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PRONGHORN FAWN MORTALITY FOLLOWING  
COYOTE CONTROL ON THE  
NATIONAL BISON RANGE

By

Patrice Showers Corneli

B.S., Beloit College, 1975


Presented in partial fulfillment of the requirements for the degree of

Master of Science

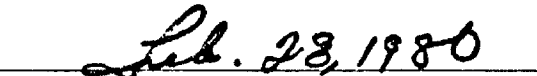
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## ABSTRACT

Corneli, Patrice S., M.S., Winter 1980

Wildlife Biology

Pronghorn Fawn Mortality Following Coyote Control on the National Bison Range (69 pp.)

Director: Bart W. O'Gara



To study pronghorn (Antilocapra americana) fawn mortality in the absence of coyotes (Canis latrans) on the National Bison Range (NBR), Moiese, Montana, 19 coyotes were killed beginning 2 weeks before the 1978 fawning season and continuing for 4 weeks through the peak fawning period. Spring and summer observations and the results from a scent station line indicated the control effort was thorough.

Thirty-four pronghorn fawns were radio-tagged between 20 May and 7 June, 1978. The fawns were tracked daily to discover causes of death during the first months following birth. Of the tagged sample, 22 died; 82% of these deaths occurred within 3 weeks of birth.

The discovery of 2 untagged fawn carcasses provided cause of death data for 24 fawns in all. The 10 fawns definitely killed by predators included 3 by bobcats (Lynx rufus), 4 by Golden Eagles (Aquila chrysaetos), and 3 by unidentified predators. Of the other 14 fawns, 1 may have succumbed to capture myopathy induced by an eagle, and coyotes probably consumed 3 others, but did not necessarily kill them. The remaining 10 included 7 who were apparently healthy and whose rapid disappearance was most plausibly explained by predator involvement.

Of a total estimated 92 fawns born on the NBR, 64 (70%) were dead by 1 August, and 65 (71%) died before mid-October. Despite coyote control, fawn mortality remained high, although a significant difference in mortality rates was noted between the 2 major fawning areas. The mortality rate was 93% on fawning grounds where the bobcat and eagle kills occurred, but it was only 27% in the fawning area where coyote-related mortality had been very high since 1975; other mortality factors did not significantly compensate for coyote predation there. Because 65% of the NBR herd apparently was over 7 years old in 1978, increased survival in this area may prevent a severe population decline in 2-3 years.

## ACKNOWLEDGEMENTS

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I express special thanks to Dr. Bart O'Gara, my major advisor, for providing so much assistance and advice during the field season and preparation of the manuscript. I also thank Drs. Lee Metzgar and John Harris, the other committee members, for critical review of the manuscript.

Rod Flynn assisted with all aspects of the study during the first few weeks and his advice greatly improved my radio-tracking technique. Dan Pond also generously contributed time assisting me with field work. The enthusiastic assistance of many study volunteers, particularly that of Sharon Gaughan, made tagging 34 fawns possible.

For his thought provoking comments and review of my writing, I am grateful to John Beecham. Useful comments and some data were provided by Dr. David Kitchen. My thanks to Mr. Guy Connolly for reviewing the manuscript.

Very special thanks are extended to Dr. John Lutz, Beloit College, Tom Ellis and my parents. Finally I thank Howard Corneli for editing my writing and for his patient support.

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## CHAPTER I

### INTRODUCTION

Pronghorns were not indigenous to the National Bison Range (NBR), Moiese, Montana, but were successfully introduced in 1951. The original herd of 15 animals increased to 120 by 1962 (Anonymous 1956-77), despite the collection of more than 44 animals during the period (Wright, University of Montana Zoologist, pers. comm.).

From 1962 to 1969, fawn recruitment remained high and the estimated fawn mortality rate never exceeded 32%. Since 1970, when it increased to 66%, the fawn mortality rate ranged from 62 to 93% (Anonymous 1956-77, Reichel 1976, Von Gunten 1978). A concurrent increase in coyote numbers prompted Reichel (1976) to study coyote-prey relationships on the NBR in 1974 and 1975. He analyzed coyote scats and found pronghorn fawns were an important food item during the fawning season in late May and June. Coyote predation was the most important proximate cause of fawn mortality among radio-tagged fawns in 1975. But because of transmitter failures, Reichel gathered cause of death data for only 7 fawns.

As an extension of Reichel's study, Von Gunten (1978) radio tagged 30 pronghorn fawns in 1977. By the end of September, 90% of

the fawns had died. Predation was the most important proximate cause of death. Coyotes were involved in the deaths of 14 fawns, bobcats killed 3, and a Golden Eagle killed 1.

Other researchers (Einarsen 1948, Buechner 1950) believed that predation rarely limited pronghorn survival. Neither Yoakum (1957) nor Compton (1958) found that predation was an important pronghorn mortality factor in Oregon, although they did not have telemetry equipment to aid them in finding the carcasses. Some researchers considered poor habitat (Udy 1953, Yoakum 1957, Howard et al. 1973), food supply (Buechner 1950), or precipitation during previous years (Howard et al. 1973, Yoakum 1978) more important limiting factors than predation.

After thoroughly reviewing the literature, Connolly (1978) concluded that predators can retard the growth of ungulate populations that have been depressed by other causes. He believed predation could be a significant source of mortality among ungulate fawns. Others (Udy 1953, Hamlin 1979) also believed predators were capable of retarding growth of ungulate herds previously reduced by other factors.

Predator control was positively correlated with antelope fawn survival in Arizona (Arrington and Edwards 1951) and with white-tailed deer (Odocoileus virginianus) fawn survival in Texas (Beasom 1974).

Of 81 radio-tagged, white-tailed deer fawns in Texas, 72% died, 53% from predation (mostly coyotes) and 16% from disease or

starvation (Cook et al. 1971). After a 5-year telemetry study in Utah, Beale and Smith (1973) attributed 50% of the pronghorn fawn mortality to bobcat predation; coyote and eagle predation was negligible. By 1978, predation accounted for 76% of all mortality and coyotes had become the principal predator, accounting for 40% of the predation (Beale 1978). Pronghorn fawns in Alberta, suffered a mortality rate of 65% and bobcat and coyote predation accounted for 68% of the deaths (Barrett 1978). Of 42 radio-tagged fawns in Idaho, 21% died from starvation-disease. Predation caused the death of 36%, including 47% Golden Eagle, 27% coyote, 13% bobcat, and 13% small raptor kills (Bodie 1979).

Reichel's (1976) and Von Gunten's (1978) studies revealed the extent of coyote predation on NBR fawns. But in the absence of predation, the fawns may have died anyway if significant compensating mortality factors existed. Investigation of the degree and causes of fawn mortality following spring coyote control, was the primary objective of my research. The study period began in April and continued through July 1978; a final pronghorn census was conducted in October 1978.

## CHAPTER II

### STUDY AREA

The National Bison Range covers over 7700 ha at the southern end of the Flathead Valley in Lake and Sanders counties, western Montana. Elevations range from 696 to 1361 m. Rocky, canyon-cut topography characterizes most of the Range south of the tour road, but my study area was restricted to the flatter northern grassland, and a small area in the southeast, where the herd congregated during summer (Fig. 1). Average annual precipitation is 32 cm and temperatures are mild, seldom exceeding 38°C in summer or falling below -20°C in winter (Kitchen 1974, Reichel 1976).

Completely enclosed by a 2.4 m tall fence, the Range is divided into 8 pastures by fences that restrict bison (Bison bison) movements, but allow other animals to pass underneath. Ungulate species on the Range include bison, white-tailed deer, mule deer (Odocoileus hemionus), elk (Cervus elaphus), big horn sheep (Ovis canadensis), mountain goats (Oreamnus americanus), and pronghorn. Coyotes and bobcats also inhabit the Range (Kitchen 1974, Von Gunten 1978).

Blue-bunch wheatgrass (Agropyron spicatum), Idaho fescue

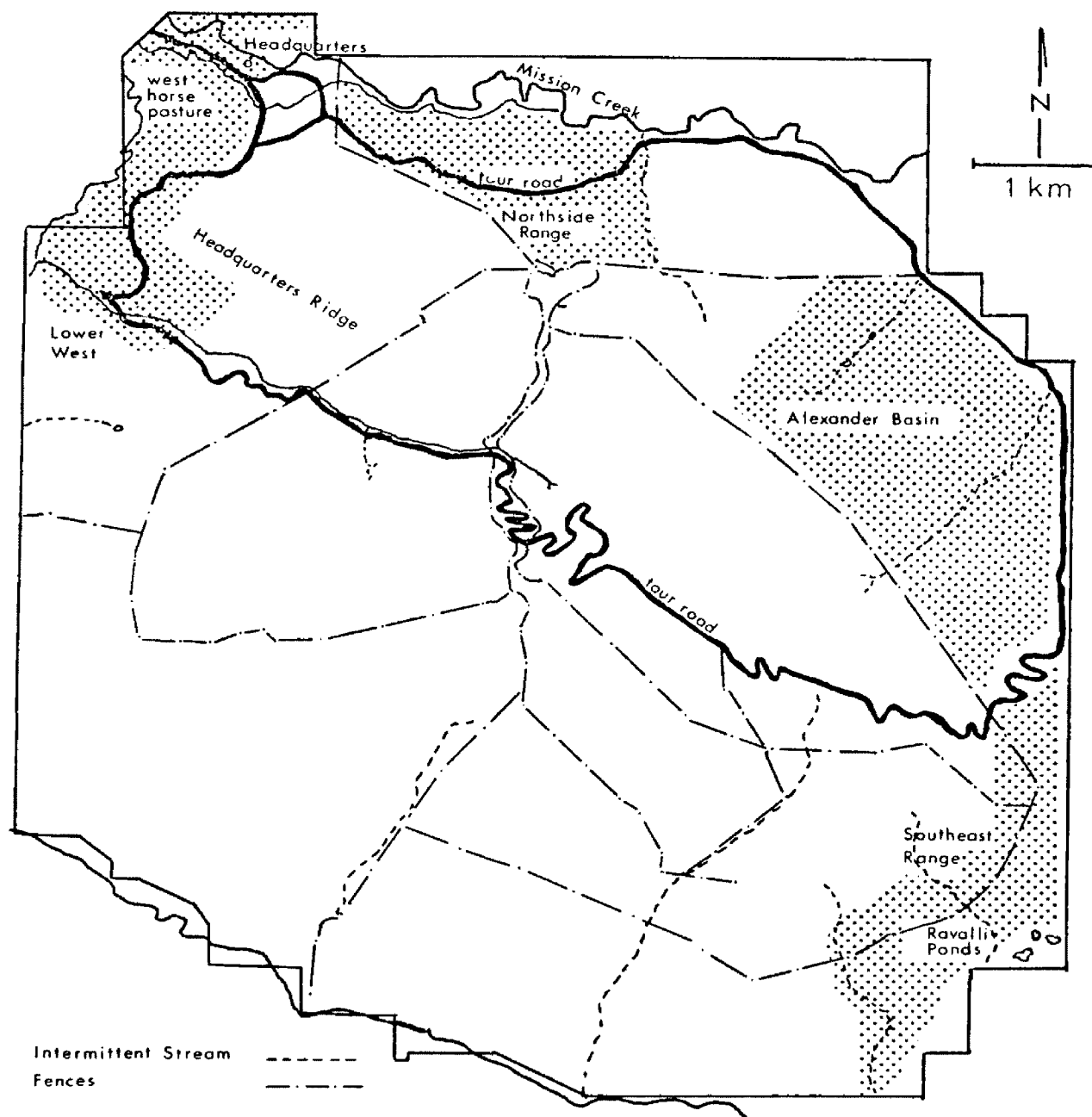


Fig. 1. The National Bison Range, Moiese, Montana. Shading depicts areas where does congregate during summer.

(Festuca idahoensis), and rough fescue (F. scabrella) cover most of the Range, a primarily Palouse Prairie grassland. Major forbs are balsamroot (Balsamorhiza sagittata) and Aster falcatus. Brush species include snowberry (Symphoricarpus occidentalis), hawthorne (Crataegus douglasii), and wild rose (Rosa spp.) in swales and drainages, and chokecherry (Prunus demissa), serviceberry (Amelanchier alnifolia), and mockorange (Philadelphus lewisii) in rocky areas. Timbered areas at higher elevations support Douglas fir (Pseudotsuga menziesii), and ponderosa pine (Pinus ponderosa), and along Mission Creek juniper (Juniper scopularum) is the major tree species (Kitchen 1974, Reichel 1976).



## CHAPTER III

### METHODS AND MATERIALS

#### Pronghorn Fawn Mortality

During the week before fawning, I wired lithium batteries to 23 transmitters that Von Gunten used in 1977 and remolded the assemblies in dental acrylic. Six packets were expected to transmit 25.5 weeks (1200 milliamp hour battery, 0.28 milliamp drain transmitter), had a 3-5 km range, and weighed about 70 g (3% of the smallest fawn's weight). Seventeen packets were expected to transmit 16-20 weeks (2400 m.a.h., 0.7-0.9 m.a. drain), had a 6-10 km range, and weighed about 110 g (5% of the smallest fawn's weight).

Although the dental acrylic was effective in preventing damage to the transmitter from chewing by a predator, it apparently was not waterproof. Moisture seeped through to the battery and wiring, rendering some of the transmitters useless during wet weather. This problem generally disappeared once the assembly dried out, but the wiring gradually corroded, possibly the reason why certain transmitters stopped functioning after several weeks. Von Gunten (pers. comm.) did not have this problem because her study occurred during a drought. A thin layer of waterproofing over the acrylic would have eliminated many problems during my study.

Situated on high vantage points overlooking major fawning areas, observers used binoculars and spotting scopes to search for does in labor and nursing does. A doe in labor tends to seek isolation, frequently lifts her tail without eliminating feces or urine, alternately stands and lies, and often licks her belly and flanks (Bromley 1977).

Following birth of the fawn, I did not disturb it until the 4-hour mother-fawn imprinting period described by Autenreith and Fichter (1975) had elapsed. The observer followed the newborn or nursing fawn with a spotting scope as it left the mother in search of a bedding site.

Using a walkie talkie, the observer directed me to the bedding location. Once the fawn was located we slowly stalked it and placed a 0.8 m salmon net over it. Stalking was most successful when the assistant held the attention of the fawn during my approach. Blind-folding the fawn as quickly as possible and stroking the anal area calmed it, minimizing handling difficulties.

Each fawn was marked with a small plastic, numbered eartag and its location, weight, length, girth, sex, age, general condition, and the date were recorded (Appendix B). Bromley's (1977) criteria, based on the fawn's response to capture and condition of its pelage and umbilical cord, were used to estimate age. Fawns 1 day old or less were docile during stalking and capture and did not resist handling. Hair was usually clumped from amniotic fluid and the umbilical cord

was still fleshy. I assumed that a fawn that retained cartilaginous tips on the hooves was no more than a few hours old. Fawns 1-3 days old were easily caught but often resisted handling by bleating or kicking. The umbilical cord was shriveled or gone. Fawns between 3 days and 1 week old were nearly impossible to capture and handling such a fawn was a challenge.

Two straps of 1.27 cm (0.5 inch) elastic, 1 around the neck and 1 behind the forelimbs, held the transmitter in place on the fawn's back. Staples secured the elastic straps, which were pulled only tight enough to remove slack, allowing the elastic to stretch as the fawn grew. Cattle back-tag cement held the transmitter in place. Eventually the harness was outgrown, the staples pulled out, and the transmitter dropped.

I searched daily for the fawns using an A.V.M. Instrument Co. LA12 receiver and a hand-held 3-element Yagi antennae. Although searches began by vehicle, climbing a prominent ridge, locating a signal and continuing on foot until a bedded fawn was found, was the usual procedure. Keeping the encounter with the fawn as brief as possible, I recorded the location, activity, and condition of the fawn, and the time of day (Appendix B).

Dead fawns were photographed and pertinent data, including location, carcass description, tracks or sign, time of death and the date, were recorded (Appendix B). O'Gara necropsied most carcasses

and determined the cause of death. Occasionally, I necropsied fawns in the field using the criteria for determining cause of death by characteristic killing and feeding patterns of predators described by Henne (1975) and O'Gara (1978b).

Pronghorn does twin over 95% of the time on the National Bison Range (O'Gara 1968), so the fawn crop was estimated by censusing pregnant does in early May. Fawn mortality rates were determined by comparing the number of fawns censused on 31 July and in October with the estimated spring fawn crop.

### Coyotes

Control. With the assistance of Animal Damage Control personnel and my field assistant, I began coyote control on 8 May, 2 weeks before fawning, and continued through peak fawning to 9 June. On the basis of coyote observations made during April and May, we set and scented 6 M-44's and 7 steel traps in the vicinity of known coyote dens and mousing grounds in the study area. Twenty-five snares were set in holes dug by coyotes under the perimeter fence. Because these control methods proved inadequate over the short control period, coyotes were also shot from a helicopter.

I sexed and weighed each carcass and removed the lower canines for later age determination. A commercial microtechnician (Matson, Milltown, MT) determined the age of each coyote by analysis

of cementum annuli in canine tooth sections.

Population. Based on the number of coyotes we removed and on the number counted during spring observations, I was able to estimate the number of coyotes residing in the study area before and after control.

In July and September, a field assistant and I ran a scent station line as described by Linhart and Knowlton (1975). The line provided an index of the coyote population remaining on, or repopulating the Range following spring control. The line followed a similar route as that used by Reichel (1976) and Von Gunten (1978; Fig. 2). The Denver Wildlife Research Center provided scent capsules, attractant, and datum sheets.

#### Rodent Population

Because rodents were important to coyotes on the Range (Reichel 1976), I censused small mammals during May and July. Von Gunten (1978) described in detail the methods used. Fifty snap-trapping stations, with 4 traps each, were set in randomly selected locations as follows: 10--riparian; 10--brushy washes; 10--forest; and 20--grassland habitats. Traps were prebaited with peanut butter and oatmeal for 2 days and then set for 4 days. Each morning, I checked the traps and reset or rebaited them when necessary. Each specimen was identified to species, measured, weighed, sexed, and

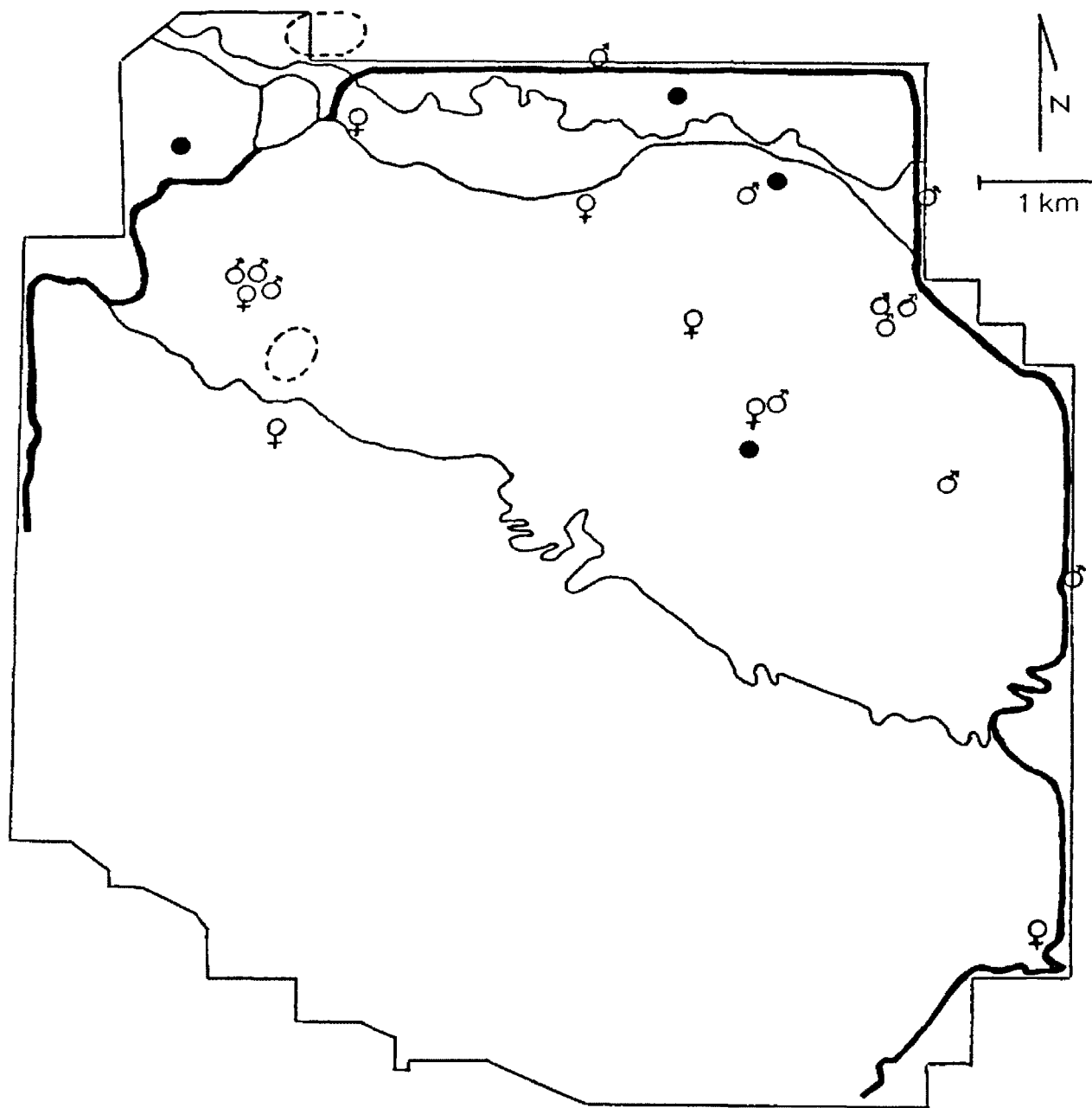


Fig. 2. Location of the scent station line (heavy black line), coyote dens (black dots and dotted circles), and collection sites of 19 coyotes.

checked for reproductive condition (Appendix B).

### Statistical Procedures

The student's t-test for the difference between 2 means (Wonnacott and Wonnacott 1972) was used to determine if the mean birth weight of surviving fawns was different from the mean birth weight of fawns that died. The  $X^2$  goodness of fit test and test of independence (Wonnacott and Wonnacott 1972) were used for all other analyses.

## CHAPTER IV

### RESULTS

#### Pronghorn Fawns

Tagging. The 47 pregnant does on the NBR produced an estimated fawn crop of 92 in 1978. Between 20 May and 7 June, we radio tagged 34 fawns, including 11 females and 23 males. This sample consisted of 13 pairs of twins, 6 fawns that had an untagged twin, and 2 fawns that were not observed with a twin.

The major fawning grounds in 1978 were Alexander Basin and the southeast range, where 63% of the fawns were born. We tagged 14 fawns in the southeast, 11 in Alexander Basin, 4 on the northside, and 5 on the lower west ranges (Fig. 3).

Of the fawns 1 day old or less, the mean weight, length, and girth were 3.5 kg, 67.3 cm, and 37.9 cm, respectively (Appendix C). The smallest of the fawns (#29) was thin and weak when captured at 3 days of age, but all other fawns appeared healthy and strong.

Data on the cause of death and age of 2 untagged fawns were gathered from carcasses I recovered after students watched an eagle kill them (Appendix A, Case 23).

Mortality. Approximately 64 fawns (70%) died before 1 August;



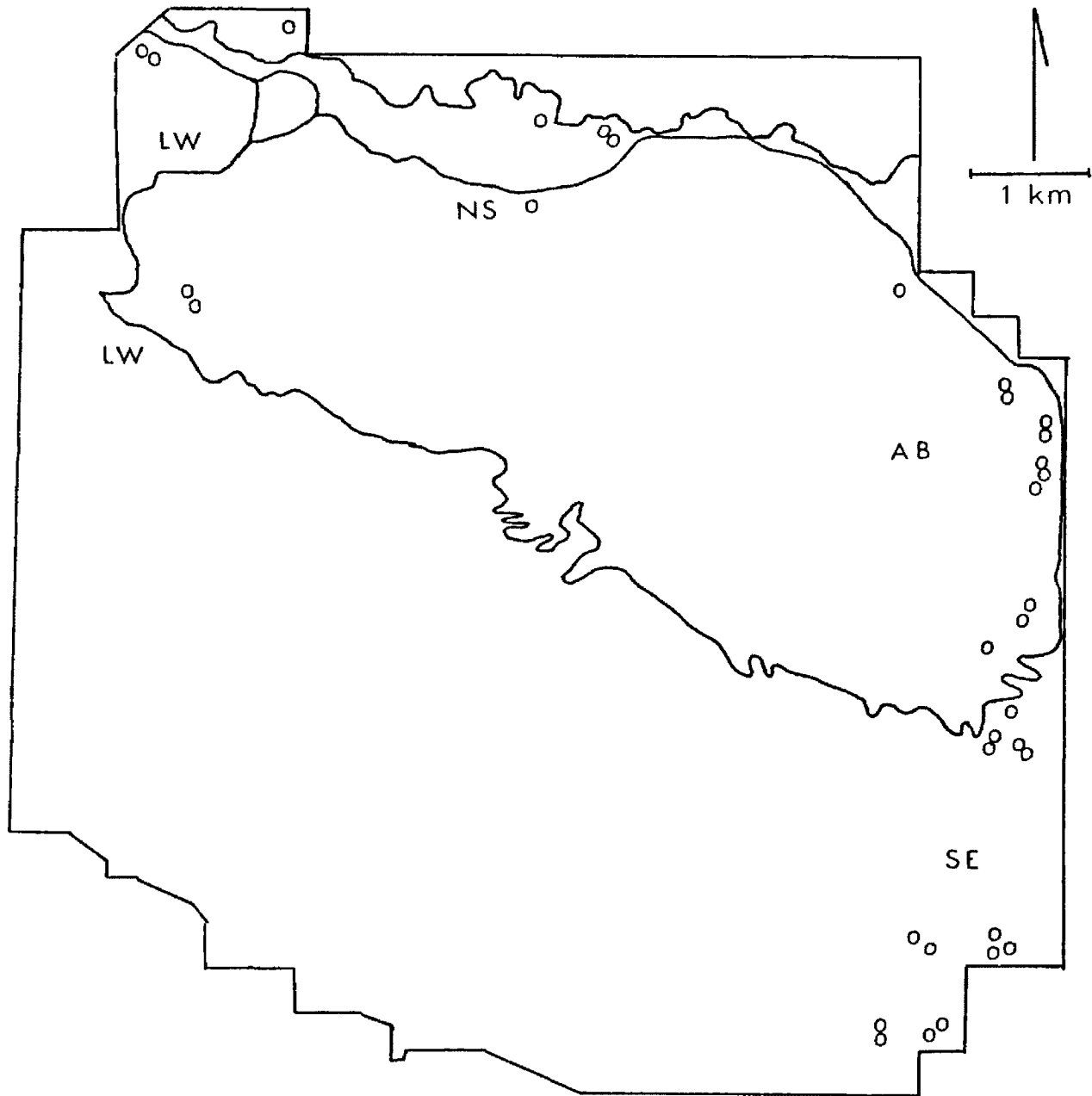


Fig. 3. Capture sites of 34 fawns in 1978. AB = Alexander Basin, SE = southeast range, NS = northside range, LW = lower west range.

in the tagged sample, 22 died (65%) by that date. By the end of October, the mortality was virtually unchanged (71%) with only 1 more fawn dead (65).

A comparison of mortality rates between Alexander Basin and the southeast range demonstrated that the fawn's fate depended on its location. Of the 14 fawns tagged in the southeast, 13 (93%) died (11 during the first 3 weeks of life), whereas in Alexander Basin, where 11 were tagged, only 3 (27%) died (Table 1). The difference between the 2 rates was highly significant ( $X^2 = 11.27$ ,  $p < 0.001$ , 1 d.f.). The one fawn that survived on the southeast range moved to Alexander Basin when she was 10 days old.

The differences in mortality among the lower west, the northside, and the southeast fawns were less striking. Fawn mortality in Alexander Basin (27%), however, was lower than in the lower west (80%).

Data from the 22 tagged fawns that died indicated high mortality among very young fawns (Table 2). Sixty-four percent of this group died within 2 weeks of birth and 82% were dead within 3 weeks.

Among the fawns tagged when 1 day old or less, the mean weight of surviving fawns (3.7 kg) was not significantly different than the mean weight (3.4 kg) of fawns that died.

Appendix A lists data gathered from 24 fawn carcasses,

Table 1. Fawn mortality rates in each fawning area and the total NBR fawn mortality rate in August and October 1978.

Location	Pregnant does	Fawns tagged	Tagged fawns alive 1 August	Mortality rate of tagged fawns (%)
Southeast	18	14	1	93
Alexander Basin	11	11	8	27
Northside	10	4	2	50
Lower West	5	5	1	80
Other	3	0	--	--
Total	47	34	12	65

Estimated fawn crop: 92

Total fawns alive, 1 August 1978: 28

Total fawns alive, October 1978: 27

Total fawn mortality rate, 1 August 1978: 70%

Total fawn mortality rate, October 1978: 71%

Table 2. Fates of 36 pronghorn fawns.

Fawn no.	Fate	Days survived	Remains
Southeast			
2	bobcat	12	head, right leg
3	predator killed	7	strips of hide
4	unknown	7	scraps of hide
6	unknown	23*	trans. failure
11	unknown	24	trans. dropped
16	capture myopathy	10	entire carcass
17	eagle	9	entire carcass
20	eagle	10	entire carcass
21	bobcat	9	head, forelimbs
22	coyote consumed	6	bone fragments
23	unknown	9	transmitter
28	unknown	21	transmitter
29	bobcat	21	head, shoulders
30	survivor <sup>#</sup>		
35	eagle	1	all but viscera, spine
36	eagle	1	entire carcass
Alexander Basin			
9	unknown	24	trans. failure
10	survivor		
12	survivor		
13	survivor		
18	mammalian predator	18	head
19	survivor		
24	survivor		
25	survivor		
32	unknown	13	strip of hide
33	survivor		
34	survivor		
Northside			
1	survivor		
14	survivor		
15	unknown	21	trans. failure
31	unknown	38	transmitter
Lower West			
5	coyote consumed	4	transmitter
7	coyote consumed	8	skull fragments
8	predator killed	8	shoulder and leg
26	unknown	6	leg
27	survivor		

\*Minimum.

<sup>#</sup>Alive on 1 August.

including the 2 untagged fawns. Of 10 known predator caused mortalities, 8 occurred in the southeast area, including 3 bobcat, 4 Golden Eagle, and 1 unknown-predator kill (Table 2). In Alexander Basin, 1 death was caused by a mammalian predator (bobcat or coyote) and the predator remained undetermined for a fawn from the lower west range. The sibling of a fawn killed by an eagle may have succumbed to capture myopathy (Appendix A, Case 11). Coyotes probably consumed at least 3 fawns, but may not have killed them (Cases 4, 6, and 16).

The remains of 6 fawns consisted only of the transmitter and sometimes bone or hide fragments. In addition, 3 transmitters failed and the packet fell off of 1 fawn prematurely, but because 3 (Cases 8, 9, and 10) had a tagged sibling, they were followed until their disappearance indicated they had died. The cause of death could not be determined for these 10 fawns, but 7 appeared healthy 24-48 hours before they died, suggesting that they were eaten by predators (Cases 8, 9, 10, 17, 18, 21, and 22).

### Coyotes

Observations. Fig. 2 shows the location of 4 dens and 2 denning areas in the study area. Before control, I frequently observed coyotes mousing or resting in the West Horse Pasture, along Mission Creek, and in Alexander Basin (Fig. 1). Field assistants twice saw a

coyote in Alexander Basin during fawning, and 1 coyote was seen in the southeast during fawning. An adult pair was observed on 2-3 occasions in the West Horse Pasture following control.

Control. From 8 May to 9 June, we killed 19 coyotes, including 7 females (5 lactating) and 12 males in the study area (Fig. 2). Steel traps failed to catch any coyotes, fence snares caught 4, an M-44 poisoned 1, and O'Gara shot the remaining 14 from a helicopter.

The coyotes weighed an average of 12 kg and ranged in age from 1 to 8 years old, averaging 2.7 years (Appendix D).

Population. Coyotes moved freely under the boundary fence, sometimes pushing a snare to the side before passing through. Although 12 of the coyotes were recognized residents, some of the 19 may not have denned on the Range, only hunting there. Eight pups were removed alive from 3 of the dens and an adult pair from the West Horse Pasture survived control. From 22 to 29 coyotes resided in the study area before control. Although this figure undoubtedly underestimates the number of pups, the number of adults should be close to the actual because NBR personnel and I rarely saw coyotes during the summer following control.

The scent station index rose from 4 in July to 69 in October (Table 3). In November, NBR personnel reported "sighting the normal

number of coyotes for this time of year" (Magadinno, NBR Biologist, pers. comm.).

Table 3. Coyote scent station line indices\* from 1974, 1975 (Reichel 1976), and 1977 (Von Gunten 1978).

	July	September
1974	41	63
1975	55	--
1977	80	132
1978	4	69

$$*\text{index} = \frac{\text{total coyote visits}}{\text{total operative station-nights}}$$

### Rodent Population

The small mammal population on the NBR was extremely low in May and July. No Microtus species were trapped in May, and in July, 1 Microtus pennsylvanicus was trapped (Table 4).

Table 4. Microtus spp. and Peromyscus maniculatus captured per 1000 trap nights for 3 habitats in 1975, 1977, and 1978. G = grassland, BW = brushy wash, R = riparian.

	Habitat	1975*	1977#	1978
<u>Microtus</u> spp.	G	1.9	8.3	0.0
	BW	14.2	--	3.1
	R	24.8	14.6	0.0
Total		13.7	7.6	0.6
<u>P. maniculatus</u>	G	83.6	172.9	4.7
	BW	78.3	95.8	9.4
	R	98.4	79.2	18.8
Total		86.8	116.0	7.5

\*Reichel 1976.

#Von Gunten 1978.



## CHAPTER V

### DISCUSSION

#### Coyotes

Coyote population figures (Fig. 4) were estimates based on casual observations until 1973, when NBR personnel began to count coyotes each spring (Anonymous 1956-77).

While prior to 1962 systematic control kept the coyote population low, an exposed stockpile of horsemeat poisoned with 1080 was often stored on the Range until 1966 (O'Gara, pers. comm.), and in addition coyotes were occasionally shot (at least 2-3/year) until 1972 (NBR personnel, pers. comm.). Presumably these factors continued to keep the population low until 1972, when shooting stopped. The population increased sharply in 1972 (measured by the same casual observations) and remained high until the spring control effort in 1978 reduced the density. The 1974 decline occurred when some coyotes apparently died after eating poison bait off the Range (Anonymous 1956-77).

Precise assessment of the number of coyotes that hunted on the Range following control was impossible, but summer observations indicated at least 2 resident coyotes survived.

Coyotes denning outside the Range dug holes under the perimeter fence north of headquarters and undoubtedly continued hunting on the Range following control. Most of the scent station line was adjacent to this fence (Fig. 2), so it should have revealed substantial movement across the fence. The scent station index in July 1978 was 4 compared to 80 in July 1977 (Table 3), indicating that the number of nonresident hunting coyotes was low. However, the coyotes that avoided fence snares because of human scent, probably were not attracted to scent posts either.

The scent station index increased to 69 in October 1978. Increases in the index from summer to fall 1974, 1975, and 1977 (Reichel 1976, Von Gunten 1978; Table 3) probably resulted from the increased coyote activity following the denning season, as described by Knowlton (1972). Immigration of coyotes from the area surrounding the Range must be another component of the 1978 increase. Coyote sightings during November were similar to other years, again indicating infiltration.

Because coyote populations are resilient, the effects of spring control are expected to be short-term. As a result of reduced population density, an increased proportion of the remaining females (particularly juveniles) should breed and litter size should increase (Knowlton 1972, Connolly and Longhurst 1975). Inasmuch as decreased intraspecific competition accompanies population reduction,

density-dependent mortality can be expected to decline as resources such as food and denning areas become more available (Connolly and Longhurst 1975).

In a model designed by Connolly and Longhurst (1975) to simulate coyote population dynamics, a population subjected to intensive control would require 3-5 years to recover to the pre-control density. This model did not include an immigration factor, so recovery on the NBR should occur quickly because of immigration from outside the Range.

#### Population Characteristics of NBR Pronghorns

Except for population declines associated with collections and translocation of excess animals, the NBR herd grew from 1960 to 1978 (Fig. 4). In 1965, the fall fawn:doe ratio began a decline that continued each year (except 1967 and 1974) until 1978, reflecting increasing fawn mortality. Despite the decline, the concurrent population increase indicated that fawn recruitment was greater than total annual mortality each year, except 1976 and 1977, when recruitment equalled mortality.

Reichel (1976) and Von Gunten (1978) reported that the fawn mortality rate from 1962 to 1970 never exceeded 32%. But the mortality rates ( $1.00 - [\text{surviving fawns}/\text{fawns born}]$ ) were probably underestimated, because the number of fawns born was underestimated (Reichel 1976). The number born was determined from the number

seen during the early summer (Anonymous 1956-77), rather than from the number of pregnant does counted in May. Some fawns undoubtedly died before they were seen, and because of their bedding behavior, many live fawns would not have been seen. By fall the fawns would have been active and conspicuous so the number of fawns counted probably was accurate. For the same reason, the fall fawn:doe ratios were probably accurate.

I recalculated fawn mortality rates (Fig. 5) for 1966-1973, estimating the number of fawns born each year from the number of adult females counted the previous fall. Two assumptions--that all adult does were pregnant and that they survived the winter--undoubtedly inflated my estimates. Nonetheless, I believe the actual rates were probably closer to my recalculations than to those of Reichel and Von Gunten; the discrepancy among the 1960-1969 mortality rates and the 1970-1977 rates probably was not as great as their rates indicated.

Pronghorn does breed at 16 months of age and yearly thereafter, and most have twins, so their reproductive potential is high (Buechner 1950, Ellis 1972, Yoakum 1978). Fawns on the NBR sometimes breed, further increasing the potential (O'Gara 1968). Buechner described a Texas population of 2 bucks and 13 does that increased to 169 animals in 6 years. Assuming all the original does were pregnant and no mortality occurred, he estimated that the potential population after 6 years could have been 327. The herd

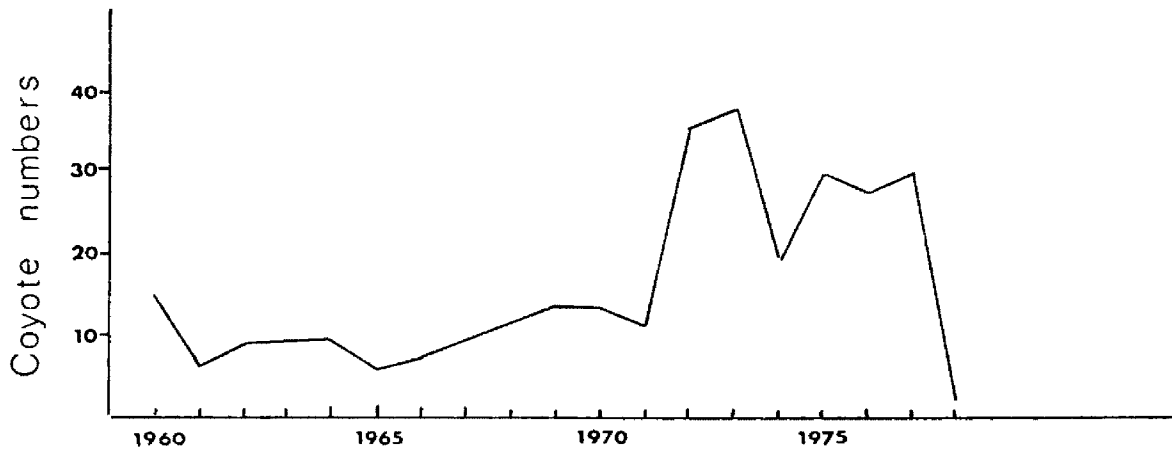


Fig. 4. Estimated number of coyotes inhabiting the NBR from 1960 to 1978. 1960-73 (Anonymous 1956-77), 1974-75 (Reichel 1976), and 1976-77 (Von Gunten 1978).

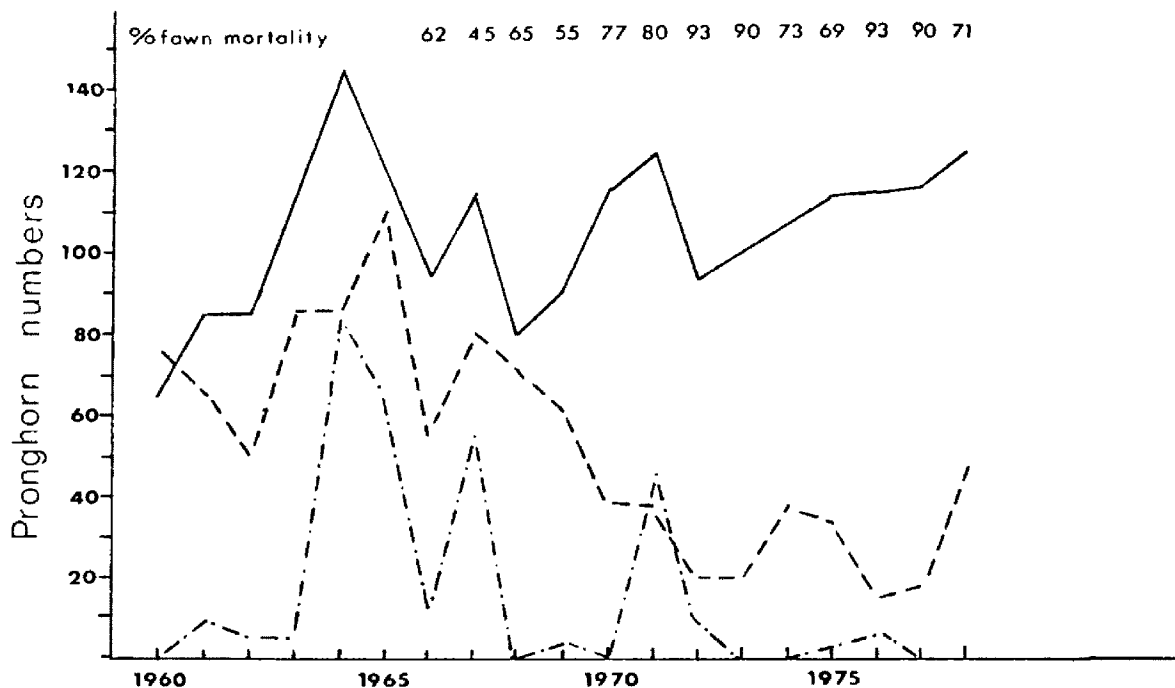


Fig. 5. Total population (—), fall fawns:100 does (---), and total collected or translocated (---) for pronghorn on the NBR, 1960-1978. 1960-77 (Anonymous 1956-77) except fawn:doe ratio, 1974, 1975 (Reichel 1976), 1977 (Von Gunten 1978). 1978 data are mine.

apparently endured a total mortality of 51%. Nonetheless it reproduced prolifically enough to increase rapidly. Similarly, the NBR herd increased from the introduced 15 in 1951 to 120 in 1962, despite the collection of more than 44 animals.

In general, high fawn mortality typifies pronghorn population dynamics. The life expectancy of pronghorns is 6-7 years (Van Wormer 1969), so the typical NBR birth rate of 195 fawns:100 does (O'Gara 1968) far exceeds the recruitment rate necessary to maintain a stable population. According to Yoakum (1978), an Oregon population remained stable for 17 years despite an annual recruitment of only 26 fawns:100 does.

The NBR herd maintained sporadic growth even after 1972, when the mortality rate reached 93%, suggesting that it successfully endured 7 consecutive years of high fawn mortality. An examination of the 1978 sex and age classes, however, revealed an unstable age composition (Fig. 6). The older cohorts (7-10 years old) comprised an unusually high proportion of the breeding age animals.

Observations made by Kitchen (pers. comm.) during the 1978 breeding season were the primary source of these data. He studied pronghorn behavior on the NBR from 1969 through 1971. Individual variations in body markings enabled him to identify virtually all members of the population born before 1972 (Kitchen 1974). During the 1978 breeding season, he recognized that 65% of the adult population

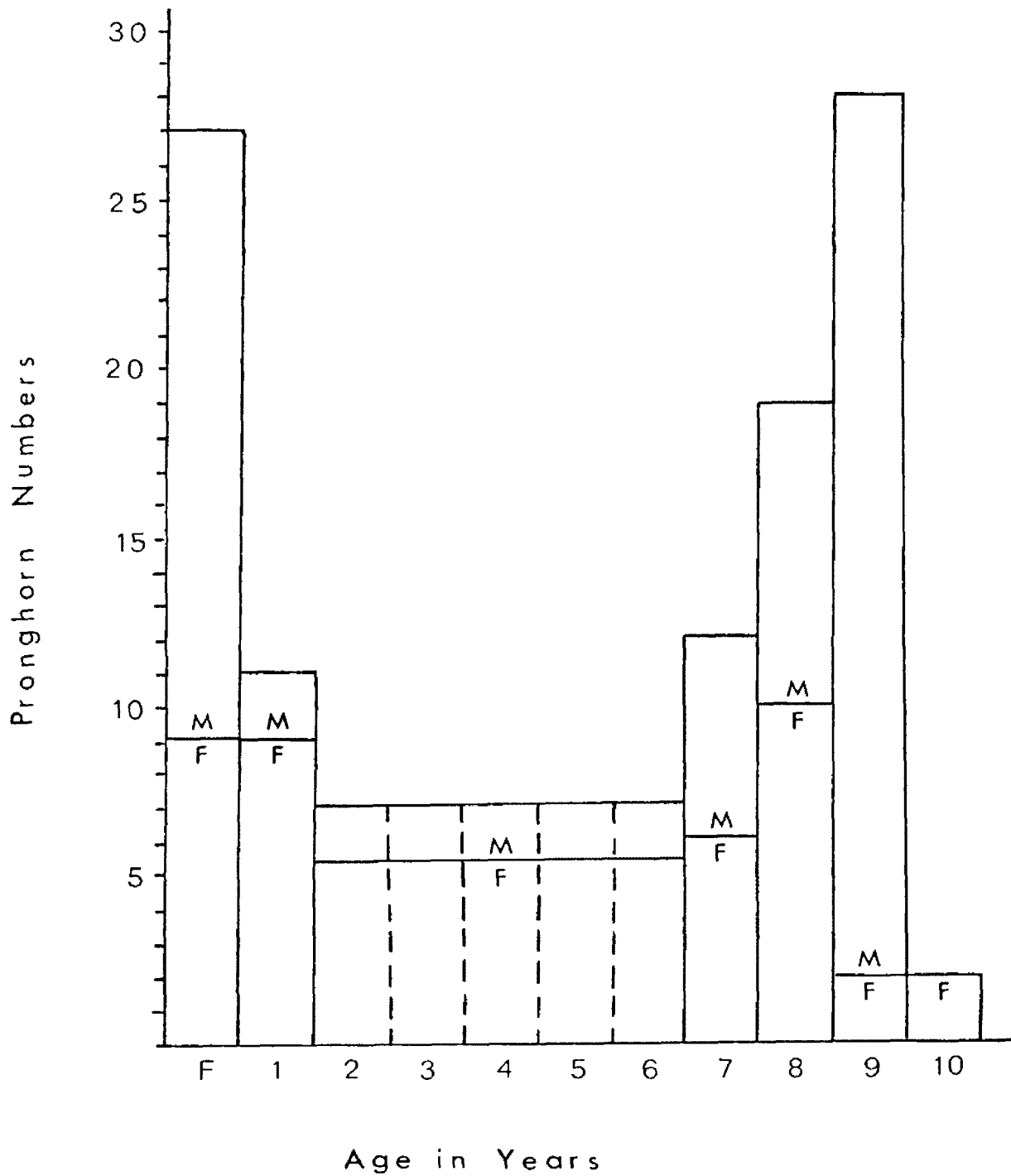


Fig. 6. Possible age and sex distribution of the 1978 pronghorn herd. Cohorts 7-10 from data provided by Kitchen (pers. comm.). Fawn to 6 years was my data.

were older than 7, and he believed a major population decline might occur in 2-3 years.

The actual distribution of the 2-6 year old cohorts was unknown (Fig. 6 depicts these as the total number of 2-6 year olds distributed evenly over 5 years). But the low fawn:doe ratios and the extremely high mortality rates indicated the animals born in 1972, 1973, and 1976 (2, 5, and 6 year olds) probably comprised smaller cohorts than those born in 1974 and 1975 (3 and 4 year olds).

At birth, 67% of the tagged fawns were males and the survival rates of females and males were equal. On that basis, I estimated 9 of the surviving fawns were female and 18 were male.

Of the breeding age males, 84% were older than 7. The loss of these males will substantially reduce the size of the herd, but most of these were nonbreeding males. Three of the older bucks were responsible for virtually all the breeding during recent years (Kitchen, pers. comm.), so the reproductive capacity of the herd should not be seriously altered by this loss.

Forty-three percent of the 1978 breeding does were older than 7. The loss of these does would significantly reduce the reproductive capacity of the herd, unless the loss occurs gradually. The potential for recovery exists as evidenced by the rapid increase of the herd from 1951 to 1962. Continued high fawn mortality in the small, isolated NBR herd, however, may preclude recovery.



### Factors Contributing to Fawn Mortality

Physical condition. Fawns who died showed no evidence of poor health at capture. All but one fawn (#29) were vigorous and healthy and averaged 3.5 kg, the average weight of Montana fawns at birth (O'Gara 1978a). Fawns that died did not weigh significantly less than surviving fawns ( $p > 0.20$ ).

Among the fawns with unknown cause of death, the possibility of disease exists. Beale and Smith (1973) found disease (salmonellosis or pneumonia) caused the death of 5 fawns, even though "all appeared healthy 1 or 2 days prior to death." Disease, however, was not a major cause of death in their study, causing only 9% of the mortality. Yoakum (1978) considered disease relatively rare in pronghorn population because they rarely congregate in large herds, infrequently use moist habitat, and change bedding and feeding locations daily. Von Gunten (1978) found no evidence of disease-caused mortality in 27 tagged NBR fawns. Neither the necropsies nor encounters with tagged fawns in 1978 revealed evidence of disease or weakness. Disease could not be shown to be an important cause of fawn mortality in 1978.

Maternal abandonment. All 34 fawns were accepted by their mothers following tagging procedures, so researcher-induced abandonment did not contribute to fawn mortality.

Precipitation. Von Gunten (1978) found a weak positive trend between annual precipitation and fawn survival on the NBR.

Habitat. Von Gunten (1978) discussed changing range condition as a factor contributing to fawn mortality, pointing out that pronghorn were not indigenous to the Range. Since 1964, when 3% of the NBR range was climax vegetation, range management has converted 83% of the Range to climax vegetation. This resulted in a reduction of forbs, including those important to the pronghorn diet (Von Gunten 1978). Von Gunten and I found no evidence, however, of weakness or poor health, which presumably would be caused by poor quality forage.

Predation. Predators were involved in the deaths of at least 14 tagged fawns, including 10 killed by and 3 consumed by predators and 1 that died of capture myopathy (Chalmers and Barrett 1977) after an eagle attack. The cause of death of 7 apparently healthy fawns was unknown, but predator involvement is the most plausible explanation for the rapid disappearance of their carcasses.

More fawns survived in 1978 (29%) than in 1977 (10%; Von Gunten 1978), but survival was no better than in 1975 (31%; Reichel 1976). Predation was still the most important cause of death in 1978, but the mortality rate was not uniformly high in all locations.

Reichel (1976) and Von Gunten (1978) thought that certain fawns may have been more susceptible to predation because of their

location. Both found coyote-involved mortality highest in Alexander Basin and the northside range, where coyotes denned.

In 1978, the mortality rate was still significantly dependent on location even though coyote predation was no longer the primary cause of death. The rate was 93% on the southeast range where 80% of the predator-involved mortality, including all of the bobcat and eagle kills, occurred. In Alexander Basin, where very high mortality in 1975 (90%) and 1977 (93%) was attributed to coyote predation (Reichel 1976, Von Gunten 1978), the rate was only 27%.

Survival in Alexander Basin apparently improved as a result of removing the 6 resident coyotes, including a breeding pair, 3 yearling males, and a 2-year-old male (Fig. 2, Appendix D). The lactating female was 5 and her mate was 4 years old, and precontrol observations suggested that the yearlings were their offspring. The pair was shot near a denning site occupied by a breeding pair, perhaps the same pair, for several years (Reichel 1976, Von Gunten 1978).

Fawn predation by older coyotes probably began in chance encounters with bedded fawns while the coyotes foraged for mice. Such "chance depredations" (Leopold 1933) served as an educational basis for deliberate or "habit depredations" as the coyotes developed the ability to find more fawns during succeeding fawning seasons. Microtines sustained the NBR coyotes throughout the year (Reichel 1976), but fawns may have been preferred because they represented a

larger energy package (Von Gunten 1978), and were easy prey. Had they survived control, the experienced pair presumably would have been efficient fawn predators in 1978. The yearlings were probably still in a trial and error phase of learning (Fox 1969) and would have been less of a threat to the fawns than the older coyotes.

Despite the removal of northside denning coyotes, fawn survival did not improve there as much as in Alexander Basin (Table 1). The proximity of northside fawns to the surviving lower-west coyote pair, and to the nonresident coyotes moving through the perimeter fence, probably accounted for continued mortality. The same factors undoubtedly contributed to the 80% mortality among the lower-west fawns, but a bobcat may have killed some of them. Tracks on the Headquarters Ridge tour road (Fig. 1) in 1978 and bobcat sightings during past years indicated that a bobcat inhabited the rocky timbered ridge above the lower-west range.

Hamlin (1979) found no relationship between coyote density and deer fawn mortality in the Missouri River Breaks. He did find a strong positive relationship between fawn survival and rodent density. In the absence of control, the scarcity of microtines on the Range in 1978 could have contributed to heavy coyote predation on fawns. Von Gunten (1978), however, noted that coyote predation was heavy even during years of high microtine abundance.

Predators caused at least 62% of the deaths on the southeast

range. Of 14 tagged fawns, the single fawn that was to survive moved to Alexander Basin on 6 June, when she was 10 days old. By the second week of June, several does had moved to Alexander Basin and I rarely saw does or fawns on the southeast range after the third week in June. The mass movement was evidently not prompted by the predation, as does showed no tendency to move from the vicinity of their dead fawns even when the sibling survived. More likely, the movement was in response to seasonal changes in vegetation (Swanger 1977). Nonetheless, the remaining fawn presumably survived because of the move.

Compared to pronghorn does of the open range, those on the fenced NBR had a limited choice of fawning locations. Among the possibilities, certain locations were probably better suited than others because of higher quality forage. Since 1969, the major concentrations of pregnant does shifted from the northern portion of the Range to the southeast near Ravalli Ponds (Fig. 1; Kitchen 1974, Reichel 1976, Von Gunten 1978). During the same period, northside vegetation changed to a near climax state, resulting in a decline of forbs (yarrow, Achilles lanulosa, and aster, Aster falcatus) that were important components of the NBR pronghorn diet according to O'Gara and Greer (1970). Because such a change did not occur in the southeast, Von Gunten (1978) reasoned that a greater abundance of forbs on the southeast could have attracted parturient does in 1977.

In 1978, 38% of the pregnant does fawned in the southeast.

The proximity of this preferred fawning area to bobcat habitat probably contributed to the extremely high mortality. Bobcats den and hunt in the type of rough, rocky terrain (Bailey 1972, Beale and Smith 1973) that characterizes the southeast range. Depending on vision and hearing to locate prey, bobcats hunt by stalking (Bailey 1972). The numerous brushy draws and rocky ridges provide the cover essential to a successful stalk. Such cover is relatively unavailable on the open terrain of Alexander Basin, accounting for the apparent absence of bobcat predation there.

Southeast bobcats may have gained experience, becoming more efficient fawn predators with each year that does fawned there, because the scarcity of suitable fawning grounds discouraged does from dispersing.

Among fawns whose fate was known, bobcat predation accounted for a higher proportion of southeast fawn mortality in 1978 (33%) than in 1977 (11%; Von Gunten 1978). Although the bobcats' experience probably contributed to the increase, bobcats may have expanded their range to include former coyote hunting grounds (Robinson 1961, Beale and Smith 1973), where fawns most commonly bedded. Robinson (1961) noted that following coyote reductions, bobcats tended to move from rougher habitat to more open terrain. Government trappers reported reciprocal population fluctuations of

coyotes and bobcats (Cain et al. 1972), suggesting competition for a resource, perhaps hunting grounds. Conversely, Bailey (1972) observed little direct competition between coyotes and bobcats inhabiting the same area; he attributed this to ecological and behavioral differences confining them to separate niches. But competitive behavior patterns between coyotes and bobcats may be subtle, the bobcat seldom overtly challenging the coyote. If competition restricted the bobcat, the removal of coyotes would have allowed them to expand the limits of their range.

Golden Eagle predation has been documented for both pronghorn fawns (Thompson 1949, Bruns 1970, Beale and Smith 1973, Goodwin 1976, Bodie 1978, Von Gunten 1978), and adults (Lehti 1947, Thompson 1949). Beale and Smith (1973) found that only 1 of 29 predator-killed fawns was taken by an eagle, but Bodie (1978) attributed 4 of 9 predator kills to Golden Eagles.

Well-developed alarm, escape, and birth behavior patterns of adult pronghorns and bedding behavior of fawns, specifically anti-avian in character, lead Bruns (1970) and Bromley (1977) to reason that avian predation has been a significant selective pressure. On the NBR, eagle predation has not been common in recent years (Anonymous 1956-77), accounting for only 1 death among 27 in 1977 (Von Gunten 1978), but in 1978 eagles killed at least 4 fawns.

All 4 fawns were killed on the southeast range. A subadult

eagle killed 2 on a ridgetop, where Range personnel and I periodically saw it perched throughout early summer (Appendix A, Cases 35, 36). From this ridgetop and the adjacent ridgetop to the south, most of the southeast fawning area was visible, suggesting that the same subadult may have killed the other 2 fawns (Cases 12, 13) as well. The sudden increase in eagle predation may have been caused by a transient subadult, and the threat to fawn survival was probably short-term.

The concentration of eagle predation in the southeast was probably related to the terrain, characterized by numerous ridges cut by draws and intermittent streams. Black-tailed deer (Odocoileus hemionus columbianus) fawns in California constituted an important prey item in nests where adult eagles hunted over abrupt ridges (Carnie 1954). Carnie watched an eagle glide from a hillside with a fawn. Similarly Bodie (1978) observed an eagle carrying a fawn from a ridgetop. He noted most eagles concentrated where air currents, associated with foothills, facilitated hunting. In my study, the eagle observed carrying sibling fawns (Appendix A, Cases 35, 36) glided from a 1200 m ridgetop, and thus did not rely exclusively on his own power to lift the fawns. The relatively flat, open terrain of Alexander Basin was not as conducive to hunting as the southeast. Eagles were sometimes seen in the vicinity of Alexander Basin, but no tagged fawns lost their lives to eagles there.



### Effects of Predation on NBR Pronghorns

In the absence of coyote predation, fawn survival could depend in part on the extent to which other mortality factors compensated for its absence. Errington (1946) defined compensation as "the process in which one or more mortality factors increase in effect as the effect of another decreases." In Alexander Basin, where very low survival in 1975 and 1977 was attributed to coyote predation, survival improved dramatically following coyote control. Other mortality factors such as disease, starvation, precipitation, and maternal abandonment, did not compensate for the absence of coyote predation. Bobcat predation apparently did compensate for decreased coyote predation in the southeast range in 1978.

Some researchers have considered that other factors cause a greater impact on ungulate population levels than predation. Caughley (1970) suggested that ungulate population irruptions are influenced by food supply and are terminated by "depletion of forage by the animals themselves." In some animals, irruptions are less severe and recruitment generally balances food supply and other resources (MacArthur and Connell 1967, Krebs 1972), but self-regulating mechanisms appear absent in many ungulates. Errington (1946) points out that ungulates tend to increase in a "Malthusian manner" (to the point of starvation) more than other vertebrates. Predators, he said, particularly canids, may have a "truly significant influence on

populations of at least some ungulates." Huffaker (1970) and Keith (1974) agreed with Pimlott's (1967) hypothesis, that in pristine communities, control by predators may have been closely associated with the absence of self-regulation in ungulates.

Although some studies have shown predators incapable of regulating ungulate populations, these probably were conducted where ungulate densities were higher or predator densities lower than in pristine times (Pimlott 1967, Huffaker 1970, Keith 1974).

That predators have had a significant impact on pronghorns seems inescapable, considering the apparent selection for sophisticated anti-predator behavior. In response to predator pressures, adaptations evolved to help protect fawns during and shortly after birth (Autenreith and Fichter 1975, Bromley 1977).

Coyotes may be capable of decimating the NBR pronghorn population. Before 1972, the NBR coyote density was low (Fig. 4), and the herd increased rapidly (Fig. 5). The 1978 age structure (Fig. 6) apparently resulted from 7 years of high fawn mortality beginning in 1972. Predators rarely decimated pristine herds, but unnatural conditions on the NBR may have increased the herd's vulnerability to decimation.

The importance of fences confining the pronghorn herd with experienced predators has been discussed (*vide supra*). Open-range pronghorns probably change fawning locations from year to year,

preventing predators from becoming experienced (Beale and Smith 1973).

Fences that divide the Range and restrict bison movements, but permit other ungulates to move under, may increase the vulnerability of inexperienced fawns. On 2 July, I observed 4 fawns wandering along a fence, apparently searching for a way to join 3 does on the other side. One fawn crawled under the fence after about 3 minutes, but the others continued wandering along the fence for about 10 minutes, stopping only after a doe rejoined them. Buechner (1950) observed 2 similar occasions when fawns refused to follow does under a fence. Both times the does had to crawl back to rejoin the fawns. The fences could have interfered with escape from predators. On the other hand, fences would interfere with escape at the age that fawns depend on running rather than bedding for protection. At that age, when they are older than 3 weeks, relatively few fawns lose their lives to predators.

Just as predators may be incapable of controlling over-populated ungulate populations (Pimlott 1967, Huffaker 1970, Keith 1974), predators probably could over-control small or restricted herds. Mech and Karns (1977) found that wolves completely exterminated a local population of white-tailed deer in Minnesota, which had been reduced by loss of habitat (forest maturation) and severe winters. They believed that if wolves had not been present, the deer

would not have disappeared. Recovery of the population began when deer from surrounding herds began to repopulate the area after wolf density declined from lack of food. On the NBR, coyote density would not be checked by declining pronghorn numbers because they do not depend on the pronghorns for food. The herd is small and isolated, so repopulation from a nearby herd would be impossible. It seems unlikely that natural stability of predator-prey interactions could be achieved on the NBR; coyotes could probably ruinously deplete the herd.

The effectiveness of increasing fawn survival by coyote control will remain somewhat limited if the southeast range continues to be a major fawning area. Bobcat predation could continue to compensate for reduced coyote predation there. Beale and Smith (1973) believed that even a low density of bobcats could inflict high mortality on pronghorn fawns, so complete bobcat removal would be necessary to significantly increase survival on the southeast range. But eradication of NBR bobcats would be unacceptable and probably unnecessary, because some fawn mortality can be endured by the herd.

The dramatically decreased mortality in Alexander Basin indicates that spring control of coyotes, especially older, experienced ones, could improve survival enough to prevent a serious population decline. Periodic control would not threaten the resilient coyote population with extirpation. When successive years of high predator-caused mortality threaten the breeding population, coyote control may be necessary if pronghorns are to be maintained on the Range.

## CHAPTER VI

### SUMMARY

1. How coyote control affected pronghorn fawn mortality on the National Bison Range was studied in 1978.
2. During May, 19 coyotes were shot, snared, or poisoned. At least 1 resident breeding pair survived control.
3. Of an estimated 92 fawns born, 34 were radio tagged between 20 May and 7 June; 22 tagged fawns died before 1 August. Ten predator-caused mortalities included 3 bobcat kills, 4 Golden Eagle kills, and 3 unidentified predator kills. One fawn may have succumbed to capture myopathy caused by an eagle, and coyotes probably consumed 3 fawns. The remains of 6 fawns consisted of only bone and hide fragments. Three transmitters failed and 1 fell off prematurely. Cause of death for those 10 fawns was not determined, but 7 were apparently healthy 24-48 hours before they died, so predator involvement was the most plausible explanation for their rapid disappearance.
4. Seventy percent of an estimated 92 fawns died before 1 August; by mid-October, the mortality rate was virtually unchanged (71%). Of the tagged sample mortality, 82% occurred within the first

3 weeks of life.

5. Although the fawn mortality rate remained high, despite control, it was not uniformly high on all fawning grounds. The rate was 93% on the southeast range, where the bobcat and eagle kills occurred. It was only 27% in Alexander Basin, where coyote-related mortality was very high in 1975 (90%) and in 1977 (93%); other mortality factors did not compensate for the absence of coyote predation there.

6. Numerous possible compensating mortality factors, including disease, precipitation, abandonment by dams, and poor habitat, were eliminated as important mortality factors. Predation, apparently a noncompensatory mortality factor among NBR fawns, was still the most important cause of death in 1978.

7. Bobcat predation compensated for the absence of coyote predation in the southeast, as bobcats moved into former coyote hunting grounds. The proximity of preferred fawning grounds to bobcat habitat on the southeast range and the bobcats' increased predator experience probably increased the fawns vulnerability to bobcat predation.

8. A transitory subadult Golden Eagle may have caused increased eagle predation in 1978. The ridges and draws on the southeast range were more conducive to eagle predation than the flatter terrain in Alexander Basin. Eagles were an intermittent,

although sometimes significant, cause of mortality on the NBR.

9. Certain conditions on the NBR may have increased the herd's vulnerability to decimation by coyotes. Fences enclosed pronghorns with experienced predators, and may have interfered with escape. Sustained throughout the year by alternate prey, coyotes do not depend on pronghorn for survival and could ruinously control the small, isolated herd.

10. During 7 years of high fawn mortality, recruitment into the breeding population was low. As a result, in 1978, 65% of the breeding age adults were probably over 7 years old. A serious population decline could occur in 2-3 years.

11. When successive years of high predator-caused mortality threaten the breeding population, spring coyote control could improve fawn survival enough to prevent a serious population decline. Coyote populations are resilient, so periodic control would not threaten NBR coyotes with extirpation.

## ADDENDUM

The following data, collected during the spring of 1979, tend to support Kitchen's observation that because of the unusually high proportion of old animals in the herd, a major population decline would occur. These carcasses accounted for 18% of the adult females and 33% of the adult males counted on the NBR during autumn 1978, although the actual winter loss may have been greater.

Ages of pronghorns that died during winter 1978-79 on the National Bison Range as estimated from jaws or skulls collected by O'Gara. Ages listed, except fawns, are ages animals would have been in spring 1979.

Estimated age	Number collected	
	Male	Female
Fawns	4	4
6-year-olds	1	
8-year-olds	2	1
9-year-olds	8	5
10-year-olds	5	2
	<u>20</u>	<u>12</u>

O'Gara (pers. comm.) explained:

One buck was headless, so 21 buck and 12 doe carcasses were found. About half of the carcasses were fresh enough to tell if they were killed by coyotes and all of them apparently were. However, from the condition of the teeth in the older animals and



the femur marrow of 3 fawns that were checked, they were "walking carrion" when killed. The 6-year-old buck was an exception. Determination of age by upper jaws is not well documented, so those 9-year-old designations are quite "shaky" and probably should have been 10-year-olds. Also, a lot of the old animals had missing or malformed teeth that could have affected tooth wear, and the animals could have been older than wear indicated.

Ninety-one pronghorns were counted during the annual NBR Big Game Census (NBR personnel, pers. comm.) in March 1979, so 33% of the animals counted during fall 1978 died by that date. A field assistant counted the herd once again on 28 July 1979. His results are listed below with census results from the same period in 1978. Despite the loss of breeding age females, almost as many fawns survived the critical early weeks after birth in 1979 as survived the same period in 1978.

National Bison Range pronghorn  
census by Dan Pond, 28 July 1979.

	Male	Female
Fawns	6	17
Yearlings	3	7
Adults	<u>12</u>	<u>28</u>
	21	52

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APPENDIX A

FAWN MORTALITY CASE HISTORIES

## Case No. 1, Fawn 2

Doe herd--Southeast

Age at death--12 days

The carcass, consisting of the head and the right leg, was inconspicuously buried in the center of a large snowberry patch, covered with 3 cm of soil and debris. Hemorrhaging at head puncture wounds on the top of the skull and below and anterior to an ear indicated a predator kill. The jaw was fractured. Multiple bites, made after death, were present in the shoulders. Because the skull was not fractured, despite numerous bites, and the puncture wounds were small, this was considered a bobcat kill.

## Case No. 2, Fawn 3

Doe herd--Southeast

Age at death--6 days

Remains consisted of two strips of hide and the transmitter package. No scats, hair tracks or other sign were present, indicating that this was not the death site. Subcutaneous hemorrhaging on both pieces of hide indicated this was predator kill, but it was impossible to determine the identity of the predator.

## Case No. 3, Fawn 4

Doe herd--Southeast

Age at death--6 days

Remains consisted of the transmitter package and a bit of hide. The fawn had been dead for several days and was found near the bottom of the same draw as its sibling (Fawn 3). Cause of death was unknown.

## Case No. 4, Fawn 5

Doe herd--Lower West

Age at death--4 days

Only the transmitter was found. Fresh blood spotted the elastic and the belly elastic was chewed. The cause of death was unknown. The carcass was adjacent to coyote dens just outside the NBR perimeter fence. The fence had numerous holes where



they frequently came into the Range. Coyote scats were abundant there. Two days before, I watched a coyote about 20 feet from the fawn's mother. Little interaction occurred at the time, beyond mutual staring. It seems likely that this fawn was coyote consumed if not coyote killed.

Case No. 5, Fawn 6

Doe herd--Southeast

Age at death--23 days minimum

The last day I received a signal from or saw this fawn was 12 June. Thorough searches throughout the summer did not reveal a sign of him, nor was he seen during the July or October censuses. This fawn had been seen regularly with other fawns in Alexander Basin before its disappearance. He also continued to range in the southeast, where he was last seen.

Case No. 6, Fawn 7

Doe herd--Lower West

Age at death--8 days

Remains consisted of the eartag, skull fragments, an incisor, a premolar, and bits of flesh. The transmitter package was found 3 m from the remains. A small oval of blood-stained matted grass suggested that the fawn was killed or consumed at the bedding site. The very fresh state of the blood and bits of brain tissue adhering to the skull indicated that the fawn had recently died and was totally consumed in a short time. A coyote can consume an entire fawn at one feeding, whereas a bobcat rarely eats an entire fawn (O'Gara 1978b). Beale and Smith (1973) found in Utah that fawns killed by bobcats were always dragged from the kill site. Apparently the fawn was consumed by a coyote.

Case No. 7, Fawn 8

Doe herd--Lower West

Age at death--8 days

The transmitter and the right front leg and shoulder were found inconspicuously buried in a dense bush. Five cm of soil

and debris had been piled over the carcass. Subcutaneous hemorrhaging indicated a predator kill.

Case No. 8, Fawn 9

Doe herd--Alexander Basin  
Age at death--24 days minimum

A signal was last received on 17 June. Thereafter, he was not seen with his mother and sibling or during any census. Cause of death was unknown.

Case No. 9, Fawn 11

Doe herd--Southeast  
Age at death--35 days

The harness dropped from this fawn on 15 June, but he was observed with his radioed sibling until 27 June. He was never seen again.

Case No. 10, Fawn 15

Doe herd--Northside  
Age at death--21 days

No signal was received after 16 June, when he was last seen. His sibling and mother were seen frequently for the remainder of the summer.

Case No. 11, Fawn 16

Doe herd--Southeast  
Age at death--10 days

The carcass was recovered by my field assistant. The fawn had been dead a few hours when found about 70 m from its twin, which had been killed by a Golden Eagle half a day earlier. Necropsy revealed no external wounds but bruises were present on the front of the shoulders, front legs, and the front of the back feet. The skeletal muscles were very pale, particularly in the hind limbs. Thin slices of these muscles revealed petechial hemorrhages. The limbs showed a small amount of edema. The liver looked normal. The fawn had an apparently normal thymus, good fat reserves, and had been eating normally (O'Gara, pers.

comm.). The fawn may have become frightened, running and stumbling in response to the eagle attack and to the mother's energetic defense of the attacked fawns. The necropsy findings were consistent with typical pathological findings for capture myopathy to the extent that retroactive diagnosis permitted. Capture myopathy is an often fatal disease characterized by extensive damage to muscular tissue and other organs following severe overexertion and vigorous use of many muscles (Chalmers and Barrett 1977). Although the necropsy was not sufficiently thorough for a confident diagnosis, the probable scenario following the attack of the fawns supports such a diagnosis for this apparently normal fawn.

Case No. 12, Fawn 17

Doe herd--Southeast  
Age at death--9 days

The carcass was found head first in a shallow ditch, "straddled as if crawling, walking" (Flynn, pers. comm.). The fawn had apparently died the day before. Numerous talon wounds in the stomach and groin area and in the front of the shoulders at the base of the neck were evidence of a Golden Eagle kill. The intestines were squeezed and ruptured and the internal organs protruded from a left ventral tear, but no significant feeding occurred.

Case No. 13, Fawn 18

Doe herd--Alexander Basin  
Age at death--18 days

The signal was lost on 31 May. After a thorough search on 8 June, I received an intermittent signal from a high ridge and followed it to the interior of Alexander Basin. The carcass was buried in a large shrub and thistle patch and was covered with 3 cm of soil and litter. The carcass was badly decomposed and had probably been dead since the loss of the signal. The right ear had been chewed off. The position of the puncture holes in the skull suggest that the fawn's head had been bitten by a mammalian

predator. The jaw was broken. Positive identification of the predator was not possible, although my field assistant saw a coyote in the same drainage about 100 m from the fawn on the last night the fawn was seen alive.

Case No 14, Fawn 20

Doe herd--Southeast

Age at death--10 days

The fawn was located on a ridge top lying on its right side with legs extended. Talon punctures and associated hemorrhaging near the jaw and on the back and hip verified that this was a Golden Eagle kill. The eagle fed on the left side behind the shoulder, consuming the viscera completely. The ribs had been cleanly severed close to the spine, a characteristic eagle feeding pattern. A large pool of blood in the body cavity suggested that the eagle began feeding on the fawn almost immediately and that the fawn died from bleeding (O'Gara 1978b).

Case No. 15, Fawn 21

Doe herd--Southeast

Age at death--9 days

The carcass, consisting of the head, front limbs, and shoulders was carefully buried near a bush. The hole was 20 cm deep and the carcass was covered with 3 cm of soil and litter. The necropsy revealed small holes in the skull, including a tear drop shaped puncture at the top of the skull. The size and shape of the puncture indicated that a bobcat killed the fawn. The skull was fractured from bites. Had these been coyote bites the skull would have been more extensively damaged (O'Gara, pers. comm.).

Case No. 16, Fawn 22

Doe herd--Southeast

Age at death--6 days

My field assistant recovered the remains, consisting of only the transmitter, eartag, and bone fragments (rib and skull). The fragments were 5 m from the transmitter, near blood-stained

grass. The apparent complete consumption indicated a coyote consumed the fawn.

Case No. 17, Fawn 23

Doe herd--Southeast  
Age at death--9 days

Remains included a strip of hide and bone fragments, including the articulating end of a scapula plus the humerus and other long-bone fragments. These bones had been cracked and chewed. The cause of death was unknown.

Case No. 18, Fawn 26

Doe herd--Lower West  
Age at death--6 days

The transmitter package was found underneath a balsamroot (Balsamorhiza sagittata) plant. The distal portion of a front leg lay on top of a large flat rock. No blood, tracks or other evidence was present, indicating that the leg had been carried or dropped there. The distal joint was swollen. Cause of death was unknown.

Case No. 19, Fawn 28

Doe herd--Southeast  
Age at death--23 days

The transmitter and elastic (chewed and bloody) remained.

Case No. 20, Fawn 29

Doe herd--Southeast  
Age at death--21 days

The carcass consisted of the head and shoulders, with the front limbs partly consumed and exposed. The proximal end of the left humerus was cracked and the distal end of each leg was gone. The skull had numerous small puncture wounds and tears below the eyes and under the chin, some with subcutaneous hemorrhaging. The skull and jaw were fractured. Bruises and muscle hemorrhages were associated with the broken neck. The shoulders and rib cage were punctured and scratched following death. The nature of the wounds (shape and size) and the small

amount of damage to the skull relative to the number of bites indicated that this was a bobcat kill. The carcass was found near the other two bobcat kills (Fig. 6).

Case No. 21, Fawn 31

Doe herd--Northside  
Age at death--38 days

Only the transmitter package remained, the elastic was chewed and bloody.

Case No. 22, Fawn 32

Doe herd--Alexander Basin  
Age at death--13 days

Only the transmitter attached to a 30-cm strip of hide was found.

Case No. 23, Fawns 33, 34

Doe herd--Southeast  
Age at death--several hours

Visiting University of California undergraduates observed an eagle feeding on an untagged fawn but apparently frightened the eagle away. Upon returning some hours later, the students saw an eagle carry and then drop a second fawn. I retrieved both carcasses that evening. The fawns were only a few hours old at the time of death. The front leg of the first fawn was disjointed at the shoulder and was partly eaten. The viscera, ribs, and spine were gone from the shoulders to the hips. The fawn bled from its mouth but no head wounds were present. Deep talon wounds showed that the fawn had been grabbed from below. His sibling was intact except for talon wounds and a small amount of feeding about 5 cm across behind the right shoulder.

APPENDIX B

PRONGHORN AND RODENT DATUM FORMS

PRONGHORN FAWN DATA

Fawn No. \_\_\_\_\_ Map location \_\_\_\_\_ Distance from twin \_\_\_\_\_

Sex \_\_\_\_\_ Weight \_\_\_\_\_ Total length \_\_\_\_\_ Approx. age \_\_\_\_\_

Girth \_\_\_\_\_ Placenta \_\_\_\_\_ Umbilical cord \_\_\_\_\_

Condition (pelage, ex. parasites, abnormalities) \_\_\_\_\_

\_\_\_\_\_

Picture # \_\_\_\_\_ Habitat \_\_\_\_\_

Radio collar frequency \_\_\_\_\_ Band \_\_\_\_\_ Channel \_\_\_\_\_

RADIO LOCATION

<u>Date</u>	<u>Time</u>	<u>Pulse</u>	<u>Remarks</u>	<u>Date</u>	<u>Time</u>	<u>Pulse</u>	<u>Remarks</u>
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____



FAWN CARCASS DATA

Date \_\_\_\_\_ Approximate time of death \_\_\_\_\_

Tracks or sign \_\_\_\_\_

Tag # \_\_\_\_\_ Weight \_\_\_\_\_ Map location \_\_\_\_\_

Carcass description \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Picture # \_\_\_\_\_

## RODENT DATUM FORM

Date:

Weather:

Species	Trap	Weight	Total length	Tail length	Hindfoot length	Ear length	Sex	Testis (S or A)	Testis size	Mammae visible?	R Embryos	L Embryos	Embryo size	Placental scars

APPENDIX C

PHYSICAL CHARACTERISTICS OF 34  
TAGGED NBR FAWNS

Fawn no.	Sex	Twin no.	Capture date	Estimated age	Weight (kg)	Length (cm)	Girth (cm)
1	♀	NT*	20 May	3 da	4.0	--	38.0
2	♀	6	20 May	1 da	2.7	62.0	34.0
3	♂	4	20 May	1 da	3.2	71.0	36.8
4	♀	3	20 May	1 da	3.2	66.0	35.6
5	♀	--	21 May	4 h	3.6	66.0	39.4
6	♂	2	21 May	1 da	3.2	68.6	35.6
7	♂	8	23 May	6 h	3.2	64.3	38.0
8	♀	7	23 May	6 h	3.6	66.0	38.0
9	♂	10	25 May	5 h	4.0	69.9	38.0
10	♂	9	25 May	5 h	4.0	74.9	39.4
11	♂	12	26 May	2 da	3.6	69.9	36.3
12	♂	11	26 May	2 da	4.7	69.3	38.7
13	♂	NT	26 May	5 da	4.5	74.9	40.6
14	♂	15	27 May	12 h	3.2	63.5	36.8
15	♂	14	27 May	12 h	3.4	63.5	38.1
16	♂	17	27 May	1 da	3.6	68.6	38.1
17	♂	16	27 May	1 da	2.5	69.9	35.6
18	♂	--	27 May	2 da	4.1	66.0	40.6
19	♀	NT	27 May	3 da	4.1	71.1	44.5
20	♂	21	28 May	12 h	3.2	66.0	38.1
21	♀	20	28 May	12 h	3.2	68.6	36.8
22	♂	23	30 May	19 h	3.9	68.6	40.6
23	♂	22	30 May	19 h	4.3	71.1	41.9
24	♂	25	31 May	1 da	3.9	66.7	38.1
25	♂	24	31 May	1 da	3.6	64.8	38.1
26	♂	27	3 June	4 h	3.4	64.8	36.8
27	♂	26	3 June	4 h	3.9	68.6	41.9
28	♀	29	3 June	3 da	3.6	63.5	--
29	♂	28	3 June	3 da	2.3	53.3	32.4
30	♀	NT	5 June	1 wk	8.0	--	45.7
31	♀	NT	7 June	1 wk	5.0	69.0	44.5
32	♂	33	7 June	5 da	4.1	67.3	39.4
33	♂	32	7 June	5 da	4.3	68.6	39.4
34	♀	NT	7 June	1 wk	5.7	--	44.5

\*Twin observed but not tagged.

Means and standard deviations of weight, length, and girth of tagged fawns in 1978.

	Weight (kg)	Length (cm)	Girth (cm)
1 day old (N = 21)	x = 3.5 s = 0.4	x = 67.3 s = 3.1	x = 37.9 s = 2.0
2-3 days old (N = 7)	x = 3.8 s = 0.7	x = 65.5 s = 6.6	x = 38.4 s = 4.1
4-5 days old (N = 1)	x = 4.5	x = 74.9	x = 40.6
6 days old (N = 5)	x = 5.4 s = 1.6	x = 68.6* s = 1.3	x = 42.7 s = 3.1

\*N = 3.

APPENDIX D

CONTROL METHODS, COLLECTION SITES, AND PHYSICAL  
CHARACTERISTICS OF 19 NBR COYOTES

Coyote no.	Date	Sex	Site	Age	Weight (kg)	Control method
1	12 May	♂	NS*	2 c#	13	snare
2	13 May	♂	AB	3 b	12	snare
3	17 May	♂	AB	4 a	15	helicopter gunning
4	17 May	♀ L§	AB	5 a	13	helicopter gunning
5	17 May	♂	AB	2 b	11	helicopter gunning
6	17 May	♀ N	NS	3 b	10	helicopter gunning
7	18 May	♀ L	NS	1 c	10	M-44
8	23 May	♀ L	SE	8 b	12	snare
9	24 May	♂	AB	1 b	15	helicopter gunning
10	24 May	♂	AB	1 b	13	helicopter gunning
11	24 May	♂	AB	1 b	13	helicopter gunning
12	24 May	♀ N	NS	1 c	7	helicopter gunning
13	24 May	♂	LW	2 c	12	helicopter gunning
14	24 May	♀ L	LW	1 b	10	helicopter gunning
15	24 May	♂	LW	5 b	14	helicopter gunning
16	24 May	♂	LW	3 b	12	helicopter gunning
17	24 May	♀ L	NS	4 b	10	helicopter gunning
18	24 May	♂	NS	3 b	14	helicopter gunning
19	28 May	♂	AB	1 c	13	snare
				$\bar{X} = 2.7$	$\bar{X} = 12.0$	
				$s = 1.9$	$s = 2.0$	

\*NS = Northside  
 AB = Alexander Basin  
 SE = Southeast  
 LW = Lower West

# a = age nearly certain  
 b = some error likely  
 c = error likely

§ L = lactating  
 N = nonlactating