1982

Food habits and spatial relations of coyotes and a lone wolf in the Rocky Mountains

Diane Boyd
The University of Montana

FOOD HABITS AND SPATIAL RELATIONS OF COYOTES AND A LONE WOLF IN THE ROCKY MOUNTAINS

By

Diane Boyd

B.S., University of Minnesota, 1977

Presented in partial fulfillment of the requirements for the degree of

Master of Science

UNIVERSITY OF MONTANA

1982

Approved by:

Robert R. Ream

Chairman, Board of Examiners

Dean, Graduate School

December 10, 1982

Date

Errata for

FOOD HABITS AND SPATIAL RELATIONS OF COYOTES

AND A LONE WOLF IN THE ROCKY MOUNTAINS

By

Diane Boyd

1982

Abstract

Page ii, Paragraph 3, lines 5-6, reads: "Mean home range size was 26 square miles (68 km^2) for males and 20 square miles (51 km^2) for females." It should read: "Mean home range size was 20 square miles (51 km^2) for males and 8 square miles (21 km^2) for females."

Results

Page 39, Paragraph 1, line 1, reads: ". . . miles (52 km^2) and for females. . . ." It should read: ". . . miles (51 km^2) and for females. . . ."

Discussion

Page 80, Paragraph 2, lines 1-3, reads: "Mean home range sizes were 20 square miles (52 km^2) for 5 males and 11 square miles (27 km^2) for 2 females, with a combined overall home range size of 18 square miles (45 km^2) (N = 7)." It should read: "Mean home range sizes were 20 square miles (51 km^2) for 5 males and 8 square miles (21 km^2) for 3 females, with a combined overall home range size of 16 square miles (41 km^2) (N = 8)."

Boyd, Diane, M.S., Fall 1982 Wildlife Biology

Food Habits and Spatial Relations of Coyotes and a Lone Wolf in the Rocky Mountains (115 pp.)

Director: R. R. Ream RRR

The movements and food habits of a radio-collared, adult female wolf in northwest Montana were investigated from April 1979 through September 1981. Similar data were collected for 9 radio-collared coyotes in the same area from November 1979 through September 1981.

The wolf occupied and scent-marked a well-defined home range of 440 square miles (1144 km^2). She used different parts of her home range during different seasons, probably based on seasonal prey availability. Apparently, no other wolves occupied the Flathead drainage during the course of the study.

The majority of captured coyotes were young males, with a disproportionate sex ratio of 1.5 males:1.0 females. Although territorial behavior was not directly observed, scent-marking and the degree of exclusiveness in home ranges indicated territoriality. Mean home range size was 26 square miles (68 km^2) for males and 20 square miles (51 km^2) for females. The highest percentage home range overlap occurred for males overlapping females, and for subadults overlapping adults, probably a function of genetic competition and dominance-related tolerance, respectively. Paired coyotes scent-marked at a rate approximately 3 times greater than lone coyotes. Scent-marking peaked in late February, coinciding with the breeding season, but lone coyotes marked relatively infrequently and at a constant rate throughout the breeding season.

Scat analyses indicated that the wolf depended on ungulates as its primary food resource, with a 53% occurrence by volume and a 77% frequency of occurrence. Ungulates were important to the wolf year-round, while coyotes apparently switched prey preferences seasonally as a function of prey availability.

The wolf avoided objects with human scent and crossing human tracks, whereas coyotes did not. Winter tracking indicated that canid scent-marks, beds, and tracks were usually interspecifically investigated. Although coyotes and the wolf utilized the same area spatially, they avoided each other temporally.

ACKNOWLEDGMENTS

This investigation would have been impossible without the help and support of many individuals and organizations. The Office of Endangered Species, U.S. Fish and Wildlife Service, provided the primary financial support to the Wolf Ecology Project (WEP) at the University of Montana, Missoula. Dr. Ream, WEP director and my major advisor, supervised the study, provided field assistants, a vehicle, and other items necessary for conducting this research. I am indebted to my committee members, Drs. Robert R. Ream, Charles J. Jonkel, and Bart W. O'Gara, for their suggestions, comments, and criticism of my thesis. Drs. L. David Mech and Stephen H. Fritts deserve special thanks for their contributions as honorary committee members and their helpful remarks.

Several organizations must be thanked for their generous support. The British Columbia Ministry of Environment, Fish and Wildlife Branch, was very helpful in providing special permits and privileges, and Ray Demarchi was especially supportive of the study. Border Grizzly Project (BGP) personnel and BGP associate, Bruce McLellan, aided the study in many ways. The Flathead National Forest generously provided WEP personnel with lodging and other logistical support. I thank the B.C. Forest Service and the Montana

Department of Fish, Wildlife and Parks for their interest and help with my study. Special permission was granted by the U. S. Customs Service and Canada Customs and Excise to cross the border during the closed season; this generous concession made winter field work possible. Glacier National Park personnel Jerry DeSanto and Cliff Martinka offered their assistance during the study.

Many individuals contributed their time, effort, and/or logistical support to the study. George Ostrom, manager of the Moose City Co-op, kindly allowed me to stay at one of the Moose City cabins during part of the study. I am very grateful for the work of all other field assistants and friends. In particular, Joe Smith captured the wolf around which the study is centered. Smith, Mike Fairchild, Sharon Gaughan, Jina Mariani, Mike Sickles, Rosalind Yanishevsky, and Phil Ogburn assisted with the field work; their help was invaluable. Bill Callaghan, Kevin Elliott, and Brian Giddings taught me scat analysis techniques, enabling me to do my own coyote scat analysis.

Several pilots from Strand Aviation, Kalispell, provided excellent flying skills to help radio-track the instrumented wolf and coyotes. Their abilities to fly in adverse weather and tight canyons, and circle over steep embankments were a great help in successfully locating the study animals.

Many heartfelt thanks go to Joe and Violet Knight, John Cromby, Dick Clouthier, and other friendly Canadians that made

working in Canada such a rewarding experience.

I reserve very special thanks for my parents who supported me through the study with words of encouragement, small loans when times were lean, and mailed canisters of chocolate-chip cookies when I was in the field.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Discussions of coyotes (Canis latrans) and wolves (C. lupus) evoke a wide range of emotional responses from people. Suggested management plans range from extirpation to total protection. In North America, European settlers tried with their ingenuity and technology to eradicate the coyote and wolf since they began to settle the original 13 colonies. Wolves once ranged from Point Barrow, Alaska, to central Mexico, and from the west to the east coasts, but their current range has been reduced to a small fraction of their previous distribution (Appendix A). Use of bounties, traps, poisons, and aerial hunting nearly succeeded in exterminating the wolf in the United States. However, the vastness of Alaska and Canada, and the inaccessibility of such places as northeastern Minnesota, created holdouts where the wolf could survive. The U.S. Endangered Species Act gave legal protection to wolves in August 1974, and hence dwindling wolf populations have slowly begun to expand; wolf packs have begun to repopulate Wisconsin and Michigan (Hendrickson et al. 1975, Thiel 1978, Mech and Nowak 1980, Thiel and Welch 1981). Canada serves as a reservoir from which dispersing wolves have been shot in Montana and Idaho--an unfortunate but accurate means of documenting their presence in an area where wolves had been eradicated (Ream and Mattson 1982).

The highly adaptable coyote has fared much better. According to Young and Jackson (1951), coyotes have expanded their distribution with the settlement of North America by Europeans (Appendix A). They claimed this range expansion was due primarily to the introduction of livestock and agriculture. Sheep, cattle, and crops became a new and easy food source for the coyote, and coyotes followed the herds into new lands. The removal of competing predator species may have been as important a factor (if not more so) than livestock and agriculture introductions. Less adaptable, competing carnivores, such as wolves, grizzly bears (*Ursus arctos*), and cougars (*Felis concolor*), were unable to survive the encroachment of civilization. Adaptability is the key survival strategy, and the coyote seems to specialize in this. Coyotes inhabit the desert, tundra, plains, mountains, remote wilderness, and even human settlements such as the suburbs of Los Angeles (Anonymous 1981). In most states, coyotes are hunted, trapped, and poisoned year-round, yet they persist. Connolly (1978) stated that "coyote populations can endure much higher annual kill rates than are likely to be obtained . . . with the funds, manpower, and methods currently available." He further maintained that coyotes regulate their populations by varying their reproductive capacity and social organization; these responses are based on food resource availability and pressure by humans trying to exterminate them.

Many studies have examined separate wolf and coyote populations, but few researchers have studied coyote-wolf interactions. General coyote and wolf distributions overlap considerably (Appendix A), although coyotes and wolves usually do not coexist peacefully (Mech 1966 and 1970, Berg and Chesness 1978, Fuller and Keith 1981). Mech (1970) stated, "What little is known about the relations between the coyote and the wolf suggests that they are not friendly." Coyotes were abundant on Isle Royale in Lake Superior until the advent of wolves. Approximately 8 years after wolf immigration to Isle Royale, no trace of coyotes could be found. "Since coyotes and wolves are closely related, and since wolves are strongly territorial, it is not unlikely that on a limited range such as Isle Royale, wolves would chase and probably kill every coyote encountered" (Mech 1966).

What might happen if the situation were reversed: a lone wolf inhabiting an area supporting a stable coyote population of moderate density? Such a circumstance existed in the forested mountains immediately northwest of Glacier National Park. The study situation in the Flathead Valley provided an opportunity to gather such information and may lend insight into coyote-wolf ecological and spatial relationships, and how this may affect the existence of a lone wolf in a coyote-inhabited area.

Goals and Objectives

Many factors must be analyzed before problems associated with natural wolf recovery can be understood, including coyote/wolf interactions. My goal was to study only a small part of this puzzle--the wolf/coyote niches. The objectives of my study were to:

1) determine the food habits of coyotes and a lone wolf; and
2) evaluate the movements and spatial relations of coyotes and a lone wolf.

CHAPTER II

STUDY AREA

Location

The North Fork of the Flathead River and its tributaries flow through an area rich in wildlife, minerals, and timber. The River originates in the McDonald Range of southern British Columbia, approximately 25 miles (40 km) north of the Montana/British Columbia border (Fig. 1). The River then flows south into Montana, forming the western boundary of Glacier National Park. The 490-square-mile (1274-km^2) study area follows the North Fork drainage.

Physiography

The topography of the study area is characterized by a relatively flat valley bottom, gentle forested slopes, and steeper, barren peaks of the Rocky Mountains. Elevation ranges from 4000 feet (1220 m) along the Flathead River, to 8600 feet (2620 m) on the Continental Divide.

Climate

Climatic data were obtained year-round from weather stations located at Polebridge, 18 miles (29 km) south of the international

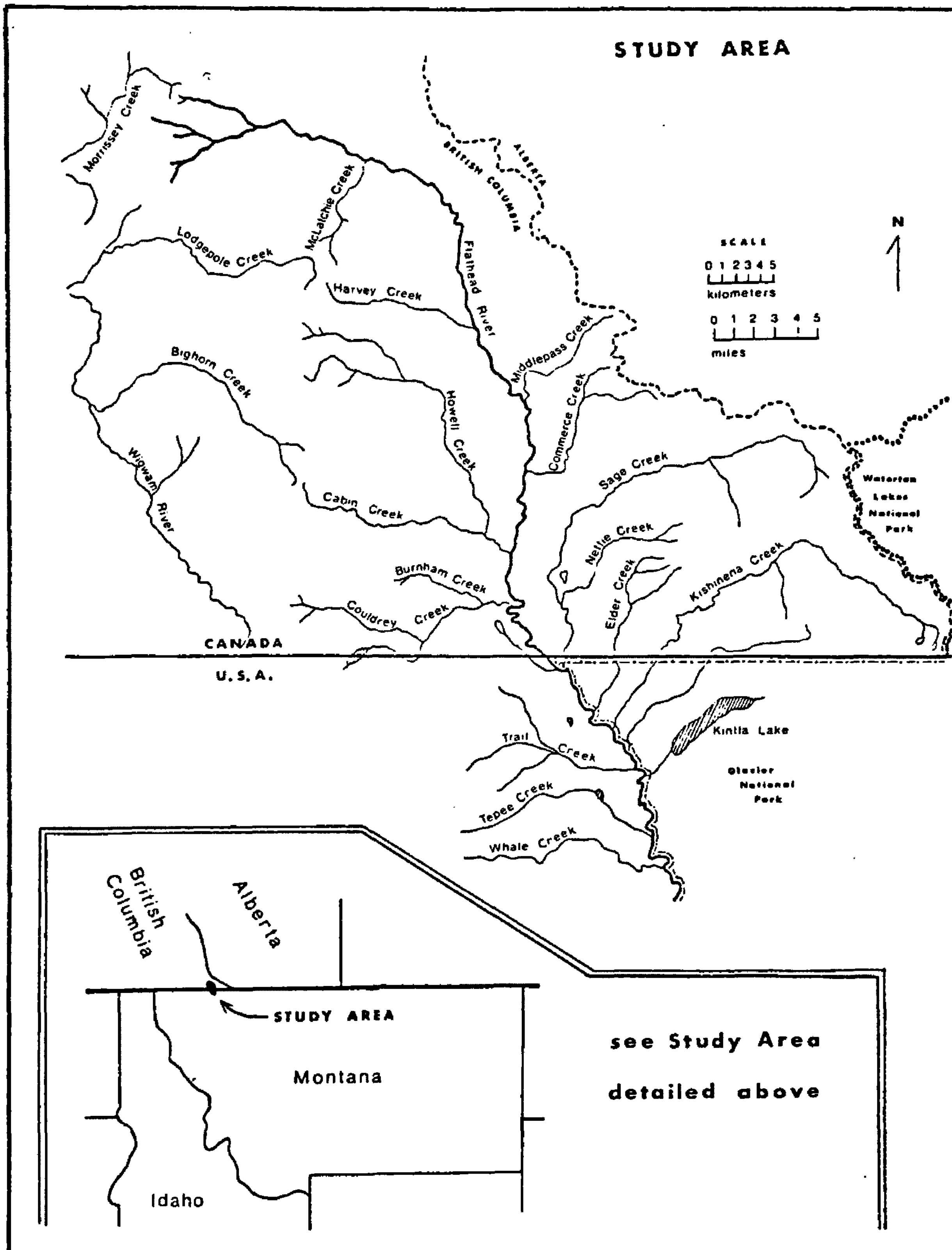


Fig. 1. Study area.

border, and Fernie, 45 miles (72 km) north of the border (Appendix B). Because the study area is located approximately half way between the weather stations, the Polebridge/Fernie data were averaged to estimate weather conditions. Snowfall may occur from September through May, but accumulates only from November through April at the lower elevations. Snowfields may persist year-round in protected areas at high elevations. Mean annual snowfall is 123 inches (321 cm). Spring and fall weather is usually cool with periods of low cloud cover and drizzle, while summers are generally warm and dry. The total annual average precipitation is 26 inches (65 cm). The summer of 1979 was unusually dry and several forest fires occurred in the study area.

Vegetation

The vegetation of the North Fork has been described by Habeck (1970), Koterba and Habeck (1971), Shea (1976), and Jonkel (1975-79). Dense coniferous forests predominate, with lodgepole pine (*Pinus contorta*) the dominant tree species. A severe infestation of mountain pine beetle (*Dendroctonus ponderosae*) has killed thousands of acres of lodgepole and continues to spread. Other conifers of the area include western larch (*Larix occidentalis*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and Douglas fir (*Pseudotsuga menziezii*). Scattered grassy openings and wet meadows occur on the floodplains of the North Fork and its larger tributaries.

These open areas support a variety of grasses and sedges. Black cottonwood (*Populus trichocarpa*), aspen (*P. tremuloides*), willow (*Salix* spp.), and alder (*Alnus* spp.) predominate along the river bottoms. Coyotes eat the berries of many plants in the area including huckleberry (*Vaccinium* spp.), strawberry (*Fragaria* spp.), and raspberry (*Rubus* spp.).

Ownership

Approximately 65% of the study area south of the international border is privately owned, with numerous habitations throughout the valley. The remaining 35% is part of the Flathead National Forest. North of the border, 98% of the land belongs to the Crown as part of the Flathead Forest. A few small parcels of government land are leased by companies such as Shell Oil Ltd. and Crowsnest Industries Ltd. for mineral exploration and base camp operations. Very few residents inhabit the area.

History of Wolves and Coyotes

Wolves were common in the North Fork area, but trapping and poisoning had greatly reduced their numbers by 1900 (Singer 1975). Wolves apparently re-invaded the North Fork drainage during the years 1948 through 1956, when 2 packs of more than 10 wolves were observed and a known 13 wolves were killed. Singer estimated that 5-10 wolves were present during most years prior to 1950. During the winters of

1950-52, the U.S. Fish and Wildlife Service set out 1080 poison stations along the eastern and North Fork boundaries of Glacier National Park. Lack of wolf killings and sign indicated that their numbers were severely reduced by 1957, and this status remains unchanged. A minimum of 14 wolves were shot and 15 more trapped between 1910 and 1974 on the United States side of the Flathead drainage. Few records of wolf captures and sightings were kept in the study area north of the international border. However, in talking with local loggers, trappers, and hunting guides, it seems evident that wolves were present in approximately the same density in the Canadian section of the Flathead as they were in the American section. Currently, wolves are protected game animals in southern British Columbia (Region 4) and are classified as an endangered species in Montana. Despite this protection, wolf numbers are minimal in the study area and surrounding region.

In the North Fork area, coyotes historically occurred in higher densities than wolves (Bailey and Bailey 1918, Lechleitner 1971). Currently, the coyote is one of the most abundant fur-bearers in the North Fork region. Coyotes are unprotected in Montana and may be killed year-round. However, in British Columbia coyotes may be trapped only from 1 November through 31 March, with no limit on numbers of coyotes taken. The coyote hunting season in British Columbia occurs 10 September through 31 March, with a seasonal limit of 10 coyotes per licensed hunter.

Land Use

Mining

In the Cabin Creek area, 2 large open-pit coal mines are planned by Sage Creek Coal Ltd., a subsidiary of Rio Algom Inc. Present plans call for the mining of 1.5 million tons of high-grade coal on Dilly and Dally Hills. Upon completion of the mining, 2 pits, each more than 1000 feet (305 m) deep and 1 mile (1.6 km) across will remain, accompanied by 2 billion tons of waste rock. Additionally, Crowsnest Industries plans to seek approval for an open-pit mine at Foisey Creek in the north end of the study area (Schwennesen 1980).

Oil and Gas Exploration

North Fork oil exploration began at the turn of the century. The first well was drilled at Kintla Lake (now in Glacier National Park) in 1901. By the 1930's, 3 more wells were drilled just north of the international border. These wells produced low quality oil and gas and were abandoned, but the old wooden derricks are still standing. Drilling efforts were inexpensive and petroleum products plentiful then, and using the North Fork's petroleum was not profitable. However, petroleum costs have soared, and today drilling companies hope to profitably exploit these resources. Shell Canada recently began drilling in the Cabin Creek area and along Middlepass Creek near the

Continental Divide. A major pipeline exists at the north end of the study area. Plans for the near future are to build a second pipeline adjacent to the first, for the transport of natural gas to the west coast.

Logging

Due to an epidemic mountain pine beetle outbreak, large scale timber harvesting has denuded a great portion of the study area. Loggers are attempting to remove the beetle-infested timber while it is still marketable and to help reduce the fire hazard created by the standing dead trees. The beetle outbreak was first noticed in 1972 on the west side of Glacier National Park. By 1975, it had spread westward to the North Fork on the Flathead National Forest's Glacier View Ranger District. By 1978, 66,570 ha were infested in the Park, and 43,927 ha in the North Fork outside the Park (Schwennesen 1980). British Columbia reported 18,623 ha infested north of the border in 1977 (Gillette, pers. comm.). More salvage logging is planned as a result.

Grazing

No grazing permits for free-ranging livestock have been issued in the study area. Occasionally, cattle stray into the Flathead headwaters region; cattle were observed there in July 1980 by WEP personnel. Within the study area south of the border, some individuals keep a few horses and goats in fenced pastures.

Recreation

Although few year-round residents live there, the abundant wildlife, rugged mountains, and wild rivers draw many visitors to the North Fork area. Activities include hiking, climbing, camping, canoeing/rafting, hunting, fishing, trapping, cross-country skiing, and snowmobiling. The North Fork is now included in the U.S. Wild and Scenic Rivers System. This change in status has increased use of the North Fork by canoeists, kayakers, and rafters. The U.S. Forest Service has already constructed several river access sites to accommodate this change. On both sides of the border, the area is heavily hunted in the fall for deer (Odocoileus spp.), elk (Cervus canadensis), and moose (Alces alces). Trapping pressure is light to moderate on coyote, lynx (Lynx canadensis), wolverine (Gulo luscus), beaver (Castor canadensis), and marten (Martes americana). Three trappers harvest fur-bearers in the American portion of the study area. Rights to trapping areas are bought in British Columbia, and the buyer has the sole right to trap in that area. Two people trap in the Canadian portion of the study area.

CHAPTER III

METHODS AND MATERIALS

Radio Equipment

Wolf-sized collars (550 gm), "H" antennas (Telonics Inc., Mesa, Arizona), and an AVM receiver (Champagne, Illinois) were used for radio-tracking. Radio-collars for coyotes were assembled at the University of Montana. Size "D" lithium cell batteries were used as the power source because of their long life (approximately 2 years). Completed collars (300 gm) were tested for frequency, pulse rate, and signal transmitting distance along a flat stretch of road.

Trapping

Nos. 4, 14, and 114 Newhouse steel traps, each with an 8-foot (2.4-m) chain and drag hook, were used to capture the wolf and coyotes, by Joe Smith and myself. Wolf urine, coyote scats, and foul-smelling lures were used as bait. All captured animals were drugged intramuscularly with a syringe on a 4-foot (1.2-m) stick. The wolf was drugged with a mixture of 0.3 cc of 50 mg/cc promazine hydrochloride (Sparine) and 0.3 cc of 100 mg/cc phencyclidine hydrochloride (Sernylan) (Seal et al. 1970). Drug dosage, sex, weight, and estimated age were recorded and Bicillin, an antibiotic, was injected.

Coyotes were drugged in a similar manner, using only one-third the dosage of that for the wolf. When I ran out of Sernylan, Ketaset (ketamine hydrochloride) was used for drugging coyotes. Ketaset dosages varied from 0.8 cc to 1.5 cc, depending on the coyote's estimated weight. Measurements and capture data similar to that for the wolf were recorded, and antibiotics were injected. Ten coyotes were fitted with radio-collars.

Radio Locations and Home Ranges

The radio-collared wolf and coyotes were located every 5 days, weather permitting, from a Cessna 182 airplane. To supplement the aerial locations, attempts were made between flights to locate collared animals from the ground by triangulation. Visual observations of study animals were infrequent because of the dense vegetation. All aerial and most ground locations were mapped (ground locations were mapped only if the located point consisted of 3 or more lines that converged in a polygon 0.25 mile (0.4 km) or less in diameter). The home range size was estimated by measuring with a planimeter the minimum area covered (Mohr 1947). Wolf and coyote home ranges were analyzed for seasonal use and inter- and intraspecific overlap.

Four periods (less than 25 hours each) of continuous radio-tracking were monitored during the summer of 1980. During these checks, coyote locations were recorded at least every 2 hours, and the movement or inactivity of the animal was also noted, based on the steadiness of signal volume. If the signal strength varied greatly during a 30-second listening period, the coyote was presumed to be active. A constant signal strength indicated inactivity.

Scent-marking

Scent-marking was most easily observed during winter. Wolf and coyote bodily eliminations were recorded, with particular emphasis placed on frequency of marking, the number of animals involved, and the presence/absence of vaginal bleeding (as an indicator of proestrus). Interspecific marking interactions of wolves and coyotes were noted.

Food Habits

Wolf and coyote tracks in the snow were followed to collect scats, observe scent-marking, and locate kills. Samples were collected from ungulates that were killed by or fed upon by wild canids. Ungulate leg bone marrow was examined to determine the animal's general condition, sex was recorded, and incisors were collected to determine age, using the cementum annuli technique (Sergeant and Pimlott 1959).

Wolf and coyote scats (feces) were collected year-round, and later analyzed for content. All scats collected were labeled as to species, location, date of collection, collector, and estimated date of deposition. Scats found on irregularly traveled roads, riverbeds, etc., were dated as "age unknown," unless obviously fresh. Ages of scats collected on roads and trails frequently traveled by Project personnel could be determined fairly accurately, allowing analysis of seasonal food habits. Scats of unknown age were analyzed separately, yielding a more general overview of food habits.

Wolf-like scats were labeled as "known" or "probable" wolf scats, to minimize confusion with cougar or black bear scats. Scats were labeled as "known" when surrounding tracks indicated that a wolf deposited the scat. In the absence of recognizable tracks, scats were classified as "probable," based on a diameter of greater than 1 inch (25 mm) (Thompson 1952, Weaver and Fritts 1979), shape, and volume (Murie 1954).

The high-density coyote population, and the very low density of other similarly sized predators, aided coyote scat identification. All scats with a diameter less than 1 inch (25 mm) with the correct shape and volume (Murie 1954), were classified as coyote scats. The extremely low numbers of bobcat, lynx, and wolverine served to minimize misidentification.

Scats were frozen as soon as possible after collection to avoid decomposition. Before beginning analysis, scats were thawed and autoclaved at 255°F for 35 minutes to kill parasites such as

Echinococcus spp. (Kennedy and Carbyn 1980). Sterilized scats were washed in a finely meshed sieve to remove amorphous fecal material and yet retain hairs, teeth, and bones, etc. The scat remains were then air-dried and stored. Later, scat remains were placed in water, to separate floating hair from heavier, sinking components such as bones and teeth. The hairs were examined under a compound microscope and identified, based on scale and color-band patterns, and other characteristics (Adorjan and Kolenosky 1969, Moore 1974). Scat analysis segregated food habits according to species, date of deposition, percent composition of food items per scat, and overall percent frequency of occurrence (Scott 1941).

Wolf and Coyote Mortality

The possibility that the radio-collared wolf had been killed was considered after her collar ceased transmitting.

Contact was maintained with local trappers and hunters to determine mortality of both tagged and untagged coyotes. Because of their wariness, coyotes were difficult to trap and rarely seen within shooting distance by hunters. Reported kills of coyotes were investigated as to age, sex, general condition, and cause of death. Natural mortality was more difficult to document. Coyote carcasses found in the wild were examined for parameters described above.

Survey for Wolves

Efforts were made to locate wolves in the study area and surrounding lands. Roads and trails were checked for wolf tracks and scats by Project personnel throughout the study. Reports of wolf sign and sightings by loggers, hunters, and local people were investigated. I spent 4 days hiking in the Wigwam drainage immediately west of my study area, and conducted interviews with 2 Canadian outfitters, Jan Skiber and Heinz Leuenberger, who have hunting rights in the Wigwam area. Their observations of wolf activity were recorded.

CHAPTER IV

RESULTS

Trapping

Wolf Capture

Throughout 1978 and the winter of 1979, local people reported observing a black wolf in the Flathead drainage of British Columbia. BGP personnel reported scats, and Bruce McLellan, a British Columbia wildlife biologist, observed wolf tracks in the Flathead area just north of the Montana/British Columbia border, and subsequently notified the WEP. On 8 April 1979, WEP trapper, Joe Smith, captured an adult female wolf (No. 114) 7 miles (11 km) north of the international border and 0.6 miles (1 km) west of the Flathead River. She was instrumented with a radio-collar and released. Smith recaptured her on 23 April 1979, 5 miles (8.8 km) north of her 8 April capture site; she was drugged and released.

Sex and Number of Coyotes Captured

Smith instrumented female coyote No. 3 and male coyote No. 5 during the spring of 1979. I trapped intermittently from 1 October 1979 to 4 September 1980, and captured 16 coyotes (9 males and 7 females). Two were recaptured once and 1 was recaptured twice, yielding a total of 20 captures (13 males and 7 females) (Appendix C). During April 1980, Smith captured 6 male and 5 female coyotes, recapturing 2 of them, for a total of 13 captures (7 males and 6 females). Smith did not collect weight or measurement data. The total captures was 21 males and 14 females, yielding a sex ratio of 1.5 males:1.0 females (N = 35). I instrumented 9 coyotes.

Non-target Species Captured

Several non-target species were inadvertently captured and released by Smith and me, including pine marten (*Martes americana*), fisher (*Martes pennanti*), wolverine (*Gulo luscus*), lynx (*Lynx canadensis*), and black bear (*Ursus americanus*).

Age

Smith estimated the wolf to be middle-aged, based on tooth condition. I classified coyotes as pups, subadults, or adults, based on tooth eruption and wear, and the season of capture. Data were collected from 9 male adults/subadults, 3 male pups, 7 female adults/subadults, and 1 female pup (Appendix C).

Weights and Measurements

Wolf No. 114 weighed 80 pounds, showed no signs of pregnancy, and appeared to be in good condition (Appendix C).

All captured coyotes appeared to be in good condition, with the exception of Nos. 9 and 150. Female No. 9 was very thin and had a sparse coat. Male No. 150 had lost the lower half of his hind leg prior to my capture. The leg was swollen and hot, with the bone ends extending through the scabbed stump end. Although he had a large frame, he was very thin.

Sixty-three percent of the coyotes examined had chipped, broken, or missing teeth (Appendix C). Female No. 532 was the only coyote that suffered excessive wear and tooth degeneration, and was estimated to be greater than 5 years old.

None of the female coyotes captured were lactating. No. 532 was the only female examined that was suspected of having pups the year she was captured. Her nipples were enlarged, whereas all other female coyotes had inconspicuous nipples (Appendix C). No. 3 exhibited vaginal bleeding when she was captured on 8 February.

Adult coyote testicles were smallest in May and June, and largest in October, November, and February (Appendix C). Testicles were not descended in 1 adult and 2 pups, and only partially developed in a third pup.

Generally, trapping occurred during snow-free periods when it was impossible to tell whether or not a coyote had been alone when trapped. The only observed incident of a companion staying with a trapped coyote occurred with the capture of male No. 550. Tracks in the snow indicated that another coyote had remained with No. 550 and bedded within 30 feet (9 m) of him while he was in the trap.

Radio Locations and Home Ranges

Wolf

No. 114 was located 115 times (Table 1) (Fig. 2). No. 114's home range size was 440 square miles (1144 km^2). However, because of the unusual crescent shape of her home range, home range calculations may have overestimated the wolf's true home range size. Deleting the non-used portion of her home range yields a home range size of 330 square miles (858 km^2). I observed her twice from an airplane on 26 April and 12 May 1980; both times she was traveling alone. On 12 May, No. 114 was traveling through thick timber and approached 2 deer on the edge of a clearcut. When she was within 75 yards (68 m) of the deer, they bounded off. The wolf did not change pace or direction, and may not have been aware of the deer. Aerial wolf locations were investigated on the ground and habitat typed (Ream, in prep.). No animal remains at these locations could be positively identified as having been killed or fed upon by the wolf. Despite extensive aerial searches within No. 114's home range and surrounding area, she could not be located on the following dates:

6 June 1979	25 July 1979
28 June 1979	10 May 1980
5 July 1979	25 May 1980

The wolf exhibited seasonal use of different parts of her

Table 1. Coyote and wolf radio location data, Flathead study area, 1979-1981.

Animal number[a]	Sex	Number of captures	Number of aerial locations	Number of ground locations	Total number of locations	Period of transmission	Home range (square miles)	Home range (km^2)
C 148	♀	1	14	0	15	11/11/79-1/21/80	4	10
C 150	♂	1	17	1	19	11/17/79-2/15/80	10	26
C 143	♀	1	14	1	16	11/18/79-1/18/80	[b]	[b]
C 3	♀	1	0	0	0	2/8/80-2/8/80	[c]	[c]
C 5	♂	1	28	14	43	2/15/80-5/9/81	23	60
C 7	♂	3	16	16	35	6/3/80-8/9/81	12[d]	31[d]
C 9	♀	1	4	11	16	7/11/80-9/24/80	12	31
C 11	♂	1	4	12	17	7/12/80-12/14/80	17	44
C 15	♀	1	5	10	16	7/17/80-2/25/81	9	23
C 17	♂	2	0	3	5	9/1/80-6/27/81	39	101
W 114	♀	2	101	12	115	4/8/79-7/22/81	440 330[e]	1144 858[e]

[a]C = coyote; W = wolf.

[b]Coyote dropped collar shortly after being instrumented.

[c]Collar did not transmit after coyote was released.

[d]Dispersal not included in determination of home range size.

[e]Excluding non-utilized portion of wolf's home range.

Note: initiation of transmission is synonymous with capture date.

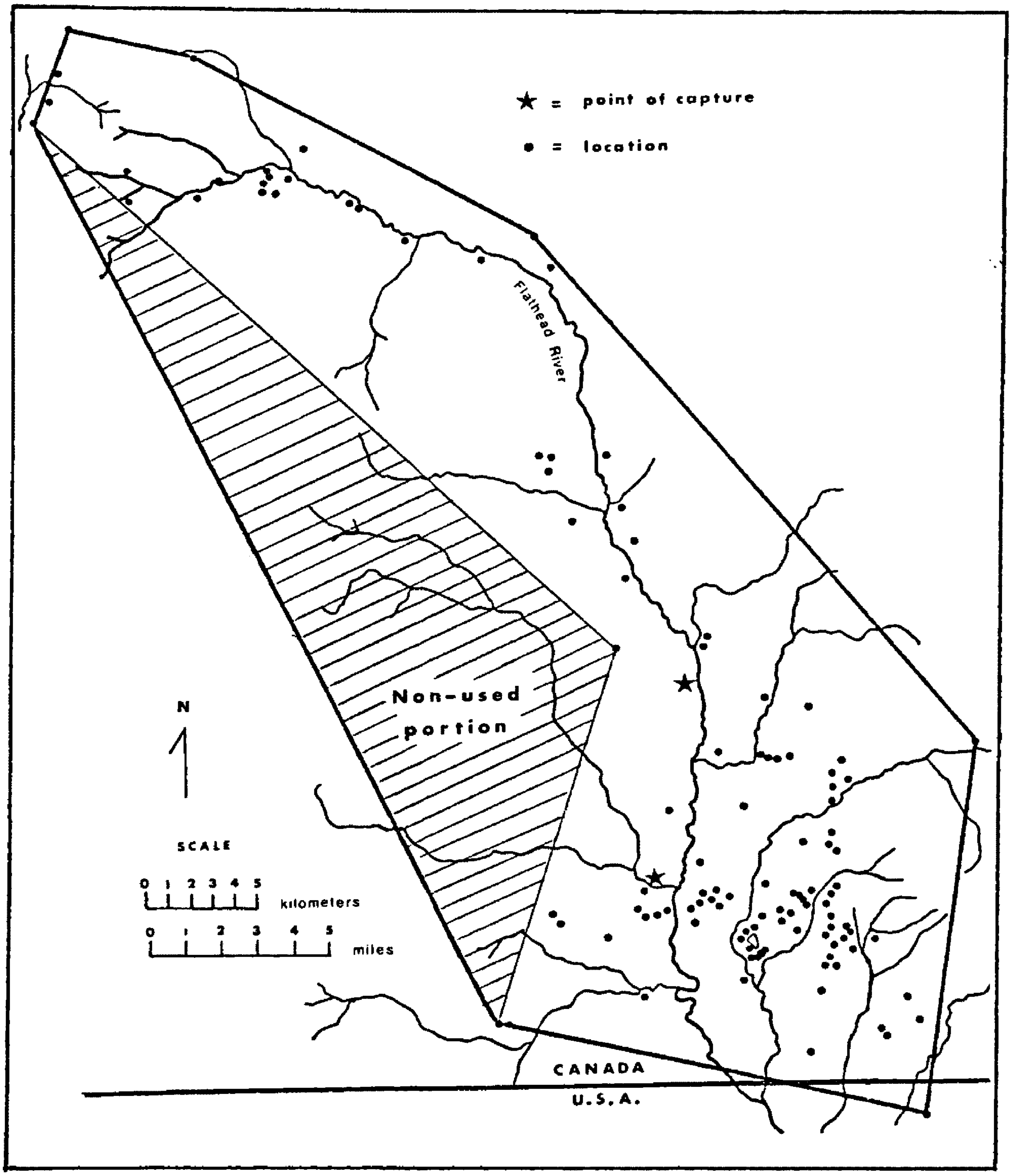


Fig. 2. Home range of female wolf No. 114 determined from 115 radio locations, 8 April 1979-22 July 1980.

home range (Ream, in prep.). She was located in the southern one-third of her home range during every month of the year, but most often during late winter. She was located in the northern quarter of her home range only during snow-free months and was located in the corridor between the southern and northern sections during spring and fall. The home ranges of radio-collared coyotes Nos. 5, 7, 9, 11, 15, and 17 were contained within her home range, while those of coyotes Nos. 143, 148, and 150 were not (Fig. 13). Although No. 114's home range overlapped the home ranges of at least 5 coyotes and 77% of a sixth coyote's home range (Table 2), I never located the wolf closer than 1.7 miles (2.7 km) to any instrumented coyote (Table 3).

Coyote

Eight out of 9 coyotes were captured along the periphery of their home ranges, with the exception being No. 150 (Figs. 3-12). All mortalities (N = 4) suffered by instrumented coyotes occurred along the periphery of, or dispersal route from, each coyote's home range.

Coyotes Nos. 143, 148, and 150 were monitored during the fall and early winter of 1979-80, and all other coyotes were monitored after that time. As a result, comparisons of same-day radio locations were analyzed separately for the 2 samples, which were referred to as the "Montana coyotes" (Nos. 143, 148, and 150) and the "B.C. coyotes" (Nos. 5, 7, 9, 11, 15, and 17). For all coyotes (omitting dropped-collar coyotes), the mean home range size of males was 20 square

Table 2. Percent home range overlap of 9 radio-collared coyotes and a radio-collared wolf.

			Animal number[a]									
Age[b]	Sex	Animal number[a]	C143	C148	C150	C5	C7	C9	C11	C15	C17	W114
S	♀	C 143	X	11	8	0	0	0	0	0	0	0
S	♀	C 148	100	X	17	0	0	0	0	0	0	1
A	♂	C 150	100	37	X	0	0	0	0	0	0	0
A	♂	C 5	0	0	0	X	0	0	0	20	0	6
A	♂	C 7	0	0	0	0	X	0	0	0	3	3
A	♀	C 9	0	0	0	0	0	X	46	20	0	6
A	♂	C 11	0	0	0	0	0	68	X	30	0	4
A	♀	C 15	0	0	0	8	0	14	15	X	0	2
S	♂	C 17	0	0	0	0	10	0	0	0	X	7
A	♀	W 114	0	1	0	100	100	100	100	100	77	X

[a]C = coyote; W = wolf.

[b]S = subadult; A = adult.

Table 3. Minimum distances (≤2.0 miles) between same-day locations of wolf and coyotes.

Date	Animals involved[a]	Distance between animals (miles)	(km)
5-17-80	C5 and W114	1.7	2.7
6-17-80	C7 and W114	2.0	3.2
7-15-80	C9 and C11	1.9	3.0
7-26-80	C9 and C11	0.7	1.1
7-31-80	C9 and C11	1.4	2.2
7-31-80	C11 and C15	0.9	1.4
8-20-80	C9 and C11	1.1	1.8
8-23-80	C11 and C15	1.9	3.0
8-25-80	C9 and C15	1.6	2.6
9- 3-80	C9 and C15	1.3	2.1
9-16-80	C9 and C15	1.5	2.4

[a]C = coyote; W = wolf.

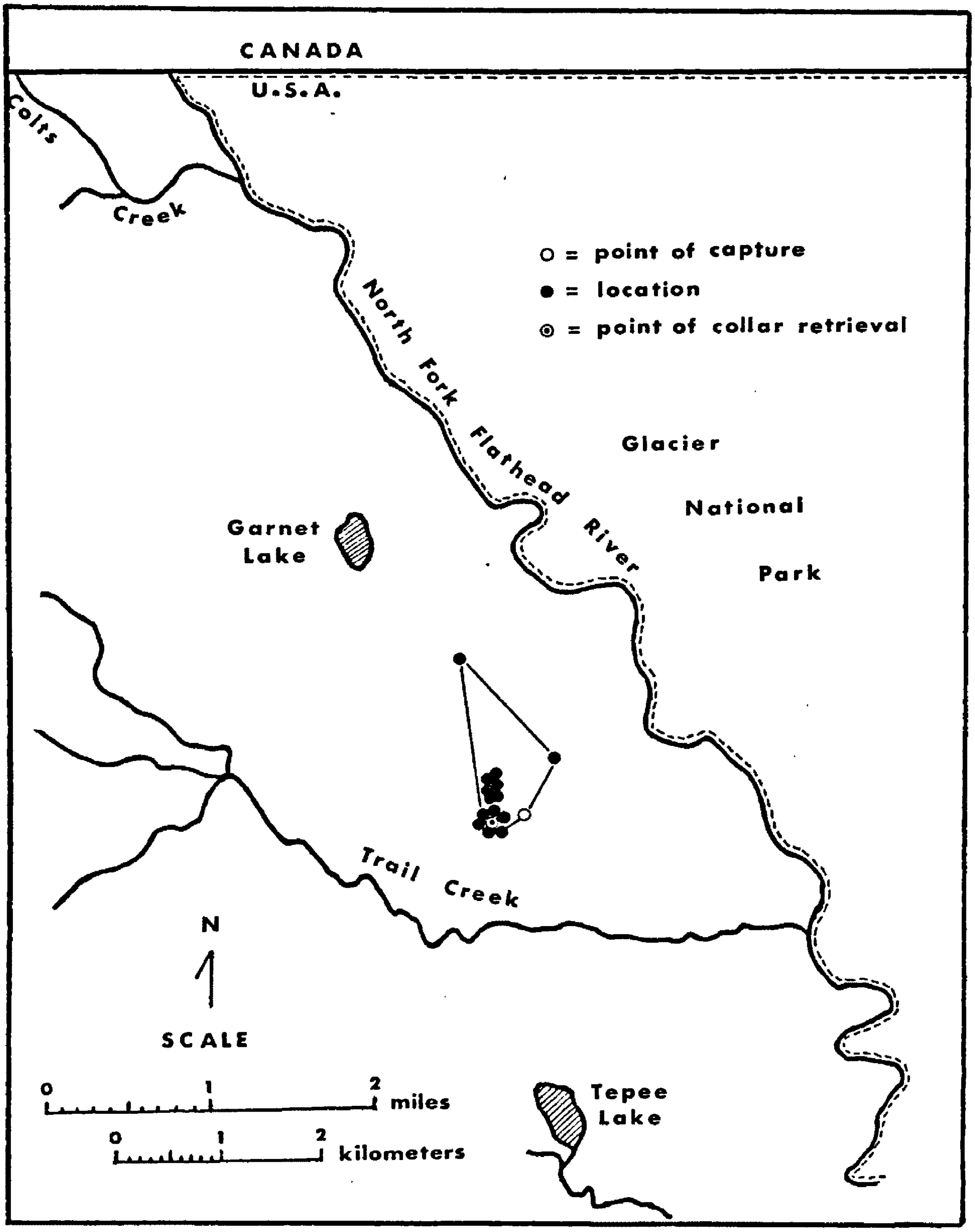


Fig. 3. Home range of female coyote No. 143 determined from 16 radio locations, 18 November 1979-18 January 1980.

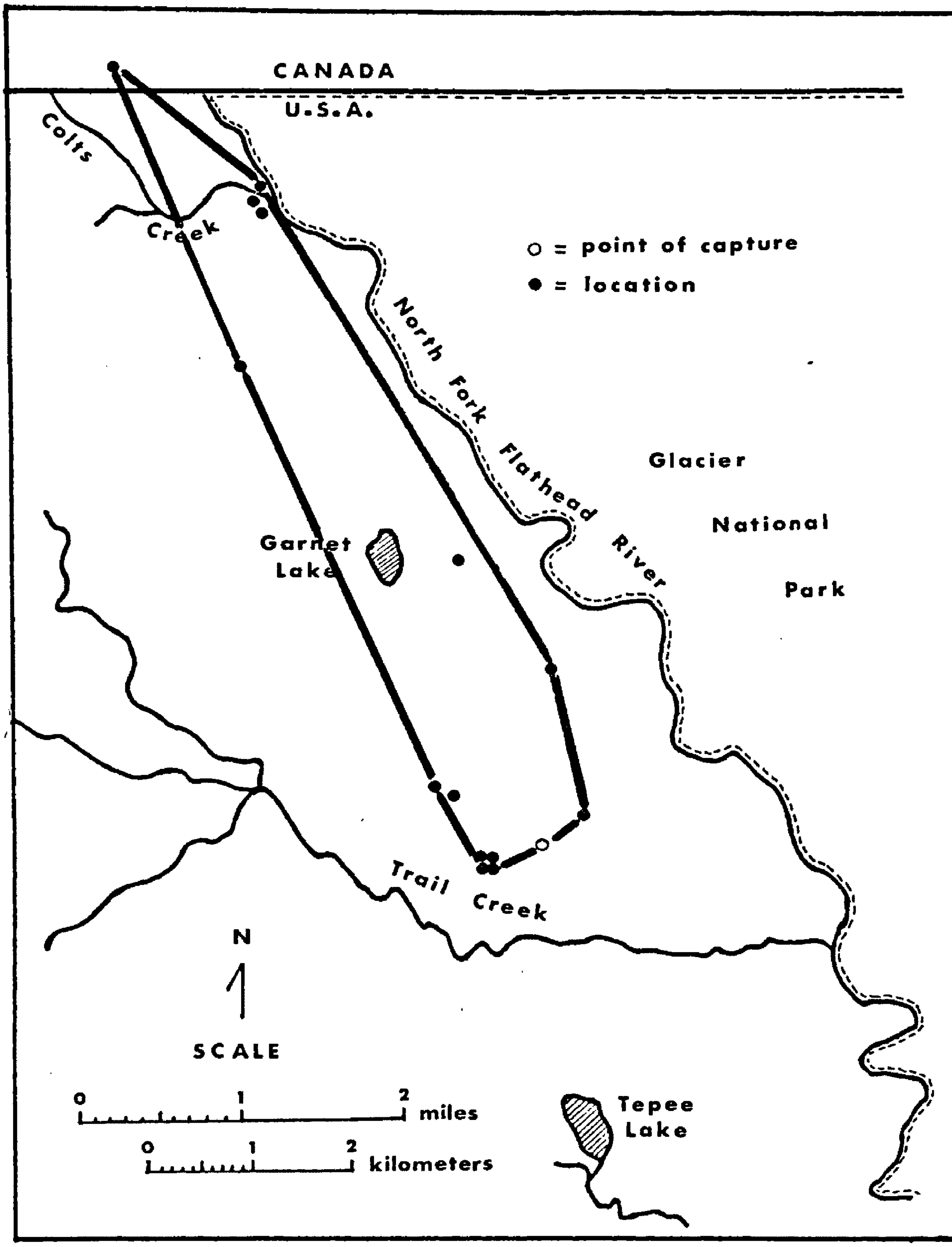


Fig. 4. Home range of female coyote No. 148 determined from 15 radio locations, 11 November 1979-21 January 1980.

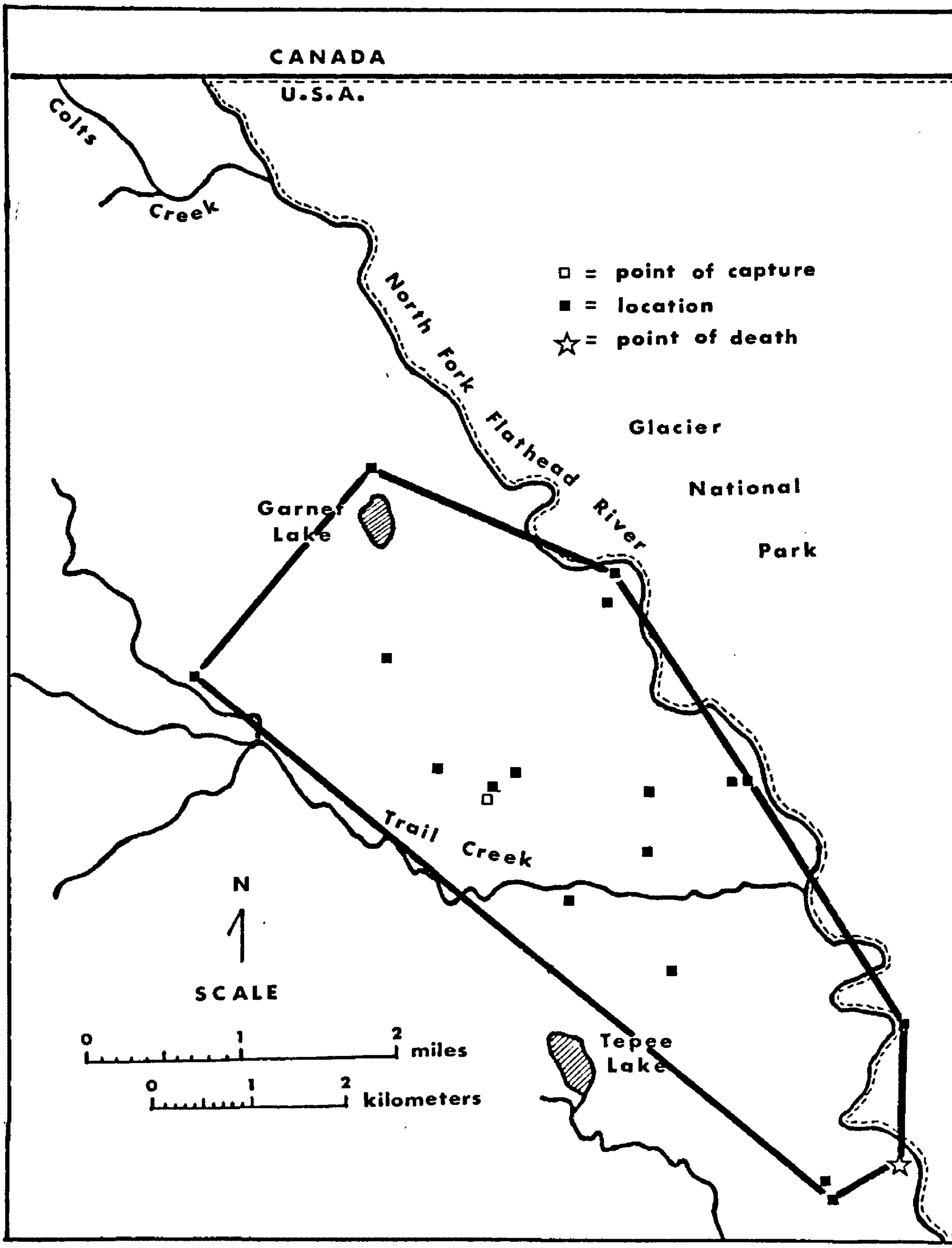


Fig. 5. Home range of male coyote No. 150 determined from 19 radio locations, 17 November 1979-15 February 1980.

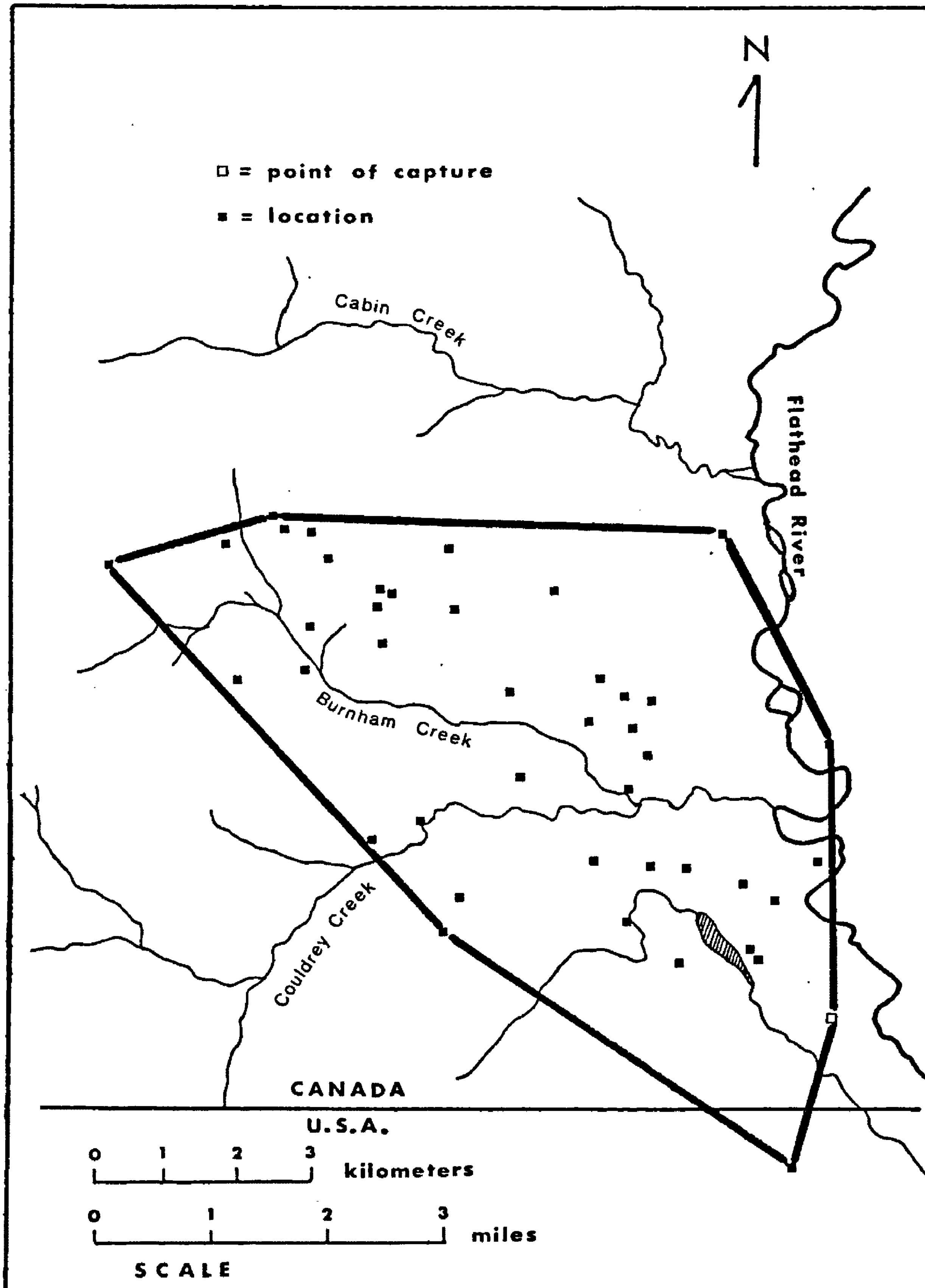


Fig. 6. Home range of male coyote No. 5 determined from 43 radio locations, 15 February 1980-9 May 1981.

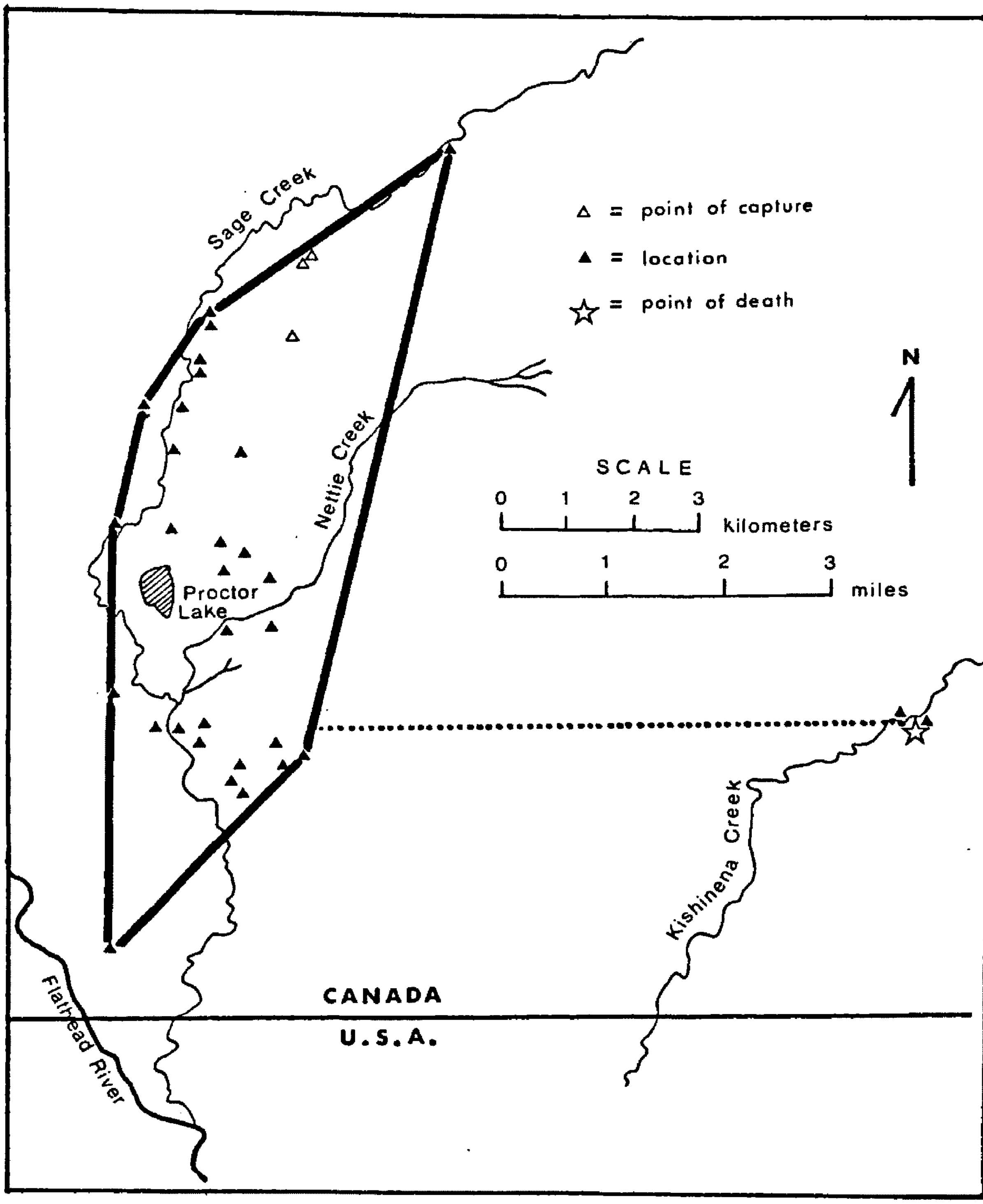


Fig. 7. Home range of male coyote No. 7 determined from 35 radio locations, 3 June 1980-9 August 1981.

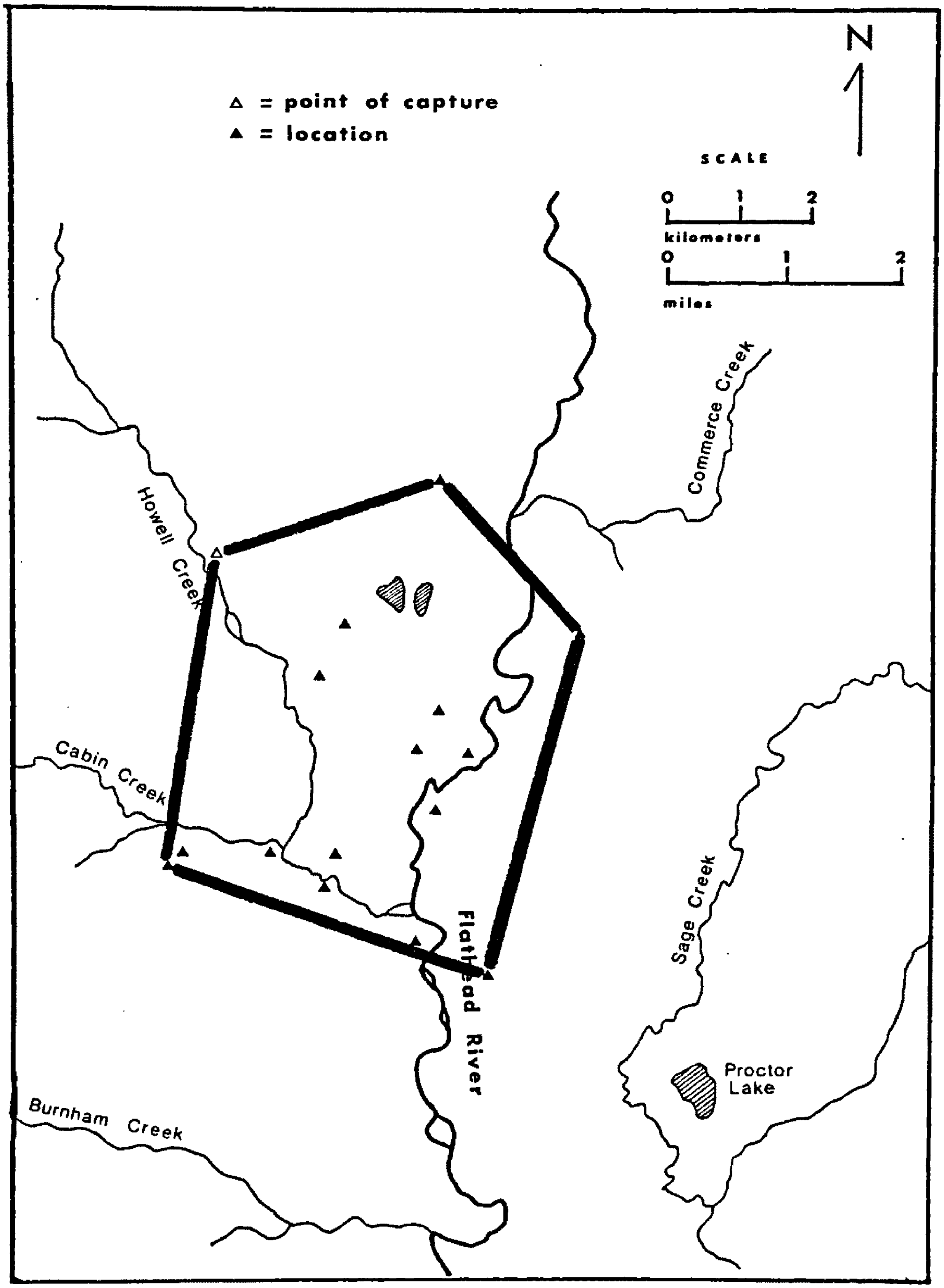


Fig. 8. Home range of female coyote No. 9 determined from 16 radio locations, 11 July 1980-24 September 1980.

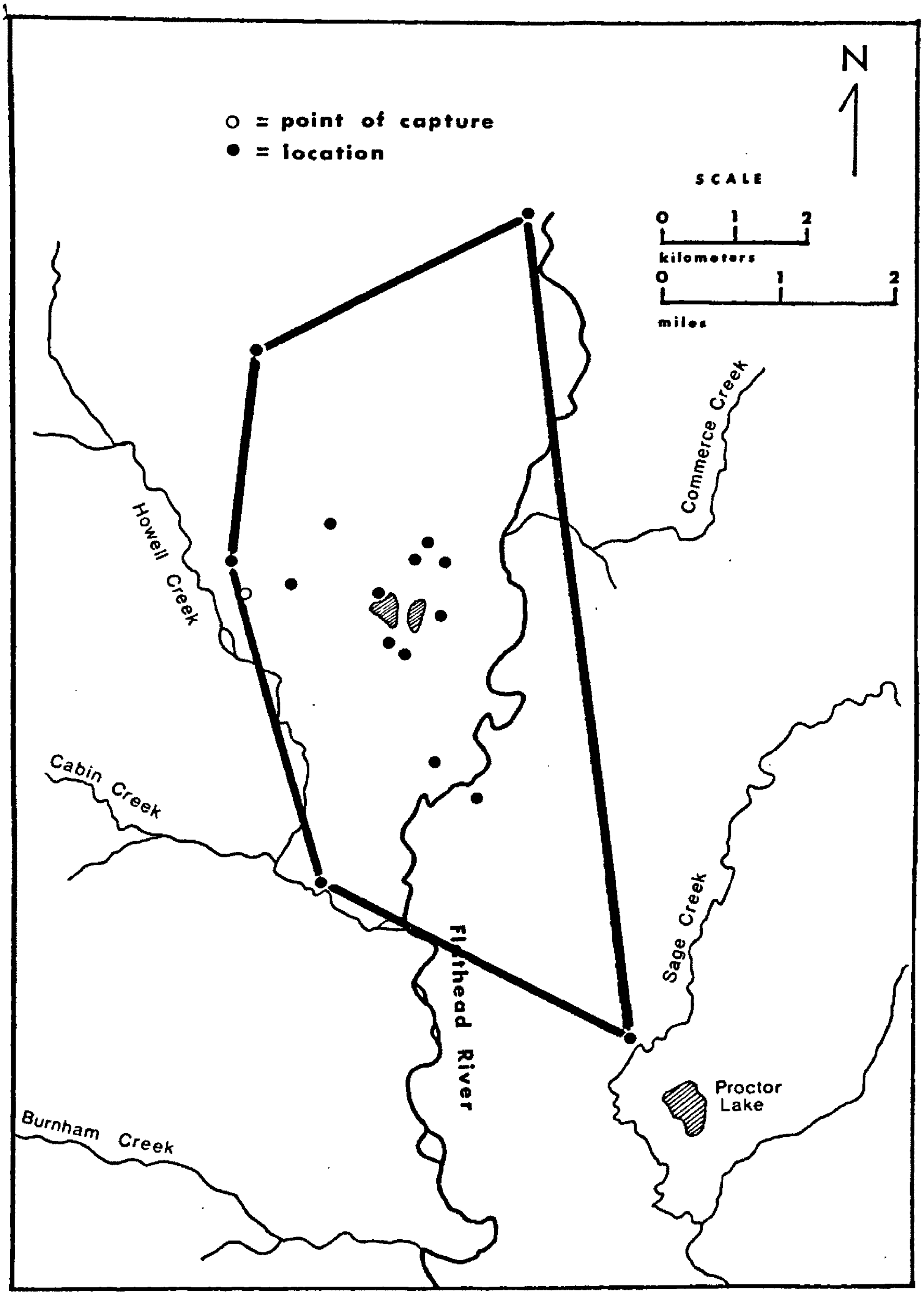


Fig. 9. Home range of male coyote No. 11 determined from 17 radio locations, 12 July 1980-14 December 1980.

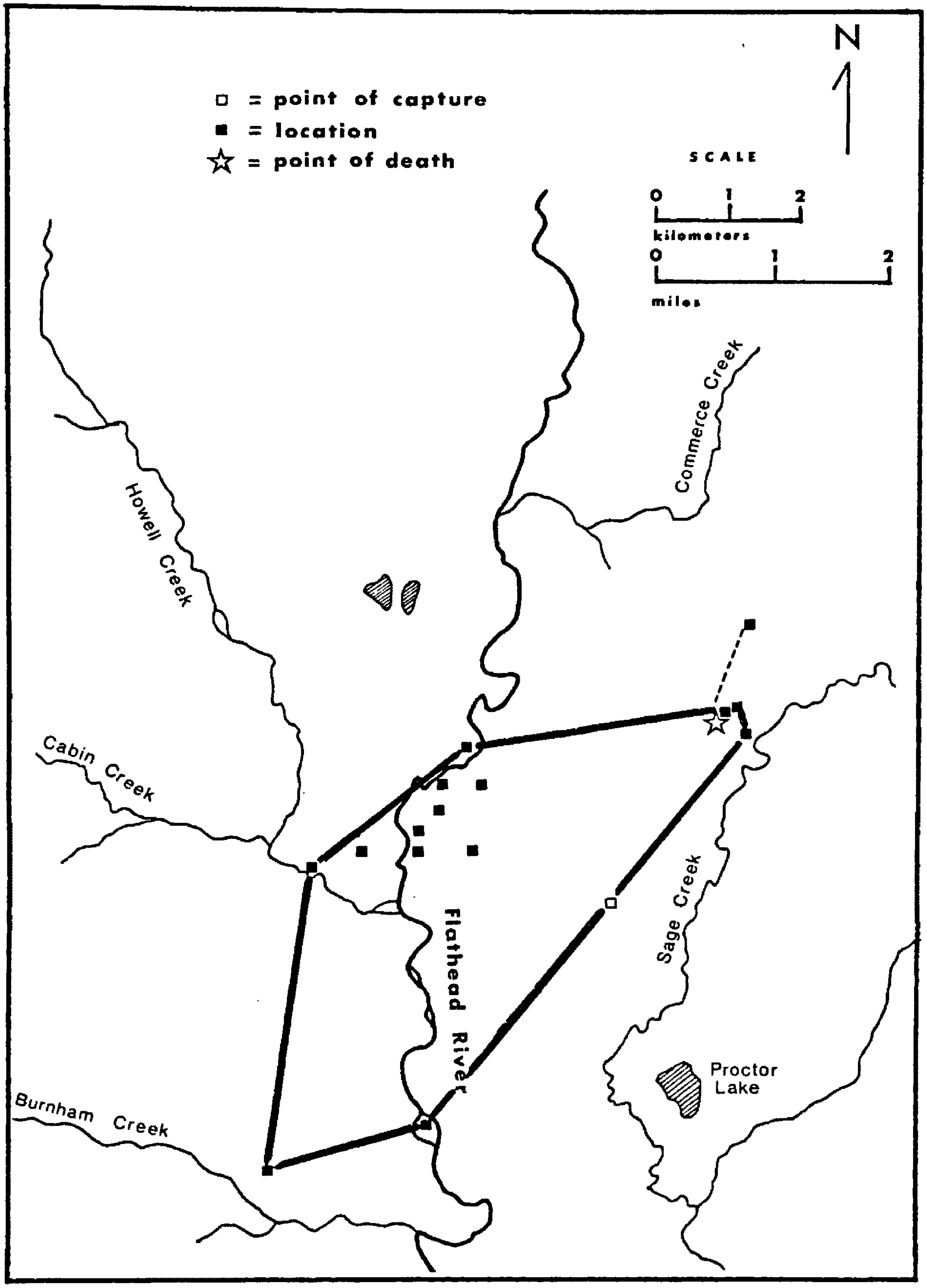


Fig. 10. Home range of female coyote No. 15 determined from 16 radio locations, 17 July 1980-25 February 1981.

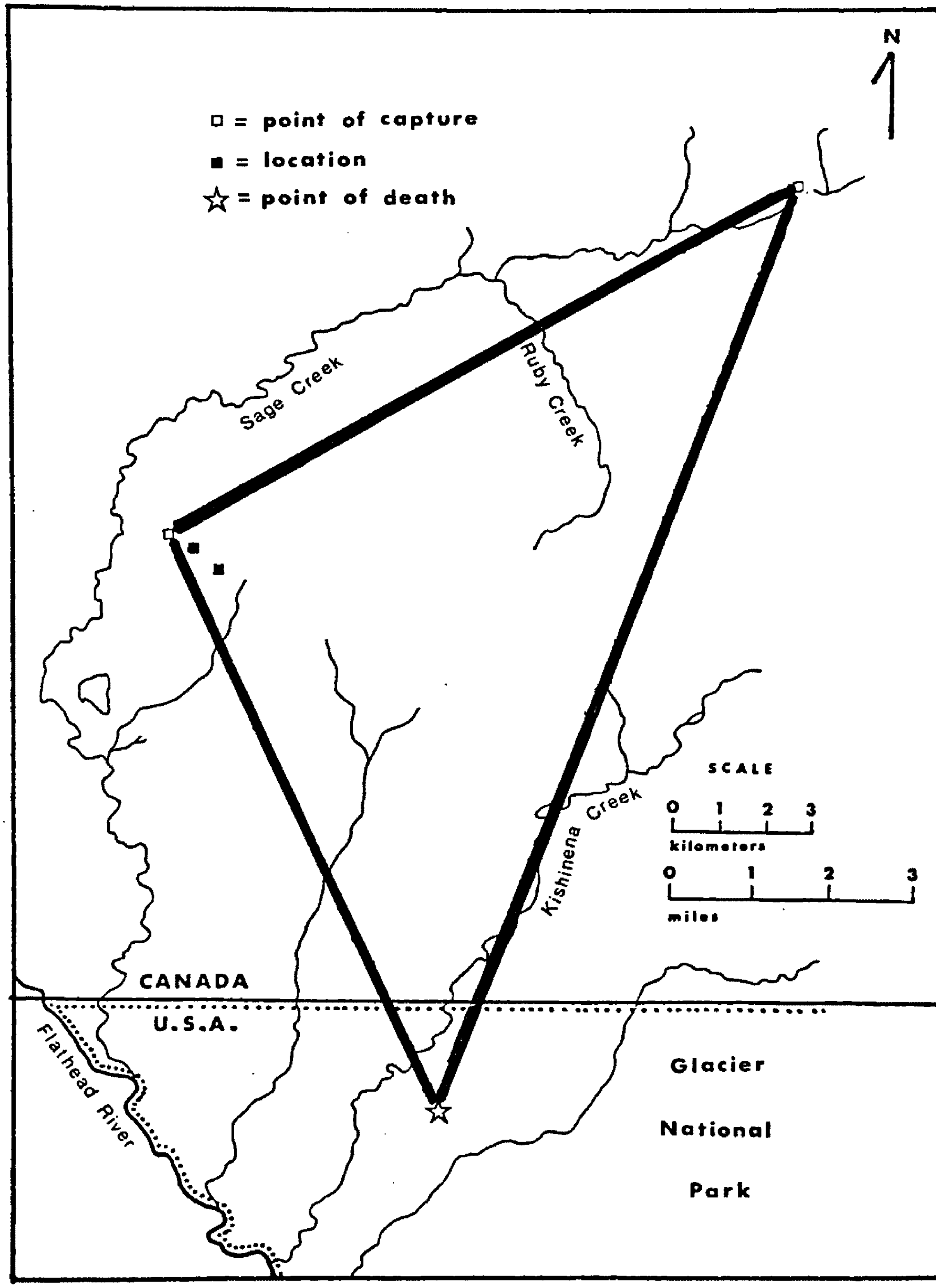


Fig. 11. Home range of male coyote No. 17 determined from 4 radio locations and a previous capture, 1 September 1980-27 June 1981.

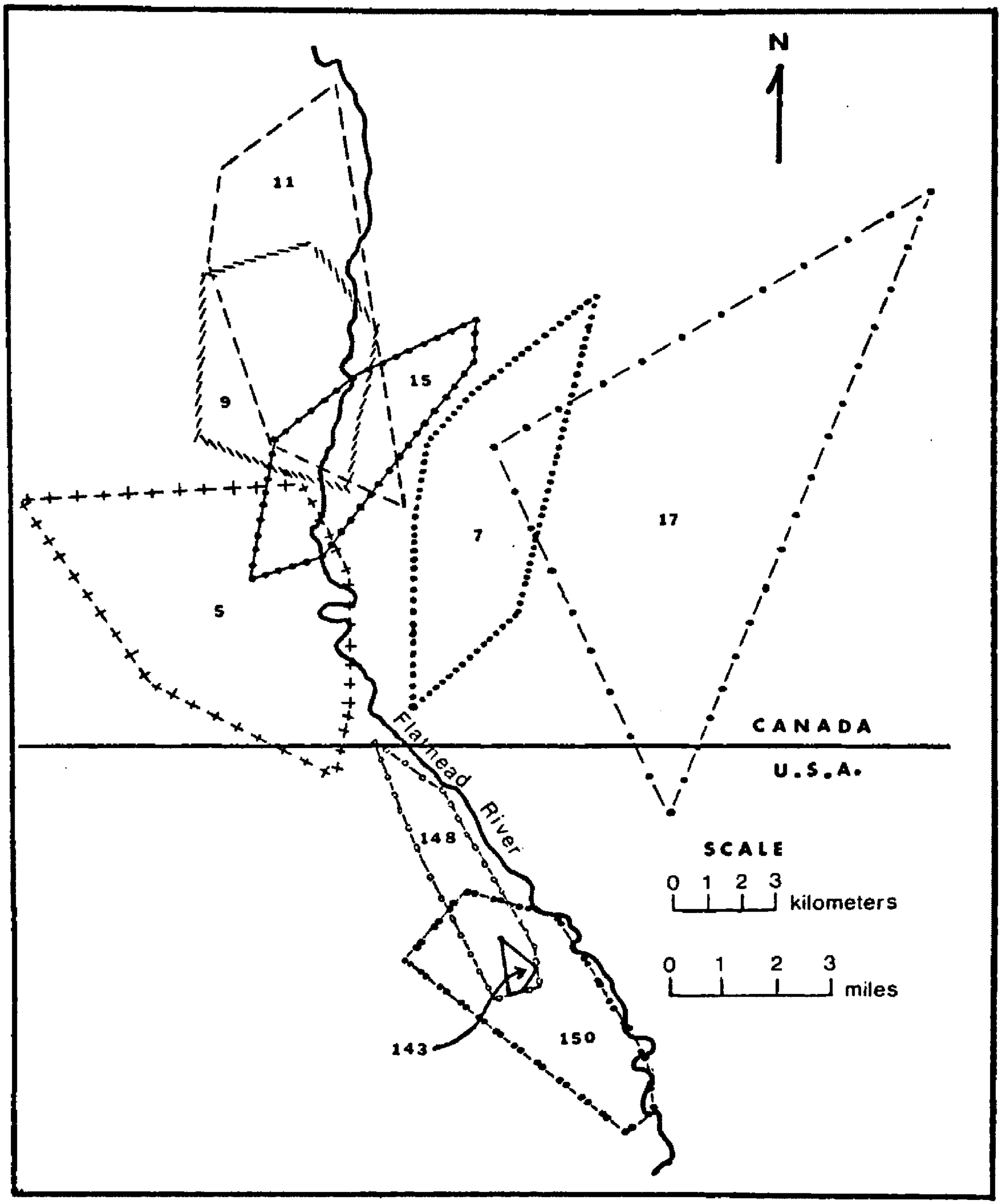


Fig. 12. Home ranges of all radio-collared coyotes.

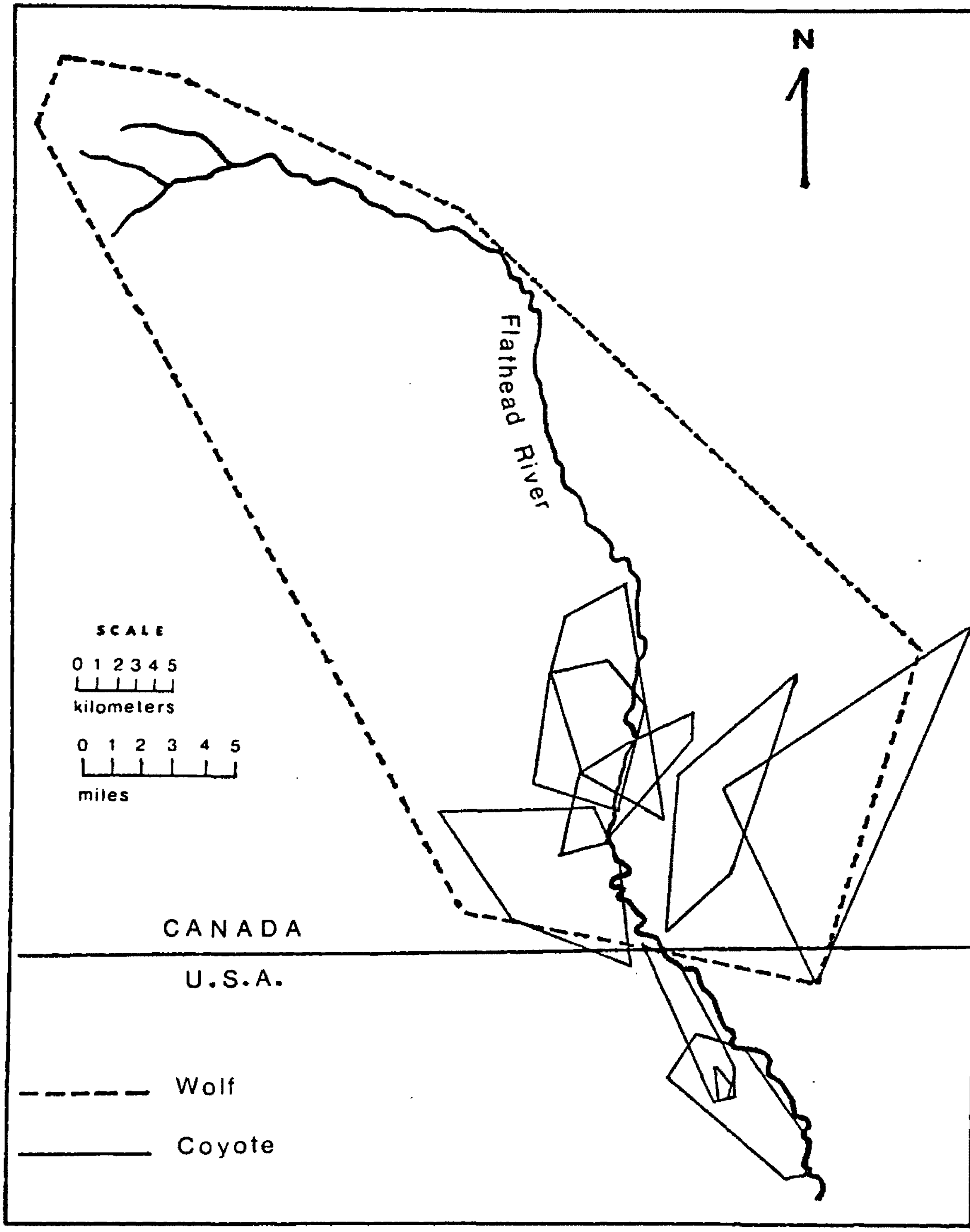


Fig. 13. Home ranges of all radio-collared coyotes and the radio-collared wolf.

miles (52 km^2) and for females, 8 square miles (21 km^2). The Montana coyotes were all captured within 0.3 mile (0.5 km) of each other and, although their home ranges overlapped extensively (Fig. 12), they were never located within 0.2 mile (0.3 km) of each other (Table 4). None of the Montana coyotes' collars transmitted long enough to permit analysis of seasonality of home range utilization. Female No. 143 dropped her collar approximately 3 weeks after being instrumented, leaving insufficient data to determine home range size. Comparisons of No. 143's closest locations to those of No. 148 and No. 150 were limited to the first 3 weeks of No. 143's collar transmission. Comparison of same-day location distances was limited to coyotes with adjacent or overlapping home ranges, and not among all coyotes' home ranges (Table 3). The home ranges of B.C. coyotes overlapped to varying degrees (Tables 2-5), but never were any 2 found closer together than 0.7 mile (1.1 km). Coyotes No. 5 and No. 7 displayed seasonal use of their home ranges. Male No. 5 used the northwestern one-third of his home range only during snow-free months. The remainder of his home range was used during all 4 seasons, with a slight concentration of winter locations in an area bounded by Couldrey Creek, the Flathead River, and Three Mile Lake. With 1 exception in March 1981, all of No. 7's winter locations (January through March) were located in the southern quarter of his home range. Sometime between 27 March and 17 April 1981, No. 7

Table 4. Distances between all same-day locations for coyotes Nos. 143, 148, and 150.

Date	Distance in miles (km)		
	Coyotes Nos. 148 & 150	Coyotes Nos. 148 & 143	Coyotes Nos. 150 & 143
11-20-79	0.8 (1.3)	0.3 (0.5)	0.9 (1.4)
11-24-79	0.5 (0.8)	0.2 (0.3)	0.7 (1.1)
11-28-79	1.4 (0.6)	0.9 (1.4)	0.5 (0.8)
12- 6-79	0.6 (1.0)	0.2 (0.3)	0.5 (0.8)
12- 9-79	0.4 (2.2)		
12-12-80	0.9 (1.4)		
12-15-80	0.6 (1.0)		
12-23-79	2.2 (3.5)		
12-30-79	1.9 (3.0)		
1- 3-80	0.4 (2.2)		
1-11-80	2.5 (4.0)		
1-17-80	1.4 (2.2)		
1-18-80	0.7 (1.1)		
MEAN	1.1 (1.8)	0.7 (1.1)	0.6 (1.0)

Note: No. 143 dropped her radio-collar 3 weeks after being instrumented.

Table 5. Means of percent coyote home range overlap, by sex and age.

Combination	Percent
Male overlapping female	39
Male overlapping male	7
Female overlapping male	22
Female overlapping female	17
Subadult overlapping adult	39
Subadult overlapping subadult	0
Adult overlapping adult	20
Adult overlapping subadult	28

left his home range and was killed a straight-line distance of 5.5 miles (8.8 km) west of his home range boundary (Fig. 7). No. 7 was the only radio-collared coyote who dispersed while being monitored.

During aerial locations, instrumented coyotes were observed on 7 occasions (Table 6).

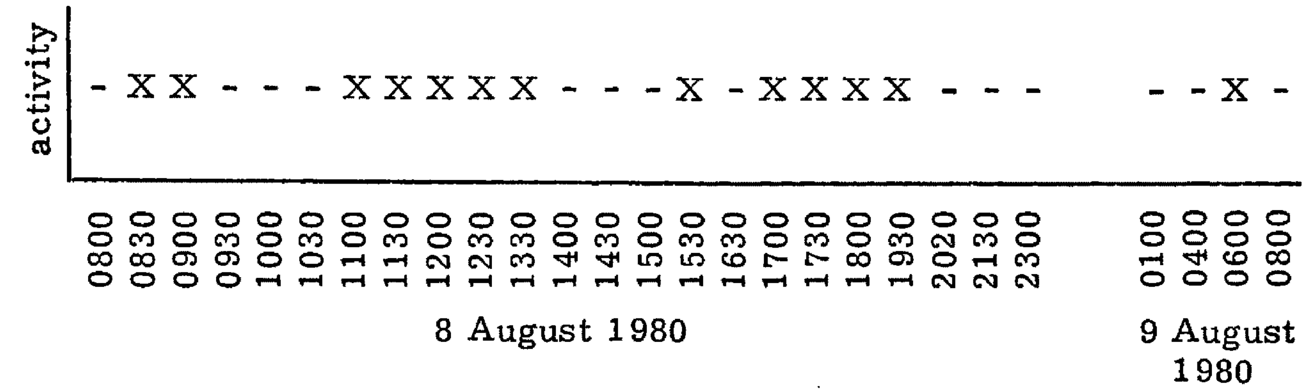
Table 6. Visual observations of instrumented coyotes.

Date	Coyote No.	Circumstances
12-23-79	150	traveling through a clearcut with a larger coyote
6-21-80	7	laying down; went into trees as we circled
6-24-80	7	walking with another coyote along a gravel bar; went into willows
7-20-80	7	walking on road; stopped and watched the plane; trotted into trees
7-31-80	15	walking alone
1-15-81	7	crossed road 100 yards (92 m) in front of me while I was radio-tracking
1-16-81	7	crossed road 80 yards (73 m) in front of me while I was radio-tracking

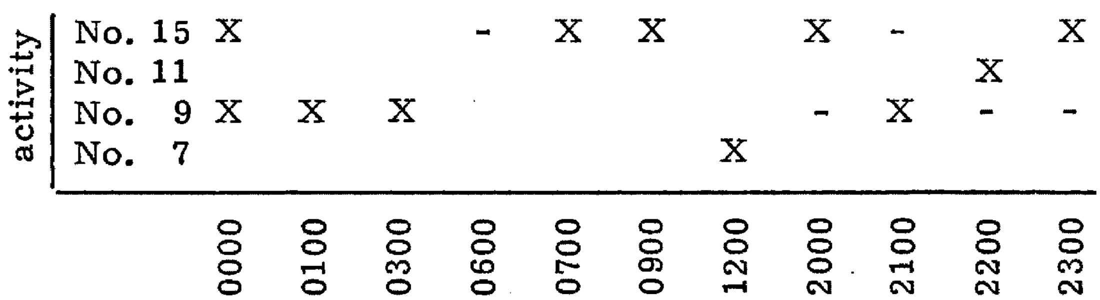
Instrumented coyotes were monitored continuously during 4 separate time intervals (Figs. 14 and 15).

Jina Mariani and I sat at a stationary point from 0800

14a. Activity of coyote No. 5.



14b. Activity of coyotes Nos. 7, 9, 11, and 15 on 10 August 1980.



14c. Activity of coyote No. 9.

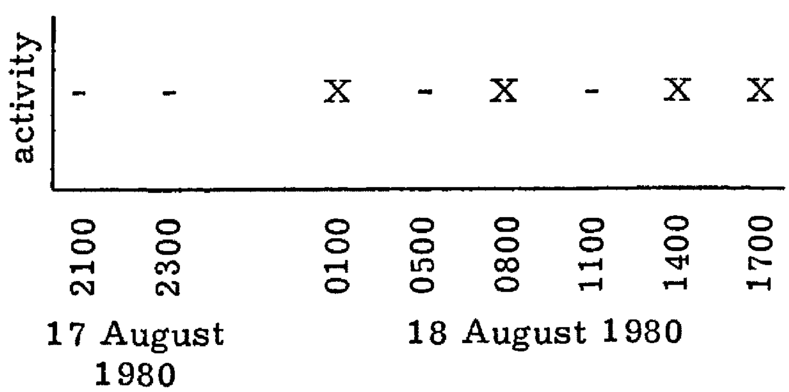


Fig. 14. Continual activity monitoring data (X = moving, - = not moving).

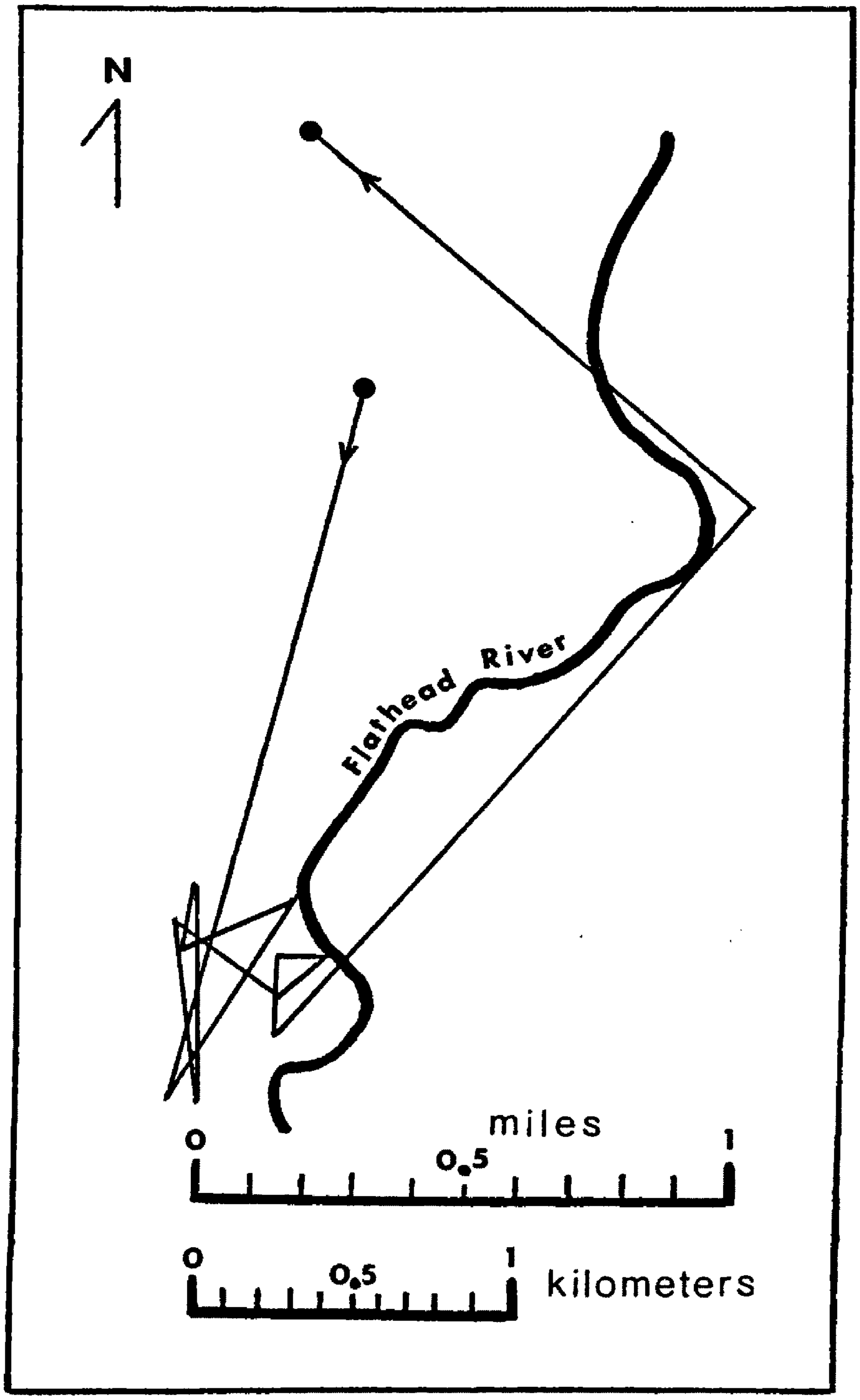


Fig. 15. Locations of female coyote No. 9 recorded every 2 hours from 1200 31 July-1200 1 August 1980.

8 August to 0800 9 August 1980 and listened at 30-minute intervals to the radio signal activity of male No. 5 (Fig. 14a). He was most active around noon and early evening. Shortly before noon while we were listening to No. 5's steady signal, a helicopter flew over, and the signal strength began varying. A thunderstorm began at 1730 and lasted several hours. The storm did not seem to affect No. 5's movement pattern as did the helicopter; he was intermittently active throughout the storm.

Mariani and Mike Sickles radio-tracked female No. 9 from 1200 31 July to 1200 1 August 1980 (Fig. 15). Efforts were concentrated on obtaining locations by triangulation rather than determining activity/inactivity. The coyote was located every 2 hours and its locations were mapped. No. 9 moved radically at the beginning and end of the listening period (including crossing the Flathead River), but remained in a 0.1 square mile (0.3 km^2) area for 18 hours during the middle part of the tracking period.

I monitored the activity of several coyotes hourly from a stationary point from 0000 to 2300 10 August 1980 (Fig. 14b). Periods of activity were sporadic with no apparent pattern.

From 2100 17 August to 1700 18 August 1980, I monitored activity signals consistently from coyote No. 9 approximately every 2.5 hours, and intermittently from other coyotes (Fig. 14c). No. 9 was active sporadically throughout the period with no apparent pattern.

Scent-marking

Wolves and coyotes inter- and intraspecifically investigated each other's urine and feces.

Wolf

Blood in the urine, indicating proestrus (Seal et al. 1979), was first observed in the Flathead female wolf on 7 February and last noted on 25 February. Rothman and Mech (1979) found periods of proestral bleeding in wild Minnesota wolves to occur from 4 January to 21 February.

I followed wolf tracks via snowshoes and skiis for 6.7 miles (10 km) during the 1980-81 winter. I discovered wolf tracks only 4 times because the wolf's radio-collar transmission had ceased.

29 January 1981: I observed wolf tracks made the previous night on the Sage Creek airstrip, but because of poor tracking conditions, could follow them only 0.7 mile (1.1 km). One squat urination was directed on a small lump of snow.

15 February 1981: I tracked a wolf from the Sage Creek airstrip for 2.2 miles (3.5 km); it did not scent-mark but did kill a moose calf (see Wolf Food Habits).

21 February 1981: I revisited the moose calf kill and followed these tracks for 1 mile (1.6 km), but the wolf did not scent-mark.

22 February 1981: I tracked 3 miles (94.8 km) further along yesterday's wolf track and observed 2 bloody squat urinations and a scat. The first urination was on a nondistinctive flat area of snow, accompanied by the wolf's 2.5-foot (0.8-m) scratch in front of the urine spot. The second urination and the scat were within 4 feet (1.2 m) of an old moose skull the wolf had dug out of the snow. Two wolf bed sites and a place where she had sat on her haunches and scratched her neck contained faint blood spots in the rear area, presumably from vaginal bleeding. As she left the first bed site, small blood spots were found 2-3 inches (6 cm) behind nearly every track for several steps.

Coyote

During the 1980-81 winter, I followed 28.8 miles (43.6 km) of coyote tracks and recorded scent-marks (Table 7). Blood in female coyote urine was first observed on 31 January and last on 13 March. The frequency of urination increased with breeding activity, with paired animals marking at a mean rate 7.5 times greater than that of lone coyotes, 3.0 marks/mile and 0.4 marks/mile respectively.

Occasionally, frequently used scent posts were found containing several scats and/or urinations. On 18 November 1979, prior to snow cover, I discovered a well-established scent post in Sullivan Meadow, Glacier National Park. The base of an old, wooden tripod

Table 7. Coyote scent-marking.

Date	Total distance tracks followed		Mean number of		Type of mark[b]	Number of coyotes traveling together[c]
	miles	(km)	Marks/mile[a]	(Marks/km)		
1-22-80	0.1	(0.2)	a		urine-VB & scratch; scat; urine	1 male and 1 female
1-26-80	0.3	(0.5)	a		urine	U
2- 2-80	0.3	(0.5)	a		scat & bed	U
2- 7-80	0.4	(0.6)	a		no mark but VB	1 female
2-25-80	0.1	(0.2)	a		urine	U
1-25-81	1.0	(1.6)	0		no mark	1
1-31-81	1.5	(2.4)	4.0	(2.5)	urine; urine; urine; urine; 2 urines	1 male and 1 female
2- 4-81	0.1	(0.2)	a		urine; urine	1

Table 7. (continued)

Date	Total distance tracks followed		Mean number of		Type of mark[b]	Number of coyotes traveling together[c]
	miles	(km)	Marks/mile[a]	(Marks/km)		
2- 7-81	1.3	(2.1)	5.4	(3.4)	2 urines; scat; 2 urines-VB & 2 urines	many
2-13-81	1.5	(2.4)	0.7	(0.4)	urine	1 male
2-20-81	2.0	(3.2)	1.0	(0.6)	scat & urine	1
2-25-81	2.5	(4.0)	1.2	(0.8)	2 urines; urine	1 male and 1 female
2-28-81	1.5	(2.4)	6.0	(3.8)	urine; urine; urine-VB & urine; urine & scat; urine-VB; urine-VB	1 male and 1 female
3-11-81	1.5	(2.4)	0		no mark	1
3-12-81	0.7	(1.1)	0		no mark	1

Table 7. (continued)

Date	Total distance tracks followed miles	(km)	Mean number of Marks/mile[a]	(Marks/km)	Type of mark[b]	Number of coyotes traveling together[c]
3-13-81	2.0	(3.2)	0.5	(0.3)	urine-VB	1 female
3-13-81	1.3	(2.1)	1.5	(0.9)	urine; scat	1
3-17-81	1.0	(1.6)	0		no mark	1
3-17-81	1.1	(1.8)	0		no mark	1
3-18-81	2.0	(3.2)	0.5	(0.3)	scat	U
3-19-81	3.0	(4.8)	0		no mark	1
3-23-81	3.5	(5.6)	0.6	(0.4)	urine; urine	1 male and 1 female

[a]Insufficient distance followed to accurately determine mean number of marks/mile.

[b]Urine-VB means a urination containing vaginal blood; VB means no urination but vaginal blood present on snow.

[c]U means unable to determine number of coyotes traveling together because of more than 1 set of tracks present in a jumbled manner.

served as a scent post that contained 45 coyote scats in a 1000 square foot (93.3 m^2) area. On 7 February 1981, a scent post consisting of 2 urinations and a scat was observed 35 yards (32 m) from a deer kill on a lake; 4 more urinations were located at the kill. Such communal scent posts were observed less frequently than individual scats or urinations.

Food Habits

Field Observations

Wolf. The radio-collared wolf appeared to depend upon scavenging for most of her food resources (Table 8). During the 2 years her behavior was monitored, she was known to have killed and consumed all or part of 1 snowshoe hare (*Lepus americanus*), 1 spruce grouse (*Canachites canadensis*), and 1 moose calf. Observed accounts of potential food resources and her responses to them are as follows:

On 11 October 1979, I examined a dead moose calf in the mud at the south end of Proctor Lake. The calf had died of unknown causes approximately 3 days earlier. Tracks indicated that a wolf had briefly investigated the calf but had not fed on it.

Joe Smith recorded the 5 following incidents during winter 1980:

23 January 1980: Approximately 800 yards (730 m) from

Table 8. Summary of winter occurrences of prey species killed and scavenged upon by coyotes and a wolf, Flathead drainage.

	Killed					Scavenged				
	Hare	Deer	Moose calf	Beaver	Grouse	Hare	Deer	Moose adult	Snake	Garbage
Wolf	1	0	1	0	1	1	0	2	0	0
Coyote	2	1	0	3	0	0	1	7	1	1

the Sage Creek Road, a wolf dug a hole 2.5 feet (0.8 m) deep and 2 by 3 feet (0.6 m by 0.9 m) at the aperture. Nothing was observed at the bottom of the hole, but 3 feet (0.9 m) from the digging was a frosty vapor hole in the snow, which Smith felt may have been a bear den.

24 February 1980: Three areas dug out by a wolf were observed--nothing was found in the first dig, blood and hare fur were observed at the second dig, and a trampled area 1 yard (0.9 m) in diameter containing much blood was observed at the third dig. Later in the day, the same wolf walked past the lower portion of a sawed elk leg bone without disturbing it. All the hair and muscle had been stripped from the bone.

25 February 1980: Tracks and blood indicated where a wolf had killed and consumed a snowshoe hare just north of Proctor Lake.

26 February 1980: At the edge of a meadow near Proctor Lake, a wolf dug out a moose calf leg; the marrow appeared to be in good condition. Later the same day, the wolf dug into the snow but obtained nothing.

21 March 1980: A wolf caught a spruce grouse north of Sage Creek and carried it 0.7 mile (1.1 km) before consuming it. During the carry, the wolf placed the grouse on the snow twice before retrieving it and resuming walking.

I observed the following wolf activity during late winter 1981:

15 February 1981: I discovered very fresh wolf tracks crossing the Sage Creek airstrip. I followed them east along Sage Creek, and eventually the tracks returned to the airstrip, completing a 2.2 mile (3.5 km) circle. Blood in the urinations indicated a female wolf in proestrus (Seal et al. 1979), probably the radio-collared wolf. As she nearly completed her circular path, the wolf crossed fresh moose tracks approximately 0.2 mile (0.3 km) southeast of the airstrip. The wolf and moose tracks ran together with much scuffling, and many broken branches and twigs littered the top of the snow. Several large clumps of moose hair (100-400 hairs per clump) were impaled on the stubs of branches broken off close to the tree trunks. The body of a female calf moose lay 75 yards (69 m) beyond the initial wolf/moose encounter point. A 9-inch (23-cm) diameter hole had been torn just behind the last rib; the stomach protruded through the hole and a few ribs had been chewed on. Several small, hairless, pink areas approximately 1 inch by 0.5 inch (2.5 cm by 1.3 cm) in size were found on both sides of the throat. Except for the noted injuries, no other damage was apparent. The moose was warm, and it steamed when I cut into it. Skinning back the hairless areas along the throat revealed massive hemorrhaging and bruising of the muscle and tissue along the trachea. Apparently the old wolf's teeth were too

blunt to puncture the neck skin and the calf probably died of strangulation. Cracking open the calf's femur revealed a layered marrow, of which the central portion was manilla-colored and the peripheral one-third was red. Throughout, the marrow had the consistency of jelly. Marrow color and consistency indicated that the calf was in fair to poor condition.

21 February 1981: I showed Jerry DeSanto, Glacier National Park Ranger, the moose carcass I had found on 15 February. The wolf had returned to the carcass on 20 February so DeSanto and I tracked her in opposite directions for approximately 1 mile (1.6 km) each way. DeSanto observed much wolf activity in his foretracking (see 22 February notes, following). My backtracking revealed much less activity: the wolf investigated 2 coyote beds and ignored a third, older coyote bed.

22 February 1981: I returned to the 15 February moose kill and followed the tracks DeSanto had observed and an additional 2 miles (3.2 km) beyond where DeSanto had stopped. Approximately 1 mile (1.6 km) southeast of the kill the wolf dug through 2 feet (0.6 m) of snow to expose a well-gleaned human-killed moose (determined to be human-killed by the sawed bone ends). The wolf partially exposed the vertebrae, but did not feed on the remains. On top of the snow surrounding the vertebrae were small, fresh bone chips and 3 small,

grooved incisors. The wolf dug out the moose skull, carried it 0.3 mile (0.5 km) upslope, dropped it, and urinated and defecated within 4 feet (1.2 m) of it. Thirty yards (27.4 m) south of the skull, the wolf dug through 10 inches (25.4 cm) of snow to partially expose a moose jaw, presumably from the same kill. She did not chew on the jaw.

Coyote. I followed 28.8 miles of coyote tracks during the winter months. My observations (Table 8) and kills reported by local people were as follows:

28 February 1979: DeSanto heard coyotes "yelling and screaming" along Kintla Lake at 0800. He investigated the commotion and saw 2 coyotes tugging on a downed deer. He returned at 0930 and observed 3 coyotes tearing at the deer. DeSanto examined the still-warm deer and began backtracking in the 2 inches (5.1 cm) of snow to determine the cause of the deer's death. Tracks indicated that coyote No. 1 had chased the deer from the forest out onto the frozen lake, where coyote No. 2 joined in the chase. The deer went down, as evidenced by the blood and tracks on the ice, but managed to rise and run again. Then coyote No. 2 held onto the deer so securely that the coyote's tracks vanished for 40-50 feet (14 m) as the deer ran, apparently carrying its pursuer along above the ground. Soon after the coyote's tracks reappeared, deer skid marks lead to its fatal fall. The third coyote later joined the other 2 successful

hunters at the kill site.

11 October 1979: Coyotes fed on the moose calf carcass described in "Wolf Food Habits."

24 November 1979: One or 2 coyotes killed and consumed a beaver on a frozen beaver pond 0.2 miles (0.3 km) south of the international border.

February 1980: Ron Wilhelm, a Polebridge resident, observed and photographed 2 coyotes chasing a deer into the Flathead River. The deer stood in the current, but the coyotes would not go into the River after it. Eventually, 1 coyote walked out onto the river ice, approaching the deer. The ice broke under its weight and the coyote was swept under the ice and did not resurface. The remaining coyote then left the area.

11 February 1980: A coyote had chewed on and then expelled part of a snake. It was unknown where the coyote found the snake.

19 March 1980: Coyotes fed extensively on the carcass of a female yearling moose, found 0.6 mile (1.9 km) south of the Trail Creek Port of Entry. The femur marrow was red with purple lumps and of runny consistency, indicating a moose in poor condition.

30 March 1980: DeSanto informed me of a moose kill along

lower Sage Creek. I investigated the site and found the spine, skull, jaws, and 2 articulated legs of a 3-4 year-old male moose. The carcass was gleaned by many coyotes and a wolverine. The femur marrow was the color and consistency of strawberry jam, indicating a moose in poor condition. Much blood and moose hair lay under the snow.

4 April 1980: DeSanto reported another dead moose located 0.3 mile (0.5 km) southwest of the 30 March carcass. I investigated the site and found the spine, ribs, and 1 femur of a female, 3-4 year-old moose. Similar to the 30 March carcass, most of the ribs had been snipped off at the spine. The femur marrow was light pink, greasy, and cohesive enough to hold its shape after being removed from the bone, indicating a moose in fair condition. Very little blood was in the snow.

13 April 1980: Two coyotes killed and entirely consumed a beaver along a swampy stretch of Colts Creek, 0.3 mile (0.5 km) south of the international border. The coyotes had apparently caught the beaver by surprise as it was crossing the ice of its dammed pond, and killed it 10 feet (3 m) from open water.

7 February 1981: I discovered an old deer kill on the ice of Proctor Lake. The greatest coyote activity was confined to an 8- by

10-foot (2.4-m by 3.0-m) area, with 24 sets of coyote tracks radiating from it. I observed scent-marks (see Scent-marking), 2 coyote digs through 15 inches (38 cm) of snow, 2 vertebrae, and deer hair at the site.

<u>12 February 1981</u>: I tracked a lone coyote in 10 inches (21 cm) of snow through a clearcut for a mile (1.6 km), during which it investigated small areas at the base of grass clumps 8 times, apparently mousing. The coyote worked its way back and forth through the clearcut, crossing a logging road several times. At 1 point, the coyote bounded over a snowbank to an area where a large bird (possibly a raven) had been sitting on the snow. Tracks indicated that the coyote chased and/or grabbed at the bird on the ground for several feet before the bird was able to take flight. Later, the coyote left the clearcut and entered the forest. Approximately 0.3 mile (0.5 km) after leaving the clearcut the coyote dug through 4 inches (10 cm) of snow to obtain an old pork ham bone, dropping it 2 feet (0.6 m) from where it was dug up.

<u>20 February 1981</u>: I returned to the wolf's 15 February kill (see Wolf Food Habits) and found that coyotes and ravens had consumed approximately 40% of the moose carcass. Coyotes had carried easily detached pieces of the moose short distances, 50 feet to 0.3 mile (16 m to 0.5 km), from the kill site, and there fed on the

scavenged parts.

25 February 1981: A coyote crossed fresh snowshoe hare tracks and followed them for 25 feet (7.6 m). This same coyote later encountered fresh grouse tracks and followed them for 15 feet (4.6 m). I frequently observed this type of behavior throughout the winter.

6 March 1981: A coyote killed and consumed a snowshoe hare at the edge of a large meadow 0.5 mile (0.8 km) south of the international border. Tracks indicated that the hare had been in alder thickets bordering the meadow, and wandered out into the open area where the coyote killed it.

11 March 1981: I tracked a lone coyote through a select-cut area containing several standing mature spruce trees. The coyote walked from spruce to spruce, investigating the sheltered area around the tree trunks created by the drooping boughs. Hare pellets were observed in 2 such shelters. The coyote investigated 7 shelters in approximately 0.3 mile (0.5 km) before killing and consuming a hare concealed under the eighth tree.

12 March 1981: I often observed coyote tracks in areas of beaver activity: coyotes used beaver lodges as scent posts, thoroughly investigated beaver channels connecting ponds, and frequently traveled over beaver dams. On this date, 1 or 2 coyotes killed a beaver in the

swampy area at the south end of Three Mile Lake, 2.5 miles (40.0 km) north of the international boundary. The beaver was in a narrow, 7-inch (18-cm) deep channel of water exiting a dammed pond when the coyotes came over the channel bank, grabbed the beaver, and dragged it 30 yards (27.5 m) through alder thickets into the spruce trees. Much fresh blood and beaver fur marked the trail leading to the carcass. Although 90-95% of the fur had been pulled from the skin, only the tail and limbs had been consumed. The kill was fresh, and I probably interrupted the feeding coyotes. I howled from the kill site, and 3 coyotes immediately replied within 0.3 mile (0.5 km) of me.

13 March 1981: I revisited the 12 March kill and found nothing but some beaver fur and the guts, which lay 25 feet (7.6 m) from where I had observed the carcass yesterday. Many more coyote tracks were present today than yesterday. I followed coyote tracks leaving the kill site; approximately 0.3 mile (0.5 km) from the site, the coyote dug through 8 inches (20 cm) of snow to uncover an old, sawed elk skull, but the coyote had not moved the skull. This coyote and another in an adjacent clearcut both exerted extra effort in their travels to investigate slashpiles, fallen trees, and spruce bough shelters (described on 11 March). Snowshoe hare pellets were observed in several of these investigated places but neither coyote encountered a hare.

<u>17 March 1981</u>: Several coyotes traveled through a large meadow 0.3 mile (0.5 km) south of the international border, digging several holes in the snow varying from 4 to 26 inches (10-66 cm) in depth; I could not detect anything at the bottom of the holes. After traveling approximately 1 mile (1.6 km), a pair of coyotes investigated several old elk beds and a similar number of fresher moose beds. Three of the moose beds had small amounts of fresh blood at 1 end. Four-tenths of a mile (0.6 km) south of these beds, coyotes fed on the remains of a female moose. One leg bone still had some red muscle on it, but all other bones were stripped of edible tissue. The moose appeared to have died several months earlier, and the remains had been scattered 100 yards (92 m) down-slope.

<u>23 March 1981</u>: I tracked a pair of coyotes as they investigated several potential food sources. One coyote followed an old snowshoe hare track for 20 feet (6.0 m) and later a second hare track for 15 feet (4.6 m) before losing interest. One coyote had excavated a moose leg bone and carried it for 60 yards (55 m) before abandoning it. A hare kill, made approximately a week earlier, was briefly examined by both coyotes. Most of the hare lay under 1.5 inches (3.8 cm) of snow, but neither coyote attempted to uncover it.

<u>12 August 1981</u>: At dusk, I saw a large white-tailed doe and 2 smaller does (probably yearlings) grazing in a large meadow 0.5 mile

(0.8 km) south of the international border. Suddenly, they stopped browsing and began to run around in a confused manner; the yearlings disappeared into the forest and the large doe stayed in the meadow and resumed browsing. Shortly thereafter, the lone doe began bounding toward the forest, pursued by a coyote from the southeast, which was joined by a second coyote from the east. When the doe disappeared into the trees, the coyotes gave up the chase and trotted back through the meadow together in a southwesterly direction.

Scat Analysis

I examined 181 coyote scats and 30 wolf scats collected in the study area (Tables 9-12). Scats were analyzed (Scott 1941) with respect to season of scat deposition as follows:

spring	4-15 through 6-14
summer	6-15 through 9-14
fall	9-15 through 11-14
winter	11-15 through 4-14
unknown	any scat older than 1 month

Interspecific Interactions

Wolf and Coyote

On numerous occasions wolf and coyote tracks were observed crossing each other, displaying neither avoidance nor following behavior; less frequently, they followed each other. Interspecific scent-marks were always investigated when encountered.

Table 9. Frequency of occurrence of food items in 30 wolf scats collected in the Flathead drainage.

	Spring	Summer	Fall	Winter			Unknown			Yearly total		
Food item	Known (N = 1)	Known (N = 1)	Probable (N = 1)	Known (N = 7)	Probable (N = 3)	Total (N = 10)	Known (N = 1)	Probable (N = 16)	Total (N = 17)	Known (N = 10)	Probable (N = 20)	Total (N = 30)
Ungulate	100	100	100	100	100	100	100	56	59	100	65	77
Hare	0	0	0	0	33	10	0	31	30	0	30	20
Microtine	0	0	0	0	0	0	0	38	35	0	30	20
Ground squirrel	0	0	0	14	33	20	0	13	12	10	15	13
Beaver	0	0	0	0	0	0	0	19	18	0	15	10
Vegetation	100	0	0	29	0	20	0	19	18	30	15	20
Avian	0	0	0	14	0	10	0	0	0	10	10	3
Totals	200	100	100	157	166	160	100	176	172	150	180	163

Note: Total does not equal 100% because scats often contained more than one food item.

Table 10. Percent occurrence by volume of food items in 30 wolf scats collected in the Flathead drainage.

Food item	Spring	Summer	Fall	Winter			Unknown			Yearly total		
	Known (N = 1)	Known (N = 1)	Probable (N = 1)	Known (N = 7)	Probable (N = 3)	Total (N = 10)	Known (N = 1)	Probable (N = 16)	Total (N = 17)	Known (N = 10)	Probable (N = 20)	Total (N = 30)
Ungulate	90	100	100	81	42	69	100	35	39	86	39	53
Hare	0	0	0	0	32	10	0	27	25	0	26	17
Microtine	0	0	0	0	T[a]	T	0	15	14	0	12	8
Ground squirrel	0	0	0	6	26	12	0	3	3	4	7	9
Beaver	0	0	0	0	0	0	0	16	15	0	13	9
Vegetation	10	0	0	11	0	8	0	2	1	9	2	1
Avian	0	0	0	1	0	1	0	0	0	1	0	T
Other	0	0	0	1	0	0	0	2	3	0	1	3
Totals	100	100	100	100	100	100	100	100	100	100	100	100

[a]T = trace, less than 1%.

Table 11. Frequency of occurrence of food items in 181 coyote scats collected in the Flathead drainage.

Food item	Spring (N = 16)	Summer (N = 26)	Fall (N = 8)	Winter (N = 58)	Unknown (N = 73)	Yearly total (N = 181)
Ungulate	19	31	38	45	25	32
Hare	44	27	50	43	41	40
Microtine	13	23	0	34	29	27
Ground squirrel	44	8	0	3	33	19
Red squirrel	0	8	0	0	0	1
Beaver	0	0	0	9	4	4
Bear	0	0	0	2	3	2
Vegetation	13	27	13	19	25	22
Seeds	13	4	0	2	7	5
Garbage	0	8	0	7	0	5
Avian	0	0	0	0	1	1
Insect	0	0	0	0	1	1
Debris	0	T[a]	T	0	T	T
Other	0	T	0	0	0	0
Totals	146	136	101	164	169	159

[a]T = trace, less than 1%.

Note: Total does not equal 100% because scats often contained more than one food item.

Table 12. Percent occurrence by volume of food items in 181 coyote scats collected in the Flathead drainage.

Food item	Spring (N = 16)	Summer (N = 26)	Fall (N = 8)	Winter (N = 58)	Unknown (N = 73)	Yearly total (N = 181)
Ungulate	17	28	35	32	18	24
Hare	33	23	31	33	34	33
Microtine	7	12	0	19	11	13
Ground squirrel	34	7	0	2	21	14
Red squirrel	0	2	0	0	0	T[a]
Beaver	0	0	0	7	3	4
Bear	6	0	0	2	T	1
Vegetation	2	12	1	2	6	5
Seeds	1	T	0	0	T	T
Garbage	0	8	0	3	3	3
Avian	0	0	0	0	1	T
Insect	0	0	0	0	1	T
Debris	0	6	33	0	1	2
Other	0	2	0	0	1	1
Totals	100	100	100	100	100	100

[a]T = trace, less than 1%.

31 January 1981: Smith tracked a wolf along the east side of Proctor Lake and observed coyote tracks walking in wolf tracks. At 1 point, the tracks were jumbled together in an area containing 2 urine spots, making it difficult to tell which animal made the marks. Three yards (2.7 m) from this area was a voluminous urination definitely made by the wolf.

15 February 1981: I followed a set of wolf tracks east from the Sage Creek airstrip. A female coyote (deduced from a bloody squat urination) paralleled the wolf tracks in an opposite direction for approximately 0.3 mile (0.5 km), and then traveled in the wolf's tracks for another 0.2 mile (0.3 km). The coyote urinated and defecated along the wolf's path. Later, the wolf investigated an old coyote bed, and although the wolf did not urinate, it scratched twice next to the bed.

21 February 1981: A wolf leaving the 15 February moose kill investigated 2 relatively fresh coyote beds and ignored a third older coyote bed.

No tracks were observed of direct encounters between wolf and coyote.

Wolf and Human

During the winter of 1979-80, Joe Smith often observed wolf tracks avoiding human ski and snowshoe tracks (Ream, in prep.). On

20 February 1981, I visited the wolf-killed moose calf (see Food Habits) and found that the wolf had returned to the kill the previous night. When the wolf had encountered my boot tracks in the snow, it would not cross them and headed back in the direction it came from, even though the moose carcass lay only 50 feet (15 m) past my tracks. Although the radio-collared wolf generally avoided direct contact with humans, she was occasionally located within 0.2 mile (0.3 km) of active logging sites and remained nearby despite the commotion created by men and equipment.

Coyote and Human

Coyotes appeared undisturbed by human scent/sign in circumstances of human travel; they often traveled in my ski and snowshoe trails, and my snowmobile track. However, coyotes were quite wary of human scent/sign in unusual circumstances, such as trapping. Coyotes did not generally display the avoidance behavior of the wolf in indirect human encounters. However, like the radio-collared wolf, coyotes avoided direct encounters with humans. Twice I observed No. 7 from the ground at a distance of less than 200 yards (183 m), and both times he ran away when he saw me, as did all coyotes.

Wolf Mortality

No known wolf mortalities have occurred in the study area during the past decade. The instrumented wolf's radio-collar ceased transmitting approximately 22 July 1980, but no reason was found to believe she had died. On 2 separate occasions, local people, Gary Gillette (a British Columbia Forestry employee) and Rusty Randall (a British Columbia Customs officer for the Flathead Port of Entry) claimed to have seen a wolf similar in size and color to wolf No. 114 several months after her collar ceased transmitting. Tracks and scent posts of a female wolf in proestrus were found during the 1980-81 winter in the areas frequented by No. 114 the previous winter.

Coyote Mortality

Eleven human-caused coyote mortalities were reported in the study area from September 1979 through September 1981. Within the United States portion of the study area, 5 males were shot and 1 trapped (No. 150), and 1 female was shot and 1 trapped. In the Canadian portion, 2 males and 1 female were trapped. Thus, a reported total of 8 males and 3 females were harvested in the entire study area. Additionally, 3 radio-collared coyotes appeared to have been killed by other predators.

The radio signal from female No. 15 became stationary for approximately 2 weeks in February 1981. I snowshoed to the radio signal on 27 February and found the front half of her body 25 feet (8 m) up a large spruce tree, tucked in among the boughs. It had snowed minimally the previous 3 weeks, so tracks were well preserved.

Cougar tracks led up to and away from the tree. The approaching tracks were accompanied by drag marks, whereas the departing tracks were not. Backtracking indicated that the cougar had killed the coyote down-slope, fed on the back half, and carried/dragged the remaining front half 0.7 mile (1.1 km) upslope and cached it in the spruce tree. Evidence of a struggle was noted at the kill site; an area of 15 by 20 feet (5 by 7 m) was packed down in the snow containing coyote fur, faded blood and brown gut fluid. Claw marks were found in the coyote's abdominal region, and small hemorrhage spots on the head indicated a bite there.

On 27 June 1981, Jerry DeSanto found the body of male coyote No. 17 stretched over a downed log, "as if he was just walking over it and had died." The body was decomposing in a sheltered area, with the hide still intact. DeSanto cut off the head to bring me the collar. On 3 September, DeSanto and I hiked in on No. 17 so I could map and photograph the kill site. The remains were exactly as DeSanto had left them in June except that the carcass was more decomposed with the hide falling off. The "primeness" of the tail fur indicated that the coyote had died before the spring shed. Cleaning the skull revealed 2 discolored indentations, a 0.4-inch (1-cm) diameter puncture, and a crushed auditory bulb (see Discussion).

The signal of male coyote No. 7 became stationary sometime in March or April 1981 while I was in Missoula. On 9 August, I found the decomposed coyote on a slope with the fur/hide down-slope from the skeleton. The skull, vertebrae, and ribs were articulated, and the leg bones were within 2 feet (0.6 m) of the spine. Sign of a struggle was evident at the kill site, with turf and vegetation torn up. The skull had several punctures between the orbits, adjacent to a 1.2-inch (3-cm) diameter hole and a missing left zygomatic arch. Approximately 110 yards (92 m) southeast of No. 7's carcass were the remains of a 7-point bull elk. The hair and bones remained but the muscle and hide were gone, indicating that the elk had died during the winter of 1979-80 or 1980-81. No sign of struggle was seen near the elk (see Discussion).

Wolf Survey

All reported wolf sign in the study area was investigated (Appendix D). Wolf sign was frequently observed in the Flathead area by Project personnel, and such occurrences were too numerous to detail. Joe Smith was originally hired by WEP to trap a black wolf that had been sighted several times during the 1978-79 winter in the Flathead drainage of Canada. He trapped a female gray wolf but saw no sign of the black wolf until September 1981 when he observed a black wolf from his truck for 10 minutes in the upper Nettie Creek area. The wolf was close enough to be observed with the naked eye and was not very concerned with the presence of the truck.

John Cromby, caretaker of the CNI Sage Creek camp, has lived in the Flathead area for 16 years. Cromby stated that in past years he had seen a pair of gray wolves, 1 larger than the other, and had often seen tracks of a pair of wolves in the area. However, during the past 3 or 4 years he has only seen tracks of a lone wolf. WEP tracking data from 2 winter field seasons indicated that all wolf tracks were of solitary animals.

I investigated reported wolf sightings in the Wigwam River drainage, west of the Flathead, between 13 and 18 May 1980. During 4 days of hiking in the Wigwam area, I discovered a possible wolf scat and a set of possible wolf tracks. One day was spent talking with Canadian outfitters Jan Skiber and Heinz Leuenberger. Both have guided in the Wigwam for 15 years and stated that the advent of wolves to the Wigwam area is a relatively recent occurrence. Skiber first found indications of wolf presence in September 1979, when 1 of her guides saw a pair of wolves crossing a hillside along the Wigwam. A month later, Skiber saw fresh tracks of a single wolf in the same area. Leuenberger first saw tracks of a lone wolf in the Wigwam drainage during 1976. In 1977, Leuenberger saw tracks of 2 wolves along Rocky Ridge, and in 1978, 1 of his guides saw 3 wolves trotting across the slopes below the China Wall (Mt. Broadwood). In the spring of 1980, Leuenberger saw a fresh wolf track along upper Morrisey Creek, in the northwestern corner of wolf No. 114's home range.

CHAPTER V

DISCUSSION

Coyote Age and Sex Ratios

Tooth condition was recorded for 35 coyotes captured by Project personnel and 11 coyotes killed by local trappers. Two out of 46 coyotes (4.4%) had excessive toothwear, indicating very old animals. Most captured coyotes were young with little toothwear. Berg and Chesness (1978) found that 74% of 960 Minnesota coyotes were less than 3 years old, based on the dental annuli aging technique. Schladweiller (1980) estimated ages of Montana coyotes with the same annuli technique and found 75% of 1215 Montana coyotes to be pups and yearlings, and 15% to be 2-3 years old. Trapping tends to favor capturing younger, less experienced animals, so the prevalence of young animals trapped may not accurately indicate actual age structure of the population.

Coyotes captured during this study yielded a disproportionate sex ratio of 1.5 males to 1.0 females. In Minnesota wolf populations, Mech (1975) found that a preponderance of males was produced by a high-density, stable or declining population, and a preponderance of females was produced by a heavily exploited, low-density wolf population. Many coyote researchers have reached the same conclusion (Young and Jackson 1951, Wetmore et al. 1970, Knowlton 1972). The combination of the preponderance of male coyotes trapped in my study area, an adequate prey base (see Food Habits), and low coyote trapping pressure (see Mortality), supported the literature.

Social Structure

Wolf. The female study wolf, No. 114, was never known to associate with another wolf; extensive searches and observations indicated that there were no other wolves within the study area from April 1979 through April 1981. Wolves are social animals with a well-developed social system (Murie 1944, Mech 1970, Fritts and Mech 1981). However, dispersing wolves occupying low density wolf range may exhibit atypical social behavior, like No. 114.

Coyote. Howling, visual observations, and track observations indicated that Flathead coyotes generally traveled alone or in pairs, and infrequently traveled in small groups (packs). I observed my radio-collared coyotes 7 times (Table 6); twice the collared coyote was accompanied by another coyote, and the other 5 sightings were of solitary animals. The noninstrumented coyotes I occasionally saw were always alone. The largest group of coyote tracks I observed together in the winter was 3. I infrequently saw groups of tracks of more than 3 coyotes but because of difference in track ages, poor tracking conditions, or opposite directions of travel, I concluded that they were not traveling together. Camenzind (1978) and Bekoff and Wells (1980) found that in the National Elk Refuge, an area of abundant elk carrion, most coyotes lived in packs or aggregations, and a few loners and pairs comprised the remainder of the population. It may have been beneficial for coyotes to live in large packs to defend their elk carrion. Murie (1940) reported that coyotes in Yellowstone National Park usually traveled alone or occasionally in small groups during the snow-free months, and often traveled together in small packs during winter. Yellowstone, like the National Elk Refuge, has an abundance of elk carrion so it is not surprising that the Yellowstone coyotes exhibit social organization similar to that of the Refuge coyotes. In the Missouri Breaks of Montana, which supports deer and antelope populations, coyotes generally lived in pairs rather than packs (Pyrah 1980), similar to the Flathead coyotes. Availability of ungulates in the Flathead varied seasonally (see Food Habits) and was not a reliable food resource for coyotes. However, mice and snowshoe hares were consistently available and were exploited year-round. The smaller social groupings of Flathead coyotes may have been a function of this smaller-sized prey base. Lone coyotes are rarely capable of killing adult ungulates, but 2 or more coyotes hunting cooperatively may kill adult deer or, infrequently, elk (Young and Jackson 1951, Hamlin and Schweitzer 1979, DeSanto pers. comm., O'Gara pers.

comm.). In areas where coyotes prey mainly on ungulates or defend ungulate carrion, living in packs may be necessary. In areas where coyotes depended on hares and small mammals for food, pack organization would be unnecessary and perhaps detrimental. Small prey items are captured solitarily and consumed solitarily; mice and hares probably could not support a pack.

Pups apparently dispersed before heavy snowfall in the Flathead drainage, as indicated by the abundance of solitary and paired tracks and absence of tracks of family groups. Pyrah (1980) reported that coyote pups began to make solitary forays in August, culminating in late fall, with October being the most intensive period of dispersal. Because of the late fall ungulate emigration from the Flathead area, coyotes relied on smaller mammals and scavenging, thus promoting fall pup dispersal. The winter food base in the study area probably could not support packs of coyotes as adequately as it does pairs and loners.

Territoriality and Home Range

Mech (1970) defined territoriality as "the area that the animal will defend against individuals of the same species," and further stated that "the defense of the area is the main difference between a territory and a home range." Bekoff and Wells (1980) stated that "a [coyote] home range has a flexible, undefended boundary, so that the home ranges of different individuals or groups may overlap considerably" but that a territory is an area that coyotes actively defend to the almost complete exclusion of conspecifics.

Wolf. According to these definitions, the radio-collared wolf's (No. 114) area of occupation was a home range rather than a territory. Due to a lack of wolves in the study area, No. 114 could not interact with other wolves in active defense of her home range, although she did scent-mark (see Scent-marking). No. 114 occupied a well-defined home range throughout the 16-month period her radio-collar transmitted. She may have made exploratory trips out of her home range, however, because she was not located during 6 flights despite extensive searches. Using Mohr's (1947) method of calculation, No. 114's home range size was 440 square miles (1144 km^2). When the non-utilized portion of her home range was deleted (Fig. 2), her adjusted home range size was 330 square miles (858 km^2), which may be a more accurate measure. This adjusted home range size is comparable to that of most lone wolves in Minnesota; Van Ballenberghe et al. (1975) reported a home range of 74 square miles (192 km^2) for a lone wolf, whereas Fritts and Mech (1981) reported home ranges of 250-540 square miles (650-1400 km^2) for 5 lone wolves.

No. 114 used certain parts of her home range seasonally. She was located in the northern quarter of her home range only during snow-free months, was found in the southern one-third of her home range throughout the year, and was located in the corridor connecting these 2 areas during the spring and fall months. During winter and early spring, No. 114 confined her movements to the Sage Creek/ Proctor Lake region, a wintering area for moose (see Food Habits). Her seasonal utilization of her home range was probably a function of prey availability.

Coyote. Like the study wolf, no territorial behavior was observed for Flathead coyotes. However, the degree of exclusiveness of the radio-collared coyotes' home ranges indicated that they were indeed territorial (Fig. 12).

Two out of 9 coyotes exhibited slight seasonal use of areas within their home ranges. None of the other 7 coyotes had radios that transmitted a full year, so I could not determine their seasonality of home range use. Male No. 5 used the northwest third of his home range only during snow-free months. That area had been clearcut and supported low brush for cover in summer. During winter, this brush was under the snow, so the area had virtually no cover for non-microtine prey species or coyotes. No. 5 may have avoided this area in winter because of a lack of prey and shelter. The more southerly portion of No. 5's home range had not been logged; it supported many animals in winter, including No. 5. Male No. 7

exhibited slight seasonal use for undetermined reasons.

Mean home range sizes were 20 square miles (52 km^2) for 5 males and 11 square miles (27 km^2) for 2 females, with a combined overall home range size of 18 square miles (45 km^2) (N = 7). This compares with Berg and Chesness' (1978) home ranges of 27 square miles (68 km^2) (N = 45) for male coyotes and 6 square miles (16 km^2) (N = 45) for females, and Ozoga's (1966) data of 50 square miles (128 km^2) for males and 20 square miles (51 km^2) for females. Bekoff and Wells (1980) found the average home range size of 10 adult coyotes on the National Elk Refuge to be 8 square miles (21 km^2) with no discernible differences according to sex. However, when he analyzed home range size according to social groupings, he found that solitary individuals and mated pairs (which were excluded from elk carrion in winter) had larger mean home ranges of 12 square miles (30 km^2), while pack members (which defended their elk carrion food resource in winter) had average home ranges of only 5 square miles (14 km^2). Coyotes in the Flathead drainage probably exist in smaller social units (pairs and loners) because of the seasonality of ungulate availability (see Food Habits and Social Structure).

Coyote home ranges were analyzed for percent overlap with adjacent home ranges (Table 2 and Fig. 12). Most home ranges overlapped very little, with the exception of female No. 9's and male No. 11's; No. 9's home range was nearly contained within No. 11's (Fig. 12).

Although these 2 coyotes were captured within 0.4 mile (0.6 km) and 24 hours of each other, they were never located closer together than 0.3 mile (0.5 km). Both animals were approximately 2.5 years old; I suspect that they may have been siblings based on their similar ages and spatial tolerance for each other. Percent home range overlap by age and sex was analyzed for all coyotes (Table 5). The most overlap occurred when subadult home ranges overlapped adults (38.6%). A lesser degree overlap occurred when adult home ranges overlapped with other adults (20.0%). Subadults may not be as aggressive and may be less of a threat to adults. Therefore, adult coyotes may better tolerate spatial intrusion (overlap) by subadults than by other adults; or perhaps the subadults were the offspring of the adults whose range they overlapped. Home ranges of coyotes of the same sex exhibited little overlap (6.5% for male:male and 17.0% for female:female) compared with home overlap between coyotes of opposite sex (38.6% for male overlapping female and 21.6% for female overlapping male). Coyotes of the same sex may be competing genetically, and therefore may benefit by keeping same-sex conspecifics out of their home range. However, coyotes of the opposite sex may be potential mates and it could be to the future genetic advantage for a coyote to allow the home range of an opposite-sex coyote to slightly overlap its own home range.

All mortalities of radio-collared coyotes (N = 4) and 89% of all coyote captures (N = 9) occurred along the periphery of their home ranges. Male No. 7 was the only instrumented coyote known to disperse during the study (Fig. 7). He stayed within a well-defined home range for 9 months. Suddenly, he left his home range and moved east over 2 ridges where he was immediately killed by a very large coyote (or possibly a small wolf) in the Kishinena drainage (see Mortality). Coyotes appeared to be more vulnerable along the periphery of their home ranges and dispersal routes, where they were more likely to encounter unfamiliar situations, dangers, and unfriendly coyotes. Pyrah (1980) reported that all of his instrumented dispersal coyotes (N = 8) were killed by hunters, whereas only 1 of his established coyotes (N = 15) was killed within its home range. Similar findings were reported in Minnesota wolf studies (Fritts and Mech 1981, Mech pers. comm.).

Scent-marking

Scent-marking has many functions including territorial maintenance, orientation, advertisement of breeding condition, a means of contact between potential breeders, and strengthening the pair bond between mated animals (Mech 1970, Peters and Mech 1975, Rothman and Mech 1979).

Wolf. A lone female wolf (No. 114) was tracked in the Flathead drainage during the winters of 1979-80 and 1980-81. She frequently raise-leg urinated (RLU) on elevated objects such as stumps or lumps of snow, and less frequently scratched near her marks. Rothman and Mech (1979) tracked lone wolves in Minnesota during winter and found only 1 series of RLU's and no scratch marks, while paired wolves or pack members RLU'd and scratched frequently. Most Minnesota lone wolves scent-marked infrequently and discreetly, probably to minimize their whereabouts. The Minnesota studies were conducted in areas of relatively high wolf density where lone wolves held no territories and were in danger of being killed by a territorial pack. The Flathead female wolf confined her activities to a well-defined home range (see Territoriality and Home Range) and RLU'd, contradicting Rothman and Mech's findings. Because of extremely low wolf densities, No. 114 was in little or no danger of being killed by a wolf pack and was safe to advertise her presence. No. 114's scent-marking behavior may have resulted from 2 opposing behaviors: 1) she was trying to keep other wolves out of her home range, or 2) she was seeking a mate and advertising her presence.

Coyote. Other researchers found that coyotes scent-marked for reasons similar to those described above for wolves (Camenzind 1978, Lehner 1978, Wells and Bekoff 1981). Coyotes in the Flathead scent-marked all year long, but intensity increased during the winter.

I observed proestral bleeding in coyote urine from 31 January through 13 March. Hamlett (1938) found that Montana coyotes generally began breeding in late February, and most females bred within a month (N = 2900). Frequency of scent-marking by paired coyotes in my study area peaked during late February, coinciding with the breeding season (Table 7). Marking frequency of lone Flathead coyotes was fairly constant throughout the courtship and breeding season (Table 7). Scent-marking serves as a strong pair-bonding mechanism (Rothman and Mech 1979), so one would expect paired animals to mark more frequently than loners. Increasing their frequency of marking during the critical courtship and breeding period may be advantageous to both members of a mated pair to deter trespassing conspecifics, thereby increasing the genetic success of both established partners.

I found 1 scent post that contained 45 coyote scats in a 112 square yard (93 m^2) area. This scent post was conspicuously located at the base of an old, human-erected tripod on the edge of a meadow. I was not familiar with the coyotes using the scent post and could not say if it played a role in territory maintenance because it was located just outside my study area. It simply may have been a "good place" to scent-mark (i.e., a high point, near a conspicuous landmark, along frequently traveled coyote routes). The presence of a scent-mark stimulates more marks (Peters and Mech 1975) and a self-feeding cycle begins. Camenzind (1978) described 2 coyote "latrines" he found on the National Elk Refuge in Wyoming. One was an empty hayshed that contained more than 500 coyote scats in an area of less than 600 square yards (500 m^2). The other latrine was a ditch under a dilapidated bridge crossing a dry creek channel, and contained several hundred coyote scats in an area of only 36 square yards (30 m^2). Both latrines were in inconspicuous, sheltered areas and Camenzind concluded that they did not serve territorial functions. Kruuk (1972) found latrines of spotted hyenas and felt they had a significant role in territory maintenance. While reviewing wolf literature I found no examples of latrine behavior by wolves.

Food Habits

Food items were analyzed seasonally for both wolf and coyote scats (Tables 9-12). Due to the small sample size for wolf scats, food habits of wolf and coyote were compared for yearly totals only, rather than seasonally. Tracks were much more obvious in winter than the other seasons so most of the "known" wolf scats (7/10) were collected in winter, possibly creating a bias in "known" wolf food habits.

Wolf. Forty-three percent of the wolf scats contained only 1 prey item. The most commonly occurring food item by volume was ungulate (53%), with snowshoe hare of secondary importance (17%), and ground squirrel (9%), beaver (9%), and microtine (8%) being approximately equal in occurrence. Miscellaneous items comprised less than 4% of all scats. Other researchers found ungulates to have the highest percent occurrence by volume, with beavers second most important and hares and medium-sized rodents third (Murie 1944, Mech 1966, Pimlott 1969, Van Ballenberghe et al. 1975, Fritts and Mech 1981). Surprisingly, ground squirrel hair was found in 2 winter wolf scats from the study area. The wolf may have dug out hibernating ground squirrels and consumed them.

Coyote. Forty-five percent of the coyote scats contained only 1 prey item, similar to the wolf scats (43%). Unlike the wolf scats, however, human garbage was found in many coyote scats, including a small belt buckle, metal staple, band-aid wrapper, cigarette butts, plastic, rope, foil, and paper. Two scats were composed almost entirely of ants. Snowshoe hare had the highest percent occurrence by volume (33%), and ungulates were second most important (24%). Hare and ungulate importance values changed seasonally, with the greatest polarization occurring in spring when hare occurred twice as frequently by volume as did ungulates (33% and 17% respectively). Most deer and many elk emigrate out of the study area in early winter (see below in Field Observations). Coyotes may have scavenged on ungulate carrion during winter but by spring the dwindling carrion supply may have been exhausted, accounting for the low percent occurrence by volume of ungulate in spring coyote scats. Microtine and ground squirrel were of approximately equal importance (13% and 14% occurrence by volume respectively). Ground squirrels were found in 44% of spring coyote scats but were relatively unimportant the rest of the year (3-8% frequency of occurrence). When ground squirrels first emerge from hibernation, there is little vegetative cover, possibly making them easier for a coyote to catch. Also, young-of-the-year ground squirrels may venture out in late spring and are much easier to capture than are the adults. Beaver was found only in winter scats and scats of unknown age. Beaver move clumsily out of the water and may be more vulnerable to predation when their ponds are frozen over and they must travel over the ice. Black bear hair was found in 1 winter and 1 spring scat. Coyotes may have dug out a denned bear and fed upon it, or perhaps killed a starving bear that emerged from hibernation early seeking food. Other researchers also found ungulate and hare to be the coyotes' primary food resource, with mice and squirrels the second most important items (Murie 1940, Niebauer and Rongstad 1975, Berg and Chesness 1978).

Scat analysis data indicated that coyotes and wolves in the Flathead drainage had significant dietary differences. Ungulate hair was found in 100% of all known-age wolf scats and in 77% of all wolf scats but in only 32% of all coyote scats. Wolves apparently depended upon ungulates as their primary food resource throughout the year. In contrast, coyotes varied their diet according to seasonal abundance and availability of prey items, and were not dependent on any 1 prey species. Pyrah (1980) felt that coyotes preyed on deer in the Missouri Breaks when more preferred prey was scarce and thus deer became a "buffer" species.

Field Observations

Wolf and coyote. Most field observations were made during the winter tracking season which may present some biases. Most deer and many of the elk leave the study area in winter and yard-up in areas of less snow accumulation to the south and east (pers. obs., McLellan pers. comm.), removing a valuable food resource for carnivores. I saw few elk and no deer tracks in the study area from mid-December through early April. High concentrations of deer and elk winter at the head of Kintla Lake in Glacier National Park. Moose did not emigrate from the study area, however, and many of them wintered in the Sage Creek/Proctor Lake area. The wolf also wintered in this area and killed and scavenged on moose throughout winter and early spring. The wolf was never located in the northern end of her home range during winter (see Territoriality and Home Range). This may be due to a lack of ungulates there and a plentiful supply of moose in the southern part of her home range. Moose were the most commonly scavenged item by both wolves and coyotes (Table 8).

Coyotes disregarded human scent on refuse and often scavenged off hunter-killed game animals, dumps, and campsites. In contrast, the wolf strongly avoided food that had any human odor on it. In February 1980, a wolf walked past a sawed elk leg bone without investigating it. Five days after I had disturbed a wolf's fresh moose calf kill the wolf returned to the area but would not cross my snowshoe tracks to feed on her kill 30 m beyond my tracks. On several occasions, other Project personnel and I witnessed similar avoidance behavior by a wolf to ski, snowshoe, and boot tracks, although the animal did travel on snowmobile tracks. Perhaps tracks of footwear carried human scent but the snowmobile track did not. Generally, coyotes did not avoid human tracks from any mode of transportation, and often traveled in them.

Wolf-Coyote Interactions

No direct interactions between wolf and coyote were observed, but indirect encounters occurred frequently as revealed by tracks; no evidence of interspecific avoidance behavior was found. Coyotes often followed wolf tracks and, less frequently, a wolf followed coyote tracks. Interspecific scent-marks were always examined and occasionally re-marked (see Scent-marking). Likewise, interspecific beds were usually examined and occasionally interspecifically scent-marked. Coyotes and a lone wolf examined each others' sign with apparently equal interest. Coyotes and a lone wolf occasionally scavenged on the same carcass, but difference in freshness of tracks indicated that they fed at different times.

Lack of direct interspecific encounters by co-habitating wolves and coyotes in the study area may be the result of 2 factors: 1) the wolf density is so low that there are very few chances for encounters, and 2) although coyotes and a wolf utilize the same areas spatially they avoid each other temporally. Berg and Chesness (1978) studied interacting low-density coyote populations and high-density wolf populations in Minnesota and reported that coyotes generally avoided the wolf-occupied range. They found evidence of wolves chasing coyotes, aerially observed a fight between a wolf and a coyote, and found 2 coyotes killed by wolves. Several researchers have found similar agonistic wolf-coyote interactions in areas of low-density coyote/high-density wolf populations (Young and Jackson 1951, Stenlund 1955, Mech 1966, Fuller and Keith 1981). All agree that interspecific interactions are detrimental to coyotes, but that coyotes benefit from co-habiting with wolves by scavenging on abandoned wolf kills.

The reverse situation existed in my study area. I found no related studies in the literature on the ecology and interspecific interactions in an area of high-density coyote and low-density wolf populations. My data indicated little direct interspecific interactions and/or competition for space and food (see Food Habits, and Territory and Home Range). However, the indirect competition may influence the natural recovery of wolves in the Flathead. The high numbers of coyotes in the area were relatively efficient at consuming scavenged carcasses, removing a possible food resource for the wolf. For example, a wolf did not return to her moose calf kill for 5 days, during which time coyotes and a wolverine consumed 70% of the carcass. This competitive scavenging may be an obstacle to lone wolves trying to establish themselves in the Flathead. An established pair or pack of wolves would be more likely to defend and more wholly consume their kills.

Mortality

Wolf. No known wolf mortality occurred in the Flathead drainage during the course of my study. Mech (1970) stated that wolves are subject to many diseases and parasites that the wolf has evolved with, but that "none of them has ever threatened to wipe the wolf off the face of the earth. Only the devices of man have been able to do this." Possible wolf predators within the study area include grizzles, cougars, competing wolves, and humans. The first 3 occur in very low densities while the latter inhabit the area in relatively high seasonal concentrations. Human utilization of thê Flathead (hunting, trapping, logging, mining) is more likely the cause of low wolf densities than natural limiting factors such as disease, food supply, or competing predators. Hendrickson et al. (1975) and Weise et al. (1975) studied very low-density wolf populations in Michigan, and Mech and Nowak (1980) and Thiel and Welch (1981) in Wisconsin. Wolves had been extirpated from these areas but occasional recent wolf observations indicated possible recovery. All authors concluded that human-related mortality was the factor limiting the wolf population. The same appeared to be true in the Flathead drainage. To enhance natural wolf recovery in the Flathead drainage, human disturbance must be minimized through careful land and resource management (see Management Recommendations).

Coyote. At least 11 Flathead coyotes were killed by people, and at least 3 were killed by wild carnivores during my 2 years of observations. Female No. 15 was killed by a cougar and cached in a tree. Teeth marks and damage to the skull of male No. 17 indicated that he was killed by a cougar (O'Gara pers. comm.). The carcass of male No. 7 was found near an elk carcass with much sign of struggle. O'Gara examined the crushed skull and determined that No. 7 was killed by a very small wolf or, more likely, a large coyote.

It appeared that No. 7 was attacked at the elk carcass and killed while trying to flee.

Minimal hunting and trapping pressure was exerted on the coyote population in the study area. I knew the local trappers and was informed of the majority of human-caused coyote mortalities in the study area.

CHAPTER VI

MANAGEMENT RECOMMENDATIONS

Wolves and coyotes have similar environmental requirements, so plans for wolf management should also benefit the coyote. The Flathead drainage supports a viable coyote population of moderate density, and a nearly extinct wolf population. Therefore, my management recommendations are directed at increasing and stabilizing the wolf population. Wolf management is an extremely controversial issue and implementing a sound management plan may be difficult.

The main considerations for increasing wolf numbers in the Flathead are: 1) potential wolf ingress, 2) human interactions, 3) adequate food resources, and 4) spatial requirements. Historically, wolves were present in the Flathead in low numbers without benefit of any management plans. Although there was human activity in the Flathead Valley, it was on a much smaller scale and less mechanized. However, the million-dollar oil rigs, vast timber sales, human recreation, and numerous roads are here now and cannot be eliminated. Realistically, wolf management must work cooperatively with these developments. One or 2 wolves may not be of economic or recreational value to the majority of the public and therefore may not be justification for management plans that would limit human utilization of the Flathead. However, if wolf numbers were increased to the point where wolves could be harvested and managed as a game species and thereby become of economic and recreational value, the public may then be willing to accept management recommendations that limit human activities in the Flathead. Management plans to increase the wolf population may benefit most predators, including the grizzly bear, so biologists should work together in creating a comprehensive predator management plan for the Flathead drainage.

1. Recommendation: Monitor the wolf population in the Flathead Valley via winter tracking census, interviewing trappers, and collecting reports of wolf sightings and sign throughout the year.

Rationale: More wolf activity information is needed to establish a more detailed management plan.

2. Recommendation: Reimburse ranchers in the Flathead drainage for wolf depredations of their livestock.

Rationale: Reimbursing ranchers for their wolf-caused livestock losses may make these losses more acceptable, decreasing ranchers' hostilities towards wolves. A Department of Agriculture reimbursement program has been established in Minnesota for wolf depredations of livestock. Dr. Fritts, director of the USFWS depredation control program, feels that the state program has reduced local wolf hostilities and thereby decreased the number of wolves illegally killed (Fritts pers. comm.).

3. Recommendation: Manage habitat to increase ungulate populations.

Rationale: Ungulates are the primary food resource for wolves, so increasing ungulate numbers may encourage the establishment of wolves in the Flathead drainage.

4. Recommendation: Establish trapping restrictions such as creating a coyote harvest season, allowing no traps larger than a no. 3 to be used on any furbearer, and setting a maximum height that neck snares may be set (i.e., 18 inches [45 cm] from the ground to the top of the snare).

Rationale: Any or all of these recommendations would decrease the chance of accidental wolf captures and thus decrease wolf mortalities, while not reducing captures of other furbearers.

5. Recommendation: Minimize human impact through careful assessment and regulation of resource use in the Flathead drainage. This would include:

--limiting access sites and the increased River usage created by the North Fork's inclusion in the Wild and Scenic Rivers Act;

--regulation of site occupation, road building, and waste disposal of coal mines and drilling operations;

--regulation of timber harvests, tree-planting, road building and road closures (logging roads should be closed via bridge removal, gates, kelly-humping, etc., after completion of logging);

--regulation of improvements on roads to be compatible with wildlife and habitat; and

--regulation of land development and subdivisions.

Rationale: These regulations may preserve habitat and minimize wolf-human encounters and, therefore, benefit wolves.

REFERENCES CITED

Anonymous. 1981. Man vs. coyote in L.A. Newsweek. October 26:35.

Adorjan, A. S., and G. B. Kolenosky. 1969. A manual for the identification of selected Ontario mammals. Ontario Dept. of Lands and Forests. 64 pp.

Bailey, U., and F. M. Bailey. 1918. Wild animals of Glacier National Park. U.S. Govt. Printing Office, Washington, D.C. 219 pp.

Bekoff, M., and M. C. Wells. 1980. The social ecology of coyotes. Sci. Am. 242:130-148.

Berg, W. E., and R. A. Chesness. 1978. Ecology of coyotes in northern Minnesota. Pp. 229-246 in M. Bekoff (Ed.). Coyotes: biology, behavior, and management. Academic Press, New York.

Camenzind, F. J. 1978. Behavioral ecology of coyotes on the National Elk Refuge, Jackson, Wyoming. Pp. 267-293 in M. Bekoff (Ed.). Coyotes: biology, behavior, and management. Academic Press, New York.

Connolly, G. E. 1978. Predator control and coyote populations: a review of simulation models. Pp. 327-345 in M. Bekoff (Ed.). Coyotes: biology, behavior, and management. Academic Press, New York.

DeSanto, J. Ranger, Glacier National Park, Montana. Personal communication.

Fritts, S. H. Biologist, North Central Experiment Station, Minnesota. Personal communication.

________, and L. D. Mech. 1981. Dynamics, movements, and feeding ecology of a newly protected wolf population in north-western Minnesota. Wildl. Monogr. 80:1-79.

Fuller, T. K., and L. B. Keith. 1981. Non-overlapping ranges of coyotes and wolves in northeastern Alberta. J. Mamm. 62:403-405.

Gillette, G. Forester, British Columbia Forestry. Personal communication.

Habeck, J. R. 1970. The vegetation of Glacier National Park. U.S. Dept. Int., Natl. Park Serv., and Univ Mont., Missoula. 123 pp.

Hamlett, G. W. 1938. The reproductive cycle of the coyote. U.S. Dept. Agric. Tech. Bull. 616. 12 pp.

Hamlin, K. L., and L. L. Schweitzer. 1979. Cooperation by coyote pairs attacking mule deer fawns. J. Mamm. 60:849-850.

Hendrickson, J., W. L. Robinson, and L. D. Mech. 1975. The status of the wolf in Michigan. Amer. Midl. Nat. 94:226-232.

Jonkel, C. J. Annual reports of the Border Grizzly Project. Univ. Mont., Missoula. 1975-79.

Kennedy, A. J., and L. N. Carbyn. 1980. Identification of wolf prey using hair and feather remains with special reference to western Canadian national parks. Canad. Wildl. Serv., Edmonton, Alberta. 51 pp.

Knowlton, F. F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. J. Wildl. Manage. 36:369-382.

Koterba, W. D., and J. R. Habeck. 1971. Grasslands of the North Fork Valley, Glacier National Park, Montana. Canad. J. Bot. 49:1627-1636.

Kruuk, H. 1972. The spotted hyena. Univ. Chicago Press, Chicago. 335 pp.

Lechleitner, R. R. 1971. Mammals of Glacier National Park. Glacier Nat. Hist. Assoc., Bull. 6. West Glacier, Montana. 92 pp.

Lehner, P. N. 1978. Coyote communication. Pp. 128-159 in M. Bekoff (Ed.). Coyotes: biology, behavior, and management. Academic Press, New York.

McLellan, B. Biologist, British Columbia Fish and Wildlife Branch. Personal communication.

Mech, L. D. Biologist, North Central Forest Experiment Station, Minnesota. Personal communication.

Mech, L. D. 1966. The wolves of Isle Royale. U.S. Dept. Int., Natl. Park Serv., Fauna Ser. 7. 210 pp.

________. 1970. The wolf: the ecology and behavior of an endangered species. Doubleday, New York. 384 pp.

________. 1975. Disproportionate sex ratios of wolf pups. J. Wildl. Manage. 39:737-740.

________, and R. M. Nowak. 1980. Return of the gray wolf to Wisconsin. Am. Midl. Nat. 105:408-409.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Moore, T. D., L. E. Spence, and C. E. Dugnolle. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. W. G. Hepworth (Ed.). Wyoming Fish and Game. 177 pp.

Murie, A. 1940. Ecology of the coyote in Yellowstone. U.S. Dept. Int., Natl. Park Serv., Fauna Ser. 4. 206 pp.

________. 1944. The wolves of Mount McKinley. U.S. Dept. Int., Natl. Park Serv., Fauna Ser. 5. 238 pp.

Murie, O. J. 1954. A field guide to animal tracks. Houghton Mifflin Co., Boston. 375 pp.

Niebauer, T. J., and O. J. Rongstad. 1975. Coyote food habits in northwestern Wisconsin. Pp. 237-251 in R. L. Phillips and C. Jonkel (Eds.). Proc. Pred. Symp., Bull. Mont. For. Cons. Exp. Sta., Univ. Mont., Missoula. 268 pp.

O'Gara, B. Biologist, University of Montana. Personal communication.

Ozoga, J. J., and E. M. Harger. 1966. Winter activities and feeding habits of northern Michigan coyotes. J. Wildl. Manage. 30:809-818.

Peters, R. P., and L. D. Mech. 1975. Scent-marking in wolves. Am. Sci. 63:628-637.

Pimlott, D. H., J. A. Shannon, and C. B. Kolenosky. 1969. The ecology of the timber wolf in Algonquin Park. Ont. Dept. Lands For. Res. Rept. (Wildl.) 87:1-92.

Pyrah, D. 1980. Effects of coyote predation on big game populations in the Missouri breaks of central Montana. State of Montana, Job final report: project W-120-R-11 (5893). 35 pp.

Ream, R. R. In prep. Scent-marking by a lone female wolf.

________, and U. Mattson. 1982. Wolf status in the northern Rockies. Pp. 362-381 in Harrington, F. H., and P. C. Paquet (Eds.). Wolves of the World. Noyes Publ., Park Ridge, NJ. 474 pp.

Rothman, R. J., and L. D. Mech. 1979. Scent-marking in lone wolves and newly formed pairs. Anim. Behav. 27:750-760.

Schladweiller, P. 1980. Coyote densities, small mammal population indices, and big game fawn production and survival in the various study areas. State of Montana, Job final report: project W-120-R-9. 78 pp.

Schwennesen, D. 1980. Glacier under seige. The Missoulian. December 30.

Scott, T. G. 1941. Methods and computation in fecal analysis with reference to the red fox. Iowa St. Coll. J. Sci. 15:279-285.

Seal, U. S., A. E. Erickson, and J. G. Mayo. 1970. Drug immobilization of the carnivora. Int. Zoo Yearbook 10:157-170.

________, E. D. Plotka, J. M. Packard, and L. D. Mech. 1979. Endocrine correlates of reproduction in the wolf: I. Serum progesterone, estradiol and LH during the estrous cycle. Biol. of Reprod. 21:1057-1066.

Sergeant, D. E., and D. H. Pimlott. 1959. Age determination in moose from sectioned incisor teeth. J. Wildl. Manage. 23:315-321.

Shea, D. S. 1976. A wintertime ecological evaluation of the North Fork Flathead River drainage, Glacier National Park. 33 pp.

Singer, F. J. 1975. The history and status of wolves in northern Glacier National Park, Montana. Glacier Natl. Park Sci. Paper 1. 55 pp.

Stenlund, M. H. 1955. A field study of the timber wolf on the Superior National Forest, Minnesota. Minn. Dept. Cons. Tech. Bull. 4. 55 pp.

Thiel, R. P. 1978. The status of the timber wolf in Wisconsin--1975. Trans. Wis. Acad. Sci. Arts Lett. 66:186-194.

________, and R. J. Welch. 1981. Evidence of recent breeding activity in Wisconsin wolves. Am. Midl. Nat. 106:401-402.

Thompson, D. Q. 1952. Travel, range, and food habits of timber wolves in Wisconsin. J. Mammal. 33:429-452.

Van Ballenberghe, V., A. W. Erickson, and D. Byman. 1975. Ecology of the timber wolf in northeastern Minnesota. Wildl. Monogr. 43. 43 pp.

Weise, T. F., W. L. Robinson, R. A. Hook, and L. D. Mech. 1975. An experimental translocation of the eastern timber wolf. Audubon Cons. Rept. 5:1-28.

Wells, M. C., and M. Bekoff. 1981. An observational study of scent-marking in coyotes. Anim. Behav. 29:332-350.

Weaver, J. L., and S. H. Fritts. 1979. Comparison of coyote and wolf scat diameters. J. Wildl. Manage. 43:786-788.

Wetmore, S. P., C. H. Nellis, and L. B. Keith. 1970. Alberta Dept. Lands For. Fish Wildl. Div., Wildl. Tech. Bull. 2. 22 pp.

Young, S. P., and H. T. Jackson. 1951. The clever coyote. Stackpole, Harrisburg, Pennsylvania and The Wildlife Management Institute, Washington, D.C. 411 pp.

APPENDIX A

HISTORICAL AND CURRENT DISTRIBUTIONS OF THE WOLF AND COYOTE IN NORTH AMERICA

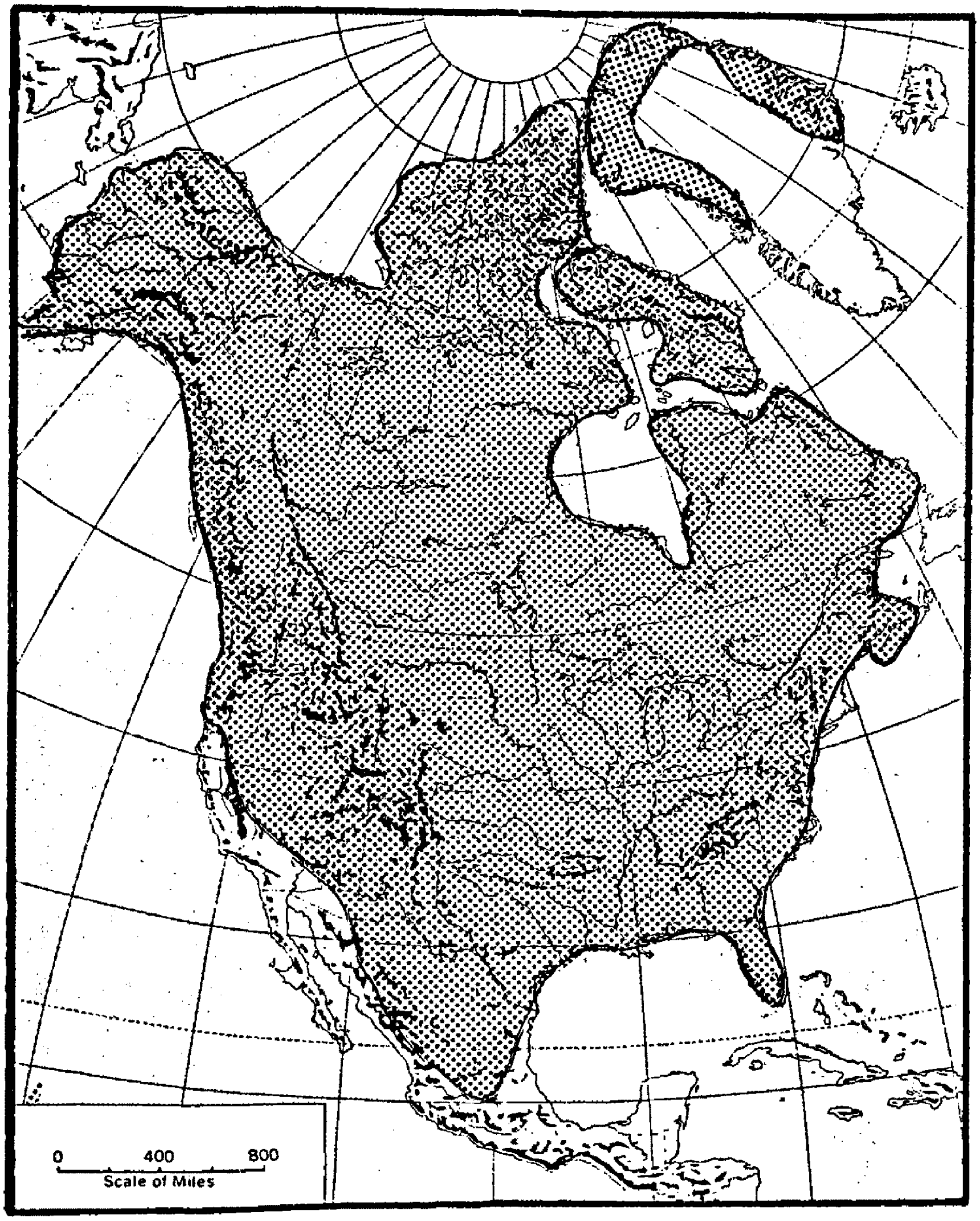


Fig. 1. Historical distribution of the wolf (from Mech 1970).

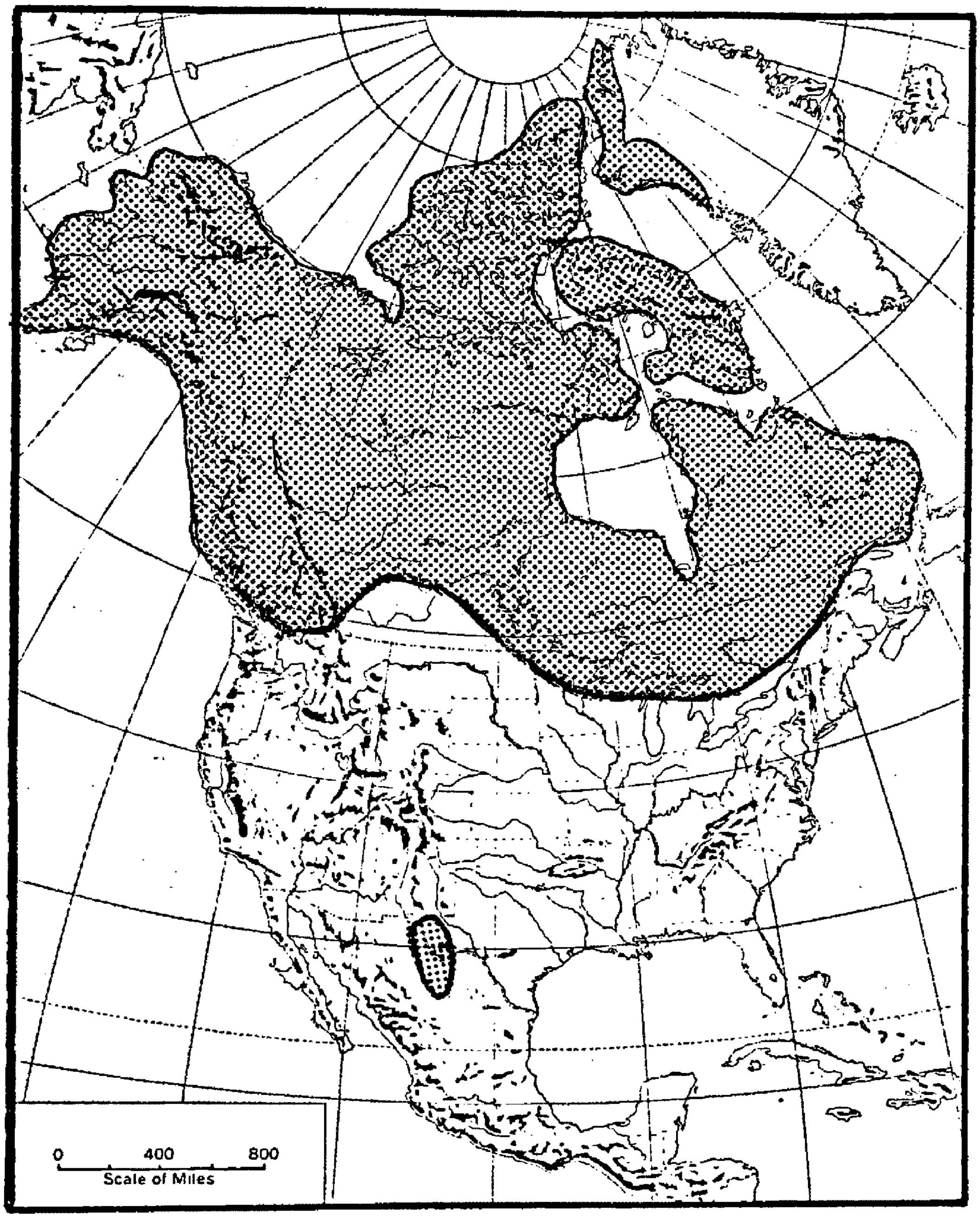


Fig. 2. Current distribution of the wolf (from Mech 1970).

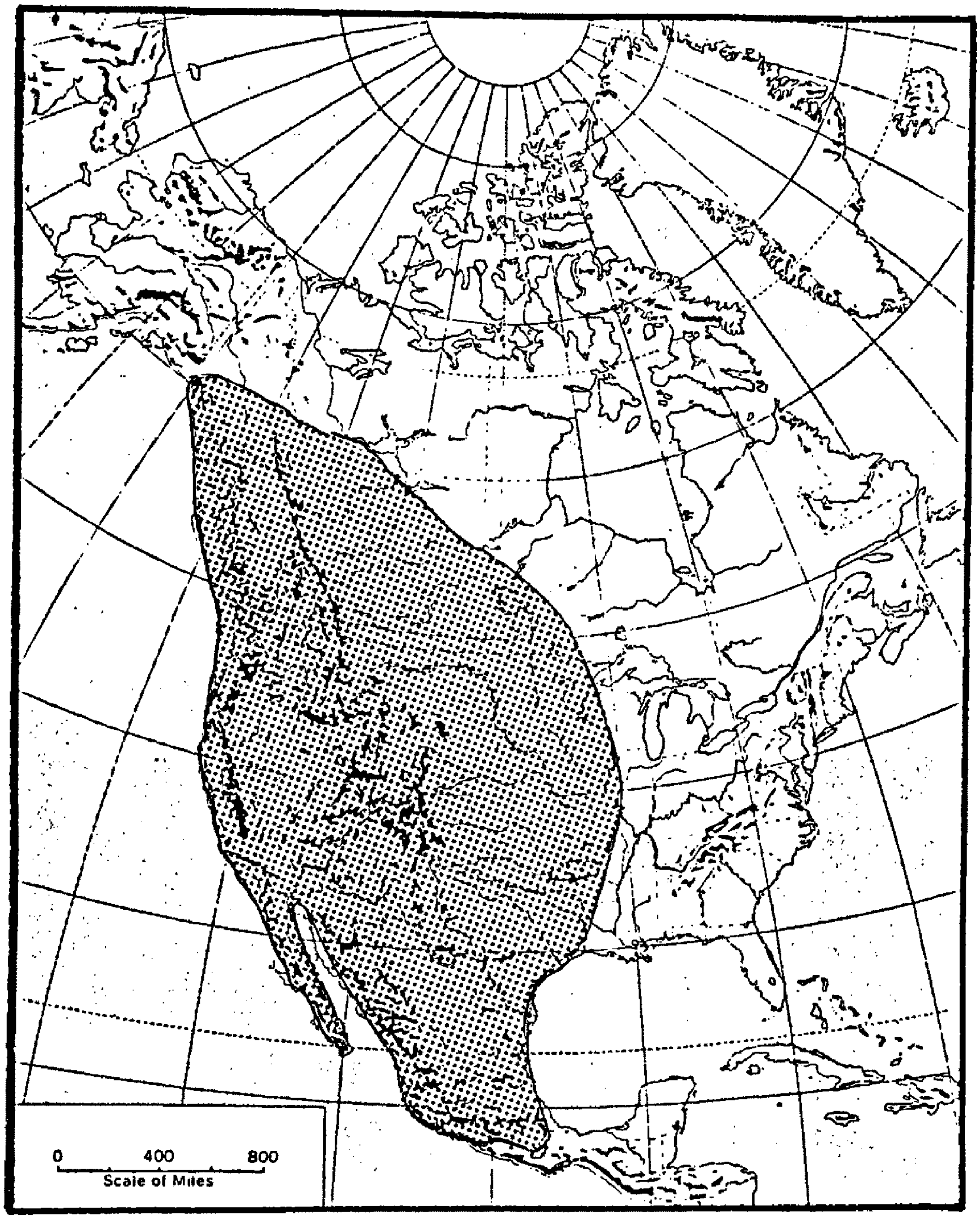


Fig. 3. Historical distribution of the coyote (from Young and Jackson 1951).

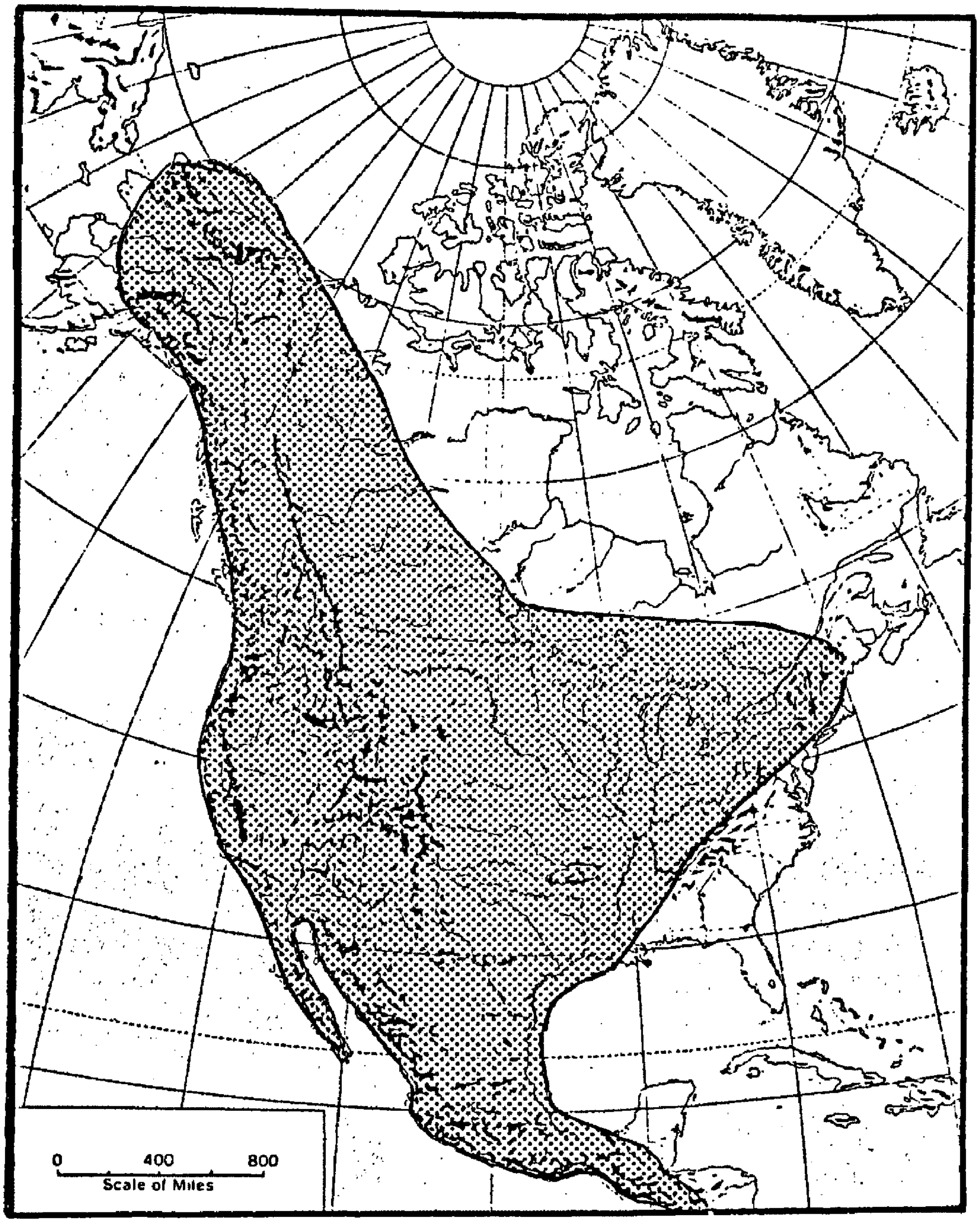


Fig. 4. Current distribution of the coyote (from Young and Jackson 1951).

APPENDIX B

WEATHER DATA

Weather Data for 1979 and 1980

Month	Means of combined Polebridge/Fernie data			
	Mean maximum (°F)	Mean minimum (°F)	Precipitation (inches)	Snow (inches)
J	18.7	8.3	1.4	24.6
F	37.5	7.8	2.2	28.5
M	44.8	11.8	1.4	15.5
A	60.0	23.5	1.6	6.6
M	68.3	31.5	3.1	0.4
J	73.3	35.8	2.5	0.0
J	80.8	40.0	1.5	0.0
A	78.5	38.3	2.0	0.0
S	72.0	33.0	1.7	0.0
O	63.5	24.3	1.8	0.0
N	42.3	14.5	2.2	8.6
D	40.0	8.5	4.7	38.4
Totals	N/A	N/A	26.1	122.6

APPENDIX C

CAPTURE DATA FROM WOLF AND COYOTES

Table 1. Body measurements.

Animal number[a]	Sex	Body length, nose to tail tip (inches)	Weight (lbs.)	Estimated age
C 537	♂	46	28	subadult
C 537	♂	46	25.5	adult
C 17	♂	45	27	subadult
C 1	♂	45	25	adult
C 550	♂	50	32.5	adult
C 150	♂	51	26	adult
C 5	♂	48	25	adult
C 7	♂	47	24.5	adult
C 11	♂	48	22	adult
MEAN		47.5	26.2	
C 532	♀	--	27	adult
C 543	♀	45	19	subadult
C 148	♀	47.5	19	subadult
C 143	♀	49.5	27.5	subadult
C 3	♀	47.5	--	adult
C 9	♀	45	19.5	adult
C 15	♀	42.5	19	adult
MEAN		46.2	21.8	
C 535	♂	42	15	pup
C 540	♂	45	24	pup
C 17	♂	45	25.5	pup
C 50	♀	--	--	pup
MEAN		44.0	21.5	
W 114	♀	--	80	adult

[a]C = coyote; W = wolf.

Table 2. Length of canine tooth.

Animal number[a]	Sex	Upper right (cm)	Upper left (cm)	Lower right (cm)	Lower left (cm)
Subadult and adult males					
C 537	♂	2.0	2.0	1.8	1.7
C 537	♂	2.0	1.6	1.8	1.8
C 17	♂	2.2	2.2	1.9	1.9
C 1	♂	1.1	1.2	1.6	1.0
C 550	♂	1.4	2.0	1.9	1.8
C 150	♂	2.4	2.3	2.1	2.0
C 5	♂	2.2	2.1	1.7	1.9
C 7	♂	1.9	1.9	1.8	1.8
C 11	♂	2.0	2.0	1.8	1.9
MEAN		1.9	1.9	1.8	1.8
Subadult and adult females					
C 532	♀	1.4	1.4	1.3	1.7
C 543	♀	0.8	1.1	1.0	1.0
C 148	♀	2.0	1.9	1.7	1.7
C 143	♀	2.0	1.8	1.7	1.6
C 3	♀	1.7	1.2	1.6	1.6
C 9	♀	1.8	1.7	1.7	1.6
C 15	♀	1.9	1.8	1.8	1.7
MEAN		1.7	1.6	1.5	1.6
Pups					
C 535	♂	1.3	1.2	1.1	1.2
C 540	♂	0.9	0.8	1.0	1.2
C 17	♂	0.8	0.8	1.0	1.0
C 50	♀	--	--	--	--
MEAN		1.0	0.9	1.0	1.1
W 114	♀	1.3	2.5	1.3	2.2

[a]C = coyote; W = wolf.

Table 3. Testicle measurements.

Date	Coyote number	Age	Right testicle length (cm)	Right testicle width (cm)	Left testicle length (cm)	Left testicle width (cm)
10- 6-79	537	subadult	1.9	1.2	2.0	1.4
5-31-80	537	adult	2.1	1.0	2.1	1.3
9- 1-80	17	subadult	--------not measured--------			
10-20-79	1	adult	--------not descended--------			
10-22-79	550	adult	2.6	1.9	2.6	1.7
11-17-79	150	adult	2.5	1.7	2.7	1.5
2-11-80	5	adult	3.0	1.4	not measured	
6- 3-80	7	adult	2.3	1.2	2.4	1.8
7-12-80	11	adult	2.3	1.4	2.2	1.3
MEAN			2.4	1.4	2.3	1.5
10- 5-79	535	pup	--------not descended--------			
10- 6-79	540	pup	2.0	1.3	too small to grasp	
10- 7-79	17	pup	--------not descended--------			

Table 4. Mammary measurements.

Date	Coyote number	Age	Mammae height (cm)	Mammae width at base (cm)
10- 4-79	532	adult	0.8	0.7
10- 7-79	543	subadult	-----inconspicuous-----	
11-11-79	148	subadult	-----inconspicuous-----	
11-18-79	143	subadult	-----inconspicuous-----	
2- 8-80	3	adult	not measured (in heat)	
7-11-80	9	adult	0.1	0.1
7-17-80	15	adult	-----inconspicuous-----	
10-27-79	50	pup	-----inconspicuous-----	

APPENDIX D

WOLF SIGN IN THE STUDY AREA

Wolf Sign Reported in the Flathead by Non-WEP People During the Study Period

Date	Observer	Location	Comments
Summer 1977	Phil and Sylvia Sue	5 miles north of Polebridge	saw a gray and tan wolf trotting
2-4-79	Ceyline Doyan	79 km on the Flathead Rd	saw a gray wolf standing there, then it ran
Spring 1979	Don Jakabec	Flathead, near border	saw a black wolf
10-21-79	3 hunters	Commerce Creek	saw a gray wolf
Fall 1979	Ron Wilhelm	near Polebridge	saw a gray wolf
5-31-80	Joe Newman	20 km on the Lodgepole Rd	saw a gray wolf
Spring 1980	Townsend boys	McLatchie Creek	saw 4 gray wolves
3-18-81	Earl Gorrie	Flathead, near border	fresh wolf tracks of a lone wolf
1979-1981	Bruce McLellan	throughout Flathead	often sees tracks and scats
3-14-81	Dan Carney	British Columbia/ Montana