Utah. In central Idaho, Fichter and Nielson (1964) found ratios ranging from 54 to 111 fawns per 100 does (including yearlings). The latter ratios would be higher if yearling does had not been included in the census. Aerial surveys from 1966 to 1975 in central Montana averaged 96 fawns per 100 mature does (Pyrah 1976).

Disease

Disease was not evident in any of the fawns handled on the NBR, but has been found in other studies. Five of 117 radio-collared fawns in Utah died of disease, two from salmonellosis and three from pneumonia (Beale and Smith 1973). Bodie (1978) reported five of 29 fawns died from disease in Idaho.

The weights and apparent vigor of the captured fawns on the NBR indicates the animals were healthy at birth. The average weight for fawns 1 day old was 3.7 kg. Beale and Smith (1970) reported the average weight of fawns 1-3 days old in Utah was 3.8 kg.

Dam Abandonment

Any study involving the handling of wild animals must consider the possibility of researcher-induced mortality. Eleven of 117 fawns were abandoned following marking in Utah (Beale and Smith 1973). Marked white-tailed deer fawns in Texas had a higher mortality than unmarked ones (White et al. 1972). McCullough (1969) reported that his presence in the vicinity of hidden elk calves resulted in the cows staying away for longer periods than normal. Only a sixth as many calves per cow survived, due to increased coyote predation, as survived in nearby herds.

The unhunted population of pronghorns on the NBR have been habituated to the presence and smell of man, due mainly to the many tourists that drive the Tour Road every summer. Even so, they are wary of any approaching human.

Three pronghorn fawns captured on the NBR were probably rejected by their dams. In spite of this, the mortality of the marked fawns (90%) was not different from that estimated for the unmarked fawns (89%).

Precipitation

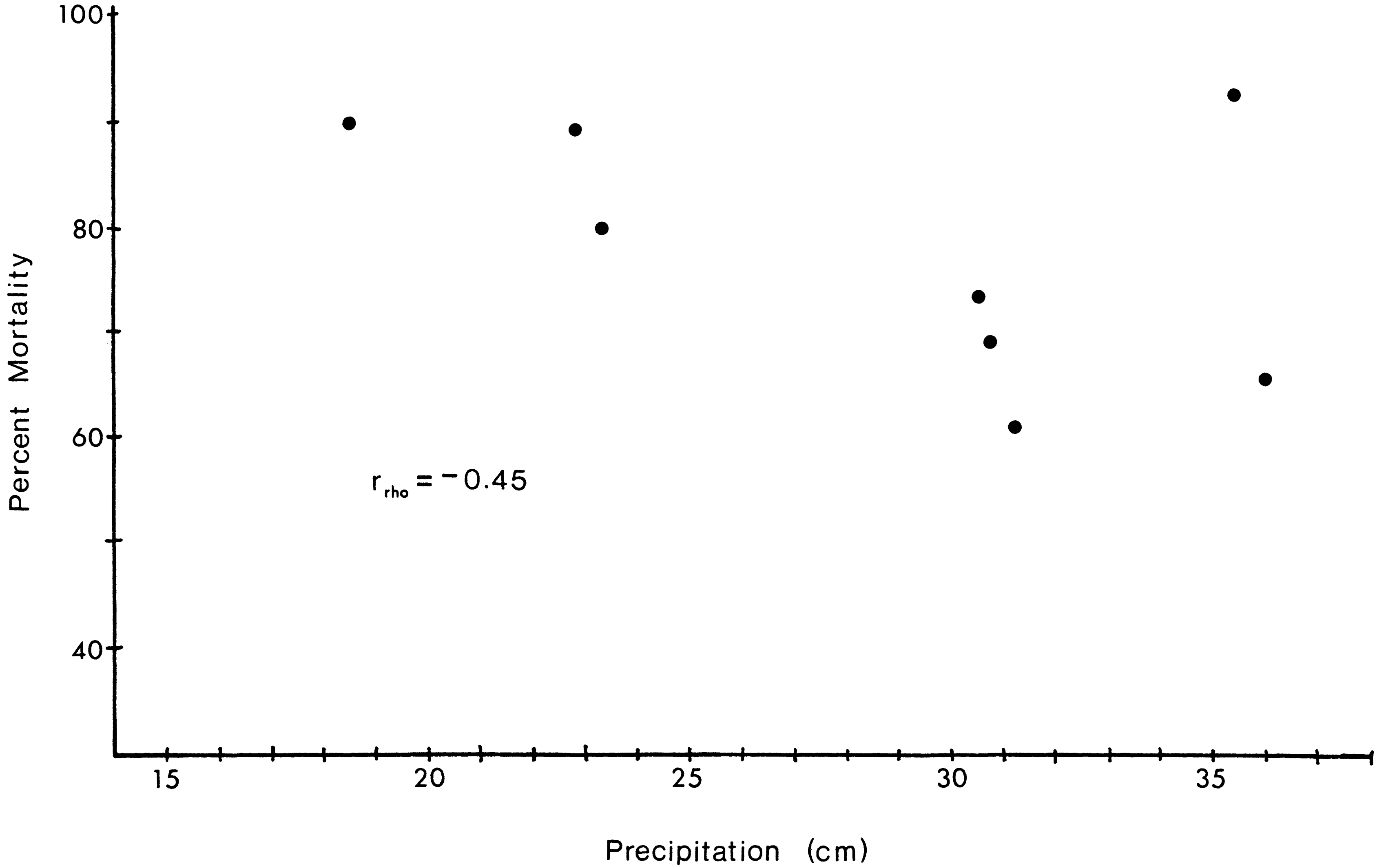
Table 8 lists the amount of precipitation that fell during September through August, what Fichter and Nielson (1962) called the ecological year of the pronghorn, and the percent fawn mortality during that year for 1969-77. There is a weak negative correlation (Fig. 7), i.e., as precipitation goes down, mortality goes up (Spearman's Rho = -0.45, $p < 0.15$).

Beale and Smith (1970) found fawn production to be significantly correlated to precipitation received during the previous summer months. They suggested that the condition of forage on the Utah desert influenced breeding activity and successful gestation. Also, they felt that poor forage conditions indirectly increased losses from predation. During dry years, antelope, presumably seeking more succulent vegetation, tended to move to higher elevations among the hills where the terrain was broken, making fawns more vulnerable to bobcat predation.

Smith and LeCount (1976) examined the relationships among seasonal rainfall, vegetative production, and mule deer fawn survival in Arizona. The 8-year study found a strong association between aggregate rainfall during October through April and forage yield from forbs and half shrubs ($r = 0.95$) as measured in April. Survival of fawns, reflected in the ratio of fawns per 100 does during January, also strongly associated with winter forb yield ($r = 0.87$) and October

Table 8. Total precipitation in centimeters from September through August, 1969-77, and the percent fawn mortality during each year as measured in August.

	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
Percent fawn mortality	66	62	80	89	73	69	93	90
Precipitation	36.22	31.22	23.42	22.86	30.53	30.78	35.46	18.52



100
80
60
40
Percent Mortality
$r_{rho} = -0.45$
15
20
25
30
35
Precipitation (cm)

through April rainfall (r = 0.65). Fawn:doe ratios in a predator-free deer enclosure on the study area did not vary much, while the forb production greatly varied. The authors found that predation was the most important proximate cause of mortality in the open area, but postulated that habitat quality, mainly its nutritional value, was the ultimate determinant. Habitat condition altered predation, probably by affecting alternate foods for coyotes, vigor of fawns, and adequate ground cover.

Fichter and Nielson (1962) observed a trend that suggested a correlation between productivity and precipitation during the preceding ecological year, based on fawn:doe ratios in August. In a later report, Fichter and Nielson (1964) suggested there might be a compensatory effect with marked increases in precipitation during the current ecological year, i.e., the lush growth during lactation could offset any deleterious effect the condition of the winter range might have on postpartum survival of fawns. They felt this lent weight to Einarsen's (1960) thesis that the postpartum mortality of fawns may be accelerated by decreases in milk production by does in response to the drying out of vegetation on summer ranges.

All the studies mentioned previously that found correlations between fawn survival and precipitation were conducted in semi-desert areas that receive less precipitation than the Bison Range. The data from the NBR only weakly supports the idea that low precipitation, less succulent forage, and therefore accelerated decrease in doe milk production, affected fawn vigor and survival. The most obvious conflict to this idea was September 1975 to August 1976, which had higher than average precipitation (35.46 cm) and extremely high fawn mortality (93%) (Table 8). The condition of the forage no doubt influenced alternate coyote food, fawn birth and bedding sites, etc., but was beyond the scope of this study. Predation was the most important proximate mortality factor.

Food Habits and Range Condition

Rumen analysis by O'Gara and Greer (1970) indicated that NBR pronghorns were not on a normal diet compared to the findings of other studies of northern pronghorn food habits. Browse, especially sagebrush, made up over 80 percent of the winter diet during studies in some northern areas (Fichter and Nielson 1962, Bayless 1969, Beale and Smith 1970). Yet, forbs made up the largest part of the NBR pronghorns' diet during winter (O'Gara and Greer 1970). Monthly use of forbs ranged from 44 to 84 percent, with yarrow and aster most frequently used. Food habit studies of pronghorns usually indicate that forbs are most important during summer. In Utah, Beale and Smith (1970) found that forbs provided 90 percent of the diet during summers of above-average rainfall; only 20 percent forbs were in the diet during below-average rainfall, with browse making up the remainder. Succulence appeared to be the major characteristic of the forage sought by the antelope.

On the NBR, grass was eaten in trace amounts during August and September and increased to about 5 percent in the autumn, while maximum utilization of about 30 percent grass prevailed from March through June (O'Gara and Greer 1970). Some browse was used throughout the year, with fringed sagebrush (Artemisia frigida) and snowberry occurring most frequently. The averages for the year were 18 percent browse, 67 percent forbs, and 15 percent grass.

Fat indices of adult females indicated that those from the NBR were in poorer condition than those from Yellowstone National Park (O'Gara 1968). One of the reasons for the difference in condition between the two populations was the smaller number of lactating does in Yellowstone Park. Another reason may have been that pronghorns cannot winter well without adequate browse. The amount of browse on the NBR has gradually increased since the early 1960's following annual deer and elk reductions to relieve pressure on the vegetation (O'Gara, pers. comm.). Probably, pronghorns have benefited from the improved management by having more winter browse available.

Range condition surveys, following U.S. Soil Conservation Service standard procedures, have been conducted on the NBR every 4 years (NBR Records). Range sites were classified as excellent (76-100% of climax vegetation), good (51-75%), fair (26-50%), or poor (0-25%), taking soil types and climate into consideration (see Appendix F). Range condition roughly corresponds with stages in secondary succession; i.e., ranges in early "weedy" stages are considered poor, those with climax vegetation are excellent. The results from the surveys are used to determine stocking rates and management of the animals on the Range (Haderlie, pers. comm.).

The results of the last four surveys show a trend toward improving range condition (Table 9).

Table 9. Results of four range condition surveys conducted on the National Bison Range. Figures are percentage of Range in that class (NBR Records).

Condition Class	1964 (%)	1969 (%)	1973 (%)	1977 (%)
Excellent	3	10	17	83
Good	42	78	67	12
Fair	54	12	16	5
Poor	1	T	T	0

The improvement trend signifies there are fewer invaders, species not present in native vegetation or natives that make up less than $2\frac{1}{2}$ percent in climax; fewer increasers, species present in climax which increase with disturbance; and more decreasers, species that decrease with grazing pressure by cattle. Climax

Palouse Prairie is about 10 percent increaser forbs and about 5 percent decreaser forbs (Kirschten, pers. comm.). Forbs such as yarrow and aster, found to be heavily utilized by NBR pronghorns (O'Gara and Greer 1970), are becoming less abundant as the range "improves."

Kitchen (1974) reported the northern portion of the NBR was most heavily used by does for fawning during his study in 1969-71. Use of the north side for fawning decreased during the following years (Haderlie, pers. comm.). During April and May 1977, does drifted into the area around the Ravalli Ponds in the SE part of the Range. Twenty-seven, over half the does on the Range, were seen there on 21 May. Range site condition for the area, which receives heavy grazing pressure from the bison for 3 months every year, was rated as fair in the 1977 survey (NBR Records). In general, the northern portion of the Range has more productive soil and near-climax vegetation than the southern part of the Range (NBR Records). Possibly, the greater abundance of forbs in the SE attracted does during spring and early summer.

Reference has been made in the literature regarding antelope fawning grounds as traditionally used areas. During his study, Kitchen (1974) found what he labelled the "Fawn Bowl," located in the NE, to be used most for pronghorn fawning. Swanger (1977) reported that does were rarely seen in the Fawn Bowl and only two sets of twins were captured there during summer 1977. The concept of a traditional fawning ground does not apply to the Bison Range. In northcentral Idaho, Autenrieth (1976) discovered no traditional fawning areas. Instead, the parturient does selected a habitat type providing greater than average brush canopy coverage, total coverage and brush height. Other studies show marked regional variations in the characteristics of birth sites chosen by pronghorn does (Fichter 1974).

Pronghorn fawns select their own bedding sites (Fichter 1974). Until they were about 3 weeks old, fawns in Idaho sought seclusion in vegetative cover resembling that in which they were born, implying that habitat imprinting occurs (Autenrieth and Fichter 1975). If so, the doe's choice of parturition site will influence the fawn's choice of bedding sites. Bromley (1977) suggested that utilization of bedding sites which combined irregular shapes of surfaces similar to the color of the fawn was an adaptation to prevent the learning of effective specific searching images by eagles. Autenrieth and Fichter (1975) postulated that selection of a bedding site that provided vertical obstructions would reduce the likelihood of detection by a coyote or bobcat, but Bodie (1978), by use of radiotelemetry, found that fawns in habitat providing maximum visual surveillance (short sage/grass community) had fewer predator-related mortalities than fawns using taller vegetation (tall sage/foothill community). He suggested mammalian predators preferred to hunt in the taller vegetation because of more cover and greater numbers of prey species. Also, the foothill wind currents may have assisted the avian predators.

The gradual increase in browse on the NBR since the early 1960's has probably enhanced diversity, improved habitat structure, and added more cover for terrestrial predators. Reichel (1976) reported that coyotes were observed hunting in brushy washes and riparian habitats significantly more than those habitats were available. During my study, pronghorn fawns were very rarely found in brushy areas.

The possible relationship between preferred cover for parturient does and similar habitat for bed-searching fawns may be of particular importance in areas with high predator densities. Survival of fawns before 1970 was high, so any detrimental effects the habitat may have had was not evident. Coyote control was discontinued in 1962 and a build-up of predators followed, probably making the availability of suitable birth sites and fawn bedding sites more crucial to fawn survival.

Predation

Predation was the most important proximate cause of pronghorn fawn mortality. One-third of the deaths of radio-collared fawns were definitely caused by predators; another third were "coyote involved" and undoubtedly consumed by coyotes. The animals had been seen recently and appeared healthy, implying that these deaths were also caused by predators. Due to equipment failures and insufficient evidence, the causes of death of the remaining fawns were unknown.

Bobcat predation. Bobcat predation was not a major factor, contributing to only three deaths of radio-collared fawns. No census was made of the bobcats on the NBR and only a few observations have been recorded in the Narrative Reports in recent years.

Twenty-five percent of successfully instrumented pronghorn fawns in Utah were killed by bobcats (Beale and Smith 1973). Only 1 percent of the deaths were attributed to coyotes. The evidence suggested that only a few bobcats were involved in the predation. The fact that the herd was confined in one locality may have intensified the problem.

Eagle predation. Golden eagles are "common" year-round residents at the Bison Range (Anonymous 1978). A few eagles a year have been sighted and very few nests located, but undoubtedly some nesting occurs on the Range (Anonymous 1956-77). Only one fawn's death was caused by an eagle during 1977. Some pronghorn mortality studies reported only negligible eagle predation (Jones 1949, Yoakum 1957, Compton 1958, Hinman 1961, Beale and Smith 1973), but Bodie (1978) found that four of nine predator-killed fawns were eagle kills.

Some nesting pairs of eagles were found to feed heavily on black-tailed deer fawns while other pairs did not (Carnie 1954).

Coyote predation. Most of the predation can be attributed to coyotes. The coyote population on the NBR has increased since 1962, but the density is not abnormally high. Knowlton (1972) reported the usual density for coyotes over most of their range to be one per 259 to 518 hectares. The Bison Range coyote density during summer 1977, estimated from observations, was slightly above that, about one coyote per 233 hectares. The coyotes were not evenly distributed over the Range, though, being concentrated in the NE during denning, so in affect their density was much higher during that time.

The other method used to obtain a population index, the standardized scent station line, has several inherent shortcomings. The method assumes that the relationship between visitation rate and density of a species is sufficiently consistent to provide a reliable index. Wind and rain may destroy tracks and necessitate resifting of the soil and renewal of the attractant. Some coyotes may ignore stations, while others visit several. Habituation to odors may occur and effectiveness of the chemical attractant is unknown (Linhart and Knowlton 1975, Lehner 1976).

Indices obtained from different areas are not comparable, due to the many variables involved, but comparison of the indices from the same area should be relatively accurate (Roughton 1977). The indices from the NBR increased from 1975 to 1977, as did the visual estimations of the coyote population. Therefore, the scent station line method was sensitive enough to pick up a density increase on the NBR.

There were 11 coyote or coyote-involved fawn deaths in the NE, but only 3 in the SE. The higher incidence of coyote involved deaths in the NE is related to the coyote denning activity that concentrated there. Adults looking for food for their pups hunted in close proximity to the dens. In Nebraska, Andelt (1976) found by use of radiotelemetry that the mean distance travelled from den sites during 24-hour monitoring periods in May and June were 1.0 km, 0.7 km, and 0.6 km for an adult male and two adult females, respectively. Home ranges increased during adolescence and pre-breeding. In Oklahoma, Litvaitis (1978) found by use of telemetry that the mean modified-minimum area home ranges for denning coyotes were 7.3 km^2 for adult males and 8.1 km^2 for adult females. Litvaitis also discovered that his radio-collared coyotes had smaller home ranges during pup nursing (16 April - 15 June) than during pup training (16 June - 15 August), and tended to travel circular routes beginning and ending near the denning or rearing sites.

If NBR coyotes also restrict their movements during pup nursing and training, fawns born in the NE, where the coyote dens were concentrated, would provide an easily accessible food source. Fawns born in the SE portion of the Range would not be as likely to be discovered by a hunting coyote.

The question arises of whether the shift of fawning sites to the SE is related to the predator pressure occurring in the NE, where most fawning took place prior to the increase in the coyote population. Geist (1971) suggested that the habitat selected by a female ungulate to give birth would have reduced visibility, reduced probability of encounter with predators, and reduced contact with conspecifics. Studies of pronghorns have found that parturient does selected birth sites with restricted visibility (Howard 1966, Bromley 1967, Pyrah 1974, Autenreith and Fichter 1975). Parturient moose (*Alces alces*) selected areas which provided visual screening and occasionally gave birth on small islands, apparently avoiding contact with wolves (*Canis lupus*) (Stringham 1974). Similarly, Shoesmith (1977) reported that woodland caribou (*Rangifer tarandus caribou*) moved to small islands during calving and were isolated from wolves.

Bromley (1977) presumed that pronghorn does could remember where they had encountered predators in the past. After searching all accessible areas in Wind Cave National Park, Bromley found the 10 births he observed were less than 300 meters from a road and usually near areas frequented by workers and tourists. He suggested that the connection between the activities of man and birth sites was the avoidance of those areas by characteristically wary predators.

Beale and Smith (1973) found no evidence that does would move away from the scene of a kill. Often a doe was seen in the same area in which one of her fawns had previously been killed. This phenomenon was also observed several times on the Bison Range during my study. It appears the doe is keying to a certain location, and the death of her fawns does not cause a shift to another area, at least not during the current fawning season. Whether or not the doe would avoid that area during fawning the following year is unknown.

The availability of food, not predation, is probably the primary force affecting the choice of parturition and rearing areas. Lactating does are under considerable physical stress and need succulent, nutritious food. Bromley (1977) also considered habitat structure and predation only secondary ecological forces, with food availability the primary force.

Anti-predator Strategy

A gregarious animal such as the pronghorn takes advantage of the sensory systems of its conspecifics, making early detection of a predator more likely (Bromley 1977). Since the pronghorn is not large enough to pose a serious threat to a wolf, historically the major predator of pronghorns, the ability to outrun the predator has evolved. When the fleeing herd is beyond the capture distance of the predator, the herd stops running and faces the predator, thus saving the energy required to run out of sight.

Immobile pronghorns, such as does in labor and newly born fawns, would be easy targets for predators. Does reduce the odor of their fawns by consuming feces and urine and licking the urogenital and anal orifices. The grey-brown pelage of a fawn blends well with the prairie environment. The newborn pronghorn is a "hider" that lies in seclusion up to 90 percent of the daytime until about 3 weeks old (Fichter 1974). If a predator appears, the fawn slowly lowers its head and ears and freezes, making detection by a predator less likely.

Pronghorn does are often aggressive toward predators. McLean (1944) observed does driving off coyotes on two occasions. Does during late May and June rushed toward approaching eagles, reared up on their hind legs and kicked with their forelegs toward the birds (McLean 1944, Autenrieth and Fichter 1975). Does on the NBR acted aggressively toward coyotes on several occasions.

Alternate Prey of Coyotes

Coyotes are opportunistic feeders, eating whatever is seasonally available. On the NBR during spring and early summer, native ungulate fawns were important (i.e., frequently found in scats) in the coyote diet (Reichel 1976). Insects, seeds, and berries were important during late summer and early fall; in winter, cattle (Bos *taurus*) were frequently eaten as carrion. *Microtus* spp. were the most important food source throughout the year, while *P. maniculatus* were relatively unimportant in the coyote diet, even though *P. maniculatus* were more abundant on the Range. Evidently, the *P. maniculatus* were less vulnerable to coyote predation.

Reichel (1976) observed during May through September that coyotes hunted in brushy washes and riparian habitat significantly more than those habitats were available. Those two habitats also had significantly more *Microtus* spp. trapped in them (Table 10). Therefore, Reichel concluded that coyotes selected hunting areas which corresponded to areas of greatest *Microtus* abundance. In 1977, no *Microtus* were trapped in brushy washes, but the highest numbers were found in riparian habitat (Table 10). The number of *Microtus* captured per 1,000 trap nights in 1977 was roughly one-half of those caught in 1975. The low number of microtines probably increased the predation upon pronghorns and other prey species that were more abundant. If coyotes preferred *Microtus* spp. to other prey during periods when the microtines were very abundant, one would expect a shift in predation away from pronghorn fawns and other prey during those peak periods. There is no data to support that hypothesis. The high pronghorn fawn mortality after 1969, presumably due mainly to coyote predation, occurred during high and low microtine populations. The coyotes preyed heavily on fawns regardless of the abundance of

Microtus spp., probably because pronghorn fawns represent a much larger energy package per unit of effort than mice.

Table 10. *Microtus* spp. and *P. maniculatus* captured per 1,000 trap nights for three habitats in 1975 and 1977. (G = grassland, BW = brushy washes, and R = riparian.)

	Habitat	1975*	1977
Microtus spp.	G	1.94	8.33
	BW	14.19	...
	R	24.85	14.58
	Combined	13.66/1,000	7.64/1,000
P. maniculatus	G	83.62	172.92
	BW	78.28	95.83
	R	98.39	79.17
	Combined	86.76/1,000	115.97/1,000

*1975 data from Reichel (1976).

The utilization of alternate prey may enhance the ability of predators to adversely affect ungulate populations (Connolly 1978). Several sources of food, and therefore more biomass, permit the maintenance of a higher predator:ungulate ratio than would be possible if the ungulates were the sole prey. Connolly noted that when coyotes are numerous they might inflict serious losses to ungulate populations during vulnerable periods such as harsh winters, parturition, or fawn rearing. On the other hand, an abundance of alternate prey could conceivably reduce or postpone coyote predation on the ungulates. In conflict with the latter, the coyote predation on pronghorn fawns on the NBR was not lessened even during peak periods of alternate prey.

Inexperienced canids acquire the patterns of attacking prey from experienced adults through observational learning and experience of trial and error (Fox 1969). Once a predator recognizes a species as a prey item, it will probably continue to prey upon it. A few coyotes that are adept at finding and killing fawns could be more detrimental than a large number of coyotes that occasionally prey on fawns. Beale and Smith (1973) reported that a few individuals (bobcats) were probably responsible for the bobcat-induced fawn mortality. They suggested that a bobcat is more likely to continue predation on a species once it starts. Since the study area was enclosed, similar to the NBR, the constant presence of pronghorns in one locality may have increased predation. Open range pronghorns may frequent a locality for a year or two, then disappear from it, reducing the likelihood of encounters with "antelope-experienced" predators. Knowlton (1968) felt that fences would facilitate the capture of pronghorns by coyotes, especially fawns unfamiliar with the area. Also, familiarity with an area allows a predator to utilize the food resources more efficiently (Tinbergen 1957). In Utah, a single coyote took 22 of 45 estimated mule deer fawns in a 202 ha enclosure (Robinette and Olsen 1944). Fences that encompass and divide the NBR may influence the degree of fawn predation, mostly by confining the animals with experienced predators.

Management Implications

Since surplus animals are not a goal on a wildlife refuge such as the NBR, high fawn mortality cannot be considered harmful as long as there are enough young animals to replace the adults that die. In the last few years, enough fawns have survived to maintain a relatively stable population. The affect predation has on a herd increases as the size of the herd decreases (Connolly 1978). If predation increases, and/or other factors add more stress, the pronghorn population faces a decline and eventual extinction from the Bison Range. Since it appears that predation is the major mortality factor of fawns, predator control may be necessary if pronghorns are to remain on the Range.

In 6 years, covering five antelope areas, antelope fawn crops increased following predator control work in Arizona (Arrington and Edwards 1951). The researchers found effective predator control operations must cover large blocks of range to prevent infiltration of predators from adjacent areas. In Texas, 4 months of intensive coyote control before fawning was not effective in reducing the predators or the predation levels (Jones 1949). Areas used were too small to prevent almost immediate influx of more coyotes. Small pronghorn herds increased following reduction of coyotes in Utah, but it was not clear that reduced predation was the cause for the increase (Udy 1953). In areas of Texas with predator control, the numbers of fawns per 100 does were 142 percent and 129 percent higher (in successive years) than in ranges with no control (Knowlton et al. 1971).

Connolly (1978) reviewed several studies of predator control involving a variety of ungulate and predator species. He concluded that certain conditions must be present before the removal program can result in increased ungulate populations. First, the ungulates must be below the carrying capacity of their range. Second, predation must be the principle reason for the low survival, or else fawns not preyed upon will die anyway due to other causes. Third, the predator control must be intensive and extensive enough to reduce sufficient numbers of predators over a large area.

The pronghorn herd on the NBR is probably well below its carrying capacity, but there are six other ungulate species to consider in the management of the Refuge. The managers must decide if more pronghorns are desirable. Predation appears to be the proximal cause of mortality: pronghorns were flourishing on the Range before the coyote increase, in spite of the fact that pronghorns were not indigenous to the area. If an objective is more pronghorns, then predator control would probably be effective in achieving that goal.

CHAPTER VI

SUMMARY

The causes and degree of pronghorn fawn mortality on the National Bison Range were studied during 1977. Twenty-seven of 30 fawns outfitted with radio-collars were dead by the end of September, a 90 percent mortality. Predation was the main proximate cause of the mortality. Nine carcasses were found with enough evidence (hemorrhage and wound patterns) to definitely determine that five were killed by coyotes, three by bobcats, and one by a golden eagle. Bits of bone and hair from nine other fawns were found in the vicinity of coyote dens, and were undoubtedly consumed by coyotes. The fawns had been seen recently and appeared healthy, giving circumstantial evidence that predation was also their fate. Three fawns were probably rejected by their mothers, predisposing the fawns to their deaths. Due to equipment failure and insufficient evidence, the causes of death for the remaining fawns are unknown.

A general increase in the coyote population has occurred since control measures were discontinued in 1962. The population during summer 1977 was estimated at 33 or more from observations. The scent station line method also indicated an increase in the population compared to indices from 1975 and 1976. Four coyote dens were located in the NE portion of the Range, and all but one radioed fawn born in the area died within the first 3 weeks of life. Fawns in the SE that later moved to the NE died at older ages.

Microtus spp., the main component of the NBR coyote diet during a previous study, were low in numbers, forcing coyotes to seek other sources of food, one of which was pronghorn fawns. Examination of past population levels revealed that pronghorn fawn mortality did not cycle as the microtine abundance cycled, suggesting that coyotes preyed heavily on fawns regardless of the abundance of their major prey item.

Pronghorns are not indigenous to the NBR, so the habitat could be affecting mortality, possibly through nutritional stress during severe winters, and through availability of adequate fawning and bedding sites, by making fawns more vulnerable to predation. Pronghorns were very productive on the Range before the coyote increase.

Other factors limiting pronghorn fawn survival were examined. Disease was not evident in any of the handled fawns and weights were comparable to those of fawns in other areas, indicating the NBR fawns were healthy at birth.

Surplus animals are not a goal on a wildlife refuge such as the National Bison Range, but if predation and/or other factors add more stress, predator control may be necessary if a herd of pronghorns is to be maintained.

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APPENDIX A

Datum Forms Used During the Study

PRONGHORN FAWN DATUM FORM

Fawn No. ____________________

Map location ____________________

Distance from twin ____________________

Sex ________ Weight ____________

Total length ________ Girth ________

Approx. age ____________________

Tooth length ____________________

Placenta present ______ Um. cord ______

Condition (Pelage, external parasites,

abnormalities) ____________________

____

____

Picture No. ____________________

Habitat ____________________

____

Radio Collar Frequency ____________

Band ______ Channel ______ F.T. ______

Pulses/5 sec.: Fast ______ Slow ______

Date __________ Time __________

Birth observed ____________________

Orients on doe ______ Tries to stand ______

Stands briefly ______ Walks few steps ______

Searches for udder ______ Nurses ______

Walks away from doe & returns ________

Follows doe short distance ________

Walks away few meters, lies down ______

Assumes rump up posture ______

Beds ________ Doe leaves ________

Response to stalking & capture __________

____

Handling ____________________

Behavior of doe ____________________

____

____

Fawn accepted _____ rejected _____ Time _____

RADIO LOCATIONS

Date	Time	Pulse	Visual	Date	Time	Pulse	Visual

FAWN CARCASS DATUM FORM

Date____________________ Approx. Time of Death____________

Tracks of Signs____

Carcass Salvaged__________ Tag #_________ Weight___________

Carcass Description____________________________________

____

____

____

____

Map Location____

Picture #_________________

COYOTE DATUM FORM

Coyote Eartag________________ Left or right ear? Date___________

Time__________

Sex____________ Age____________ Weight____________

Measurements:

Total___________ Tail___________ Hindfoot_________ Ear_______

Tranquilizer tab chewed?___________

Behavior when approached____

____

Drug dosage_________________________ Time under__________________

Surgery: Toe removed______________

Notes:

SMALL RODENT DATUM FORM

Date:

Plot:

Weather:

Start: Finish:

						Length								Embryos or Placental Scars	
Station	Number	Species	Sex	Age	Weight	Total	Tail	Hind-foot	Ear	Testis Position (S or A)	Vaginal Orifice Open?	Mammae Visible?	Lactating?	L	R

APPENDIX B

Physical Characteristics of Three Coyotes Captured on the National Bison Range, 1977

Ear/Eartag Color/Number	Date Captured	Sex	Age	Weight (kg)	Length Measurements (cm)			
					Total	Tail	Hindfoot	Ear
Left/Silver/G808	6/23/77	♂	Juvenile	4.8	96.0	26.5	16.0	10.5
Left/Blue/G664	7/09/77	♂	Juvenile	5.4	105.5	30.5	17.0	10.0
	10/28/77	Trapped north of the Bison Range by a fur trapped--weighed 12.7 kg.						
Right/Green/G334	7/11/77	♀	Adult	9.5	124.5	35.0	18.0	12.0

APPENDIX C

Mean Body Measurements of Small Rodents Trapped on the National Bison Range During May, July, and September 1977

Measurement (mm)	*Peromyscus maniculatus*			*Microtus montanus*			*Microtus pennsylvanicus*			*Sorex vagrans*			*Zapus princeps*			*Eutamias amoenus*		
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
Total length:																		
adult ♂	134	160.4	13.4	2	143.0	1.4	2	154.5	7.8	4	105.0	3.9	3	226.7	6.7	1	201.0	
adult ♀	92	160.5	8.6	4	136.8	11.6	1	147.0		3	105.7	2.3	0			2	215.5	2.1
juvenile ♂	35	135.6	13.5	4	118.3	12.7	0			7	98.9	5.6	0			1	194.0	
juvenile ♀	27	140.8	8.8	2	107.5	3.5	1	133.0		2	93.5	5.0	0			0		
Tail length:																		
adult ♂	134	67.2	9.7	2	31.5	2.1	2	36.5	3.5	4	40.5	1.9	3	133.0	6.2	1	76.0	
adult ♀	92	67.9	5.7	4	29.5	4.2	1	34.0		3	41.3	1.5	0			2	90.0	5.7
juvenile ♂	35	58.3	7.3	4	31.8	9.5	0			7	39.1	3.9	0			1	83.0	
juvenile ♀	27	59.2	6.3	2	28.5	0.7	1	30.0		2	40.5	0.7	0			0		
Hindfoot length:																		
adult ♂	134	19.1	0.8	2	18.5	0.7	2	18.0	1.4	4	13.0	2.0	3	29.3	0.6	1	32.0	
adult ♀	92	18.9	0.7	4	17.5	1.3	1	18.0		3	11.7	0.6	0			2	29.5	0.7
juvenile ♂	35	18.4	0.8	4	17.3	0.5	0			7	11.6	0.8	0			1	29.0	
juvenile ♀	27	18.5	0.6	2	17.0	0.0	1	17.0		2	11.5	0.7	0			0		
Ear length:																		
adult ♂	134	17.5	1.3	2	12.5	0.7	2	14.5	0.7	4	6.8	1.3	3	15.7	0.6	1	15.0	
adult ♀	92	17.6	1.2	4	12.3	1.0	1	12.0		3	6.3	2.1	0			2	17.0	1.4
juvenile ♂	35	16.9	2.0	4	11.5	1.73	0			7	5.1	1.8	0			1	15.0	
juvenile ♀	27	17.3	1.0	2	11.0	1.4	1	12.0		2	6.0	1.4	0			0		

APPENDIX D

Number of Small Rodents Captured Distributed into 5 Gram Weight Categories for Each Age and Sex Class

	Species																							
	Peromyscus maniculatus				*Microtus montanus*				*Microtus pennsylvanicus*				*Sorex vagrans*				*Zapus princeps*				*Eutamias amoenus*			
Weight class (g)	A♂	A♀	J♂	J♀	A♂	A♀	J♂	J♀	A♂	A♀	J♂	J♀	A♂	A♀	J♂	J♀	A♂	A♀	J♂	J♀	A♂	A♀	J♂	J♀
0- 4														1	2	1								
5- 9			5										4	2	6	1								
10-14	3	1	22	17			1	1																
15-19	34	38	7	10			1										1							
20-24	86	45					1					1					2							
25-29	11	7				1																		
30-34					1	1			2	1														
35-39																								
40-44					1	2																		
45-49																							1	
50-54																					1			
55-59																						1		
60-64																						1		
Sample size	134	91	34	27	2	4	3	1	2	1	0	1	4	3	8	2	3	0	0	0	1	2	1	0
Mean (g)	20	20	13	14	37	35	17	14	31	31		21	7	6	5	5	21				51	59	45	

APPENDIX E

Reproductive Condition of Small Rodents Trapped on the National Bison Range During May, July, and September 1977

	Peromyscus maniculatus	*Microtus montanus*	*Microtus pennsylvanicus*	*Sorex vagrans*	*Zapus princeps*	*Eutamias amoenus*
MAY						
Adult Females:						
Sample size	39	4	0	2	0	1
% pregnant	59	100		50		100
$\bar{x}$ number of embryos*	4.8 (SD = 1.1)	5.3 (SD = 1.5)		6		4
$\bar{x}$ number of placental scars**	4.3 (SD = 1.5)	0		0		3
Adult Males:						
Sample size	77	2	1	3	3	1
$\bar{x}$ testes size (mm)	10.8 x 6.5 (SD = 1.7, 0.7	9.5 x 6.5 (SD = 0.7, 0.7)	14 x 8	4.3 x 2.7 (SD = 2.9, 1.5)	6.7 x 3.7 (SD = 0.6, 0.6)	6 x 4
% with scrotal testes	97	100	100	67	67	
Juvenile Males:						
Sample size	11	3	0	5	0	1
$\bar{x}$ testes size (mm)	4.8 x 2.7 (SD = 1.3, 0.8)	3.7 x 2.0 (SD = 2.1, 1.0)		1.2 x 1.0 (SD = 0.5, 0)		5 x 2

*Includes only pregnant females.

**Includes only females in which placental scars were visible.

APPENDIX E (continued)

	Peromyscus maniculatus	Microtus montanus	Microtus pennsylvanicus	Sorex vagrans	Zapus princeps	Eutamias amoenus
JULY						
Adult Females:						
Sample size	17	0	0	0	0	0
% pregnant	24					
x̄ number of embryos*	4.5 (SD = 1.0)					
x̄ number of placental scars**	5.2 (SD = 1.9)					
Adult Males:						
Sample size	26	0	0	0	0	0
x̄ testes size (mm)	10.4 x 6.1 (SD = 2.4, 1.6)					
% with scrotal testes	92					
Juvenile Males:						
Sample size	15	1	0	2	0	0
x̄ testes size (mm)	3.7 x 2.1 (SD = 1.7, 1.2)	5 x 3		1 x 1 (SD = 0, 0)		

*Includes only pregnant females.

**Includes only females in which placental scars were visible.

APPENDIX E (continued)

	Peromyscus maniculatus	Microtus montanus	Microtus pennsylvanicus	Sorex vagrans	Zapus princeps	Eutamias amoenus
SEPTEMBER						
Adult Females:						
Sample size	38	0	1	1	0	1
% pregnant	8		0	0		0
$\bar{x}$ number of embryos*	4.0 (SD = 1.0)		0			
$\bar{x}$ number of placental scars**	4.6 (SD = 1.0)		0	0		0
Adult Males:						
Sample size	31	0	2	1	0	0
$\bar{x}$ testes size (mm)	4.9 x 3.0 (SD = 2.7, 2.1)		10.5 x 6.0 (SD = 5.0, 2.8)	1 x 1		
% with scrotal testes	16		50			
Juvenile Males:						
Sample size	9	0	0	0	0	0
$\bar{x}$ testes size (mm)	2.9 x 1.8 (SD = 0.6, 0.7)					

*Includes only pregnant females.

**Includes only females in which placental scars were visible.

APPENDIX F

Range Condition Surveys

U. S. Department of Agriculture
Soil Conservation Service
October 1977

A GUIDE TO RANGE SITE CONDITION CLASSES AND RECOMMENDED STOCKING RATES IN THE FOOTHILLS AND MOUNTAINS OF MONTANA 10-14" PRECIPITATION ZONE

Part I. ECOLOGICAL POSITION OF INDIVIDUAL SPECIES IN THE CLIMAX COMMUNITY AND RESPONSE TO GRAZING BY CATTLE.

DECREASERS /1	INCREASERS /2	MAXIMUM PERCENT OF INCREASERS (DRY WEIGHT) PRODUCED ANNUALLY IN CLIMAX BY RANGE SITES *																				INVADERS /3 (Annuals, introduced species, or natives that make up less than 2½% in climax)
		WL	Sb	SL	OV	Sa	Sy	Si	Cy	TH	St	Ly	SwC	SwG	Sw	Ps	DC	TB	Gr	VS	SU	
American sloughgrass	Blue grama	-	-	-	-	-	-	5	-	-	-	-	-	5	5	-	-	-	5	5	-	Annual bromes
Alkaligrass	Idaho fescue	-	-	-	-	-	15	20	20	5	10	-	15	-	15	-	10	10	-	d	-	Canada bluegrass
Alkali bluegrass	Needleandthread	-	-	-	-	10	20	10	-	15	20	20	-	d	10	10	-	10	d	10	-	Foxtail barley
Basin wildrye	Mat muhly	-	10	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Kentucky bluegrass
Bearded wheatgrass	Plains muhly	-	-	-	-	-	5	10	-	15	10	20	-	d	10	10	-	10	d	10	-	Needleleaf sedge
Big bluestem	Plains reedgrass	-	-	-	-	-	-	5	5	5	-	-	10	-	5	5	5	-	5	5	5	Red threeawn
Bluebunch wheatgrass	Prairie junegrass	-	-	-	-	5	5	5	-	5	5	5	-	5	5	5	-	5	5	5	-	Sixweeks fescue
Canada wildrye	Saltgrass	-	-	20	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	d	Canada thistle
Canby bluegrass	Sand dropseed	-	-	-	-	-	5	-	-	-	-	-	-	5	-	-	-	-	d	-	-	Curlycup gumweed
Cordgrasses	Sandberg bluegrass	-	-	-	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	Dandelion
Green needlegrass	Sedge increasers	25	15	10	5	-	10	5	-	-	-	5	-	5	-	-	-	5	5	-	-	Goatweed
Indian ricegrass	Squirreltail	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	d	d	Knapweeds
Mannagrass	Western & thick-	-	5	20	20	-	15	20	30	10	5	10	30	5	10	20	d	10	5	10	d	Leafy spurge
Plains muhly	spike wheatgrass																					Rabbitbrushes
Prairie sandreed	Forb increasers	10	10	5	5	5	5	5	10	5	5	5	10	5	5	-	5	5	5	5	5	Salsify
Rough fescue	Big sagebrush	-	-	-	-	-	-	5	5	5	-	-	5	-	-	-	-	5	-	-	-	Thistles
Sedge decreasers	Coniferous trees	-	5	-	-	-	-	-	-	5	-	-	5	5	5	-	-	10	-	5	-	Toadflaxes
Slender wheatgrass	Greasewood **	-	-	15	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	20	Woolly Indianwheat
Tall reedgrasses	Silver sagebrush	-	-	-	5	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	Broom snakeweed
Tufted hairgrass	Other woody inc.	10	15	5	10	5	5	5	5	5	5	-	5	-	-	-	-	5	-	5	-	All other annuals,
Forb decreasers																						biennials and exotics
Winterfat																						
Bitterbrush																						
Mountain mahogany																						
Skunkbush sumac																						
Other woody decreasers																						

*The symbol "-" means the species has less than 2½% coverage or is not present in the climax vegetation of the site
The symbol "d" means the species is a decreaser on the site and the amount present is considered climax. WL - WET LAND; Sb - SUBIRRIGATED; SL - SALINE LOWLAND; Ov - OVERFLOW: Sa - SANDS; Sy - SANDY; Si - SILTY; Cy - CLAYEY; TH - THIN HILLY; St - STONY; Ly - LIMY; SwC - SHALLOW CLAY; SwG - SHALLOW TO GRAVEL; Sw - SHALLOW; Ps - PANSPOTS; DC - DENSE CLAY; TB - THIN BREAKS; Gr - GRAVEL; VS - VERY SHALLOW; SU - SALINE UPLAND. Range sites are described with determinant features in the Technical Guide, Section II-E-3. **Decreases with summer grazing.

Part II. GUIDE FOR MAKING RECOMMENDATION ON STOCKING.

A. Guide to Departures From Basic Table by Range Sites. /4

WET LAND sites use three times the value for the 20-24" P.Z.
SUBIRRIGATED use two times the value of the 20-24" P.Z.
SALINE LOWLAND and OVERFLOW use values one-half to one zone higher than P.Z. where located.
SANDS, SANDY, SILTY, and CLAYEY use values for the P.Z. where located.
THIN HILLY, STONY, LIMY, SHALLOW CLAY, SHALLOW TO GRAVEL, SHALLOW, PANSPOTS, and DENSE CLAY use values one-half to one zone lower than the P.Z. where located.
THIN BREAKS use values one and one-half zones lower than the P.Z. where located.
GRAVEL, SALINE UPLAND, and VERY SHALLOW use values one and one-half to two zones lower than the P.Z. where located but not less than one-half the value for the 5-9" P.Z.

B. Basic Table for Normal Soils of Each Precipitation Zone

Average Annual Precipitation Zone (Inches)	Range Condition Percentage and Classes 100 - EC - 75	- GC - 50	- FC - 25	- PC
	(Animal Unit Months Per Acre) /5			
25-29	1.0	.75	.5	.25
20-24	.8	.6	.4	.2
15-19	.6	.45	.3	.15
10-14	.4	.3	.2	.1
5-9	.2	.15	.1	.05

/1 Climax species that decrease with grazing pressure by cattle. No limit to amount in climax. In determining range condition count percentage found on the site.
/2 Climax species that increase with disturbance. In determining range condition count present amount not to exceed maximum percentage for the site.
/3 Do not count any invaders in determining range condition.
/4 Departures do not include utilization cuts because of inaccessibility. Apply any necessary cut to grazing unit after AUM's are totaled.
/5 All stocking rates may be higher if grazing is limited to season of complete dormancy

INSTRUCTIONS FOR USE OF THE "GUIDE TO RANGE SITE CONDITION CLASSES AND STOCKING RATES"

1. Determine the range site.
2. Prepare a sheet of paper with three columns.
3. In the first column:
   a. List significant species in the plant community. (5 percent or more)
   b. Determine, from the Guide, if they are decreasers, increasers or invaders for the site.

   In the second column determine, by clipping or ocular estimate, the percent (by dry weight) composition of each species. The total should equal 100 percent.

   In the third column:
   a. For decreasers, record the total from column 2.
   b. For increasers, record for each species the lessor of: the percentage in column 2 or the percentage shown in the Guide.
   c. For invaders, record a "0".
4. The sum of column 3 subtracted from 100 percent is the departure from climax for the range site. The sum of column 3 is expressed as range condition and stocking rate.

GUIDE FOR RECOMMENDED STOCKING RATES
10-14" P.Z.

Range Condition Percentages and Classes
(Animal Unit Months Per Acre)

	100%	EC	75%	GC	50%	FC	25%	PC
WL	2.4		1.8		1.2		.6	
Sb	1.6		1.2		.8		.4	
SL, OV	.5-.6		.38-.45		.25-.3		.12-.15	
Sa, Sy Si, Cy	.4		.3		.2		.1	
TH, St, Ly, SwC, SwG, Sw, Ps, DC	.2-.3		.15-.22		.1-.15		.05-.08	
TB	.1		.08		.05			
Gr, VS, SU, SH, Bl	.05-.1		.04-.08		.02-.05			

CONVERSION FROM AUM'S PER ACRE

AUM'S per ACRE	ACRES per AUM	ACRES for 3 Mos.	ACRES for 6 Mos.	ACRES for 9 Mos.
.025	40.0	120	240	360
.05	20.0	60	120	180
.1	10.0	30	60	90
.15	6.7	20	40	60
.2	5.0	15	30	45
.25	4.0	12	24	36
.3	3.3	10	20	30
.35	2.9	8.5	17	26
.4	2.5	7.5	15	23
.45	2.2	6.5	13	20
.6	1.7	5.0	10	15
.75	1.3	4.0	8	12
.8	1.2	3.5	7	11
.9	1.1	3.3	6.6	10
1.0	1.0	3.0	6.0	9
1.2	.8	2.4	4.8	7
2.0	.5	1.5	3.0	5
5.0	.2	.6	1.2	2

May 1972

LEGEND FOR RANGE SITES

Range sites are kinds of rangeland that differ from each other in their ability to produce a significantly different kind or amount of climax or original vegetation. Only natural grasslands are classified as range sites. In order to fully designate a range site, a soil-group name is combined with the precipitation zone and geographic location, e.g., Sandy 10-14" p.z.; Glaciated Plains, Montana.

The following range soil-groups are listed in presumed order of natural productivity, considering total airdry weight of all herbage produced through the entire year by all seed plants per unit of area, in ordinary years under climax plant cover.

Names of range sites occuring on your ranch are underlined.

Precipitation Zone____________

Range Site Descriptions:

I. Soil-groups that can produce more herbage than ordinary range uplands because of plainly superior soil moisture availability.

WL - WET LAND: Lands where seepage, ponding, etc., raises the water table to above the surface during only a part of the growing season. Too wet for cultivated crops but too dry for common reed, cattails, or true aquatics.

Sb - SUBIRRIGATED: Lands with an effective subsurface ground water table and water rarely over the surface during the growing season.

SL - SALINE LOWLAND: Subirrigated and overflow lands where salt and/or alkali accumulations are apparent and salt tolerant plants occur over a major part of the area.

Ov - OVERFLOW: Areas regularly receiving more than normal soil moisture because of run-in or stream overflow.

II. Soil-groups with no obvious soil or moisture limiting factors. The vegetation can make a normal response to climate.

Sa - SANDS: Sands and loamy sands more than 20 inches deep.

Sy - SANDY: Coarse to fine sandy loams more than 20 inches deep.

Si - SILTY: Soils more than 20 inches deep of very fine sandy loam, loam, or silt loam. This includes soils with 2 inches or more of silt loam over clayey subsoils.

Cy - CLAYEY: Granular clay loam, silty clay loam, silty clay, sandy clay or clay more than 20 inches deep.

III. Soil-groups with characteristics or topographic features that limit moisture holding capacity or affect infiltration rates.

TH - THIN HILLY: Loamy or clayey soils on steep or hilly landscapes with a thin A horizon and weak or no structure in the subsoil, but with significant root penetration deeper than 20 inches. It is usually calcareous but contains less than 15 percent calcium carbonate.

St - STONY: Soils more than 20 inches deep with cobbles or stones occupying 40 - 80 percent of the surface.

Ly - LIMY: Soils more than 20 inches deep that are nearly white and very limy (15 percent or more calcium carbonate) within four inches of the surface.

SwC - SHALLOW CLAY: Shallow granular clay soils that are 10 to 20 inches deep to underlying shale or nearly impervious clays.

SwG - SHALLOW TO GRAVEL: Soils that are 10 to 20 inches deep to sandy gravel. Few roots penetrate deeper than 20 inches.

Sw - SHALLOW: Soils 10 to 20 inches deep to hard rock or softbeds of decomposed granite, siltstone, or sandstone. Few roots penetrate deeper than 20 inches.

Ps - PANSPOTS: Areas of silty, clayey or sandy soils in complex with shallow depressions of hard clays or other nearly impervious materials at or near the surface. The shallow depressions occupy 20 to 50 percent of the site.

DC - DENSE CLAY: Relatively impervious deep nongranular clays--may be overlain by thin ineffectual layers of other materials. The dispersed layer is very hard to extremely hard when dry and very sticky when wet.

TB - <u>THIN BREAKS</u>: Mixed soils of various depths with hard rock or other resistant bed ourcroppings at different levels on steep irregular slopes. Trees may occur locally above outcrops.

Gr - <u>GRAVEL</u>: Coarse textured soils with more than 50 percent gravel and cobbles underlain by loose sand and gravel at less than 20 inches.

VS - <u>VERY SHALLOW</u>: Areas where few roots can penetrate deeper than 10 inches. Outcropping of gravel or bedrock is characteristic. Joints in bedrock may develop deep soil pockets usually marked by tall grasses, shrubs, or stunted trees.

SU - <u>SALINE UPLAND</u>: Soils more than 20 inches deep with salt and/or alkali accumulations. Salt tolerant plants occur over a major part of the area.

Sh - <u>SHALE</u>: Readily puddled uplands where some unweathered angular raw shale fragments are exposed at the surface and little, if any, soil profile development is evident.

Bl - <u>BADLANDS</u>: Nearly barren lands broken by drainages intermingled with small grazable areas.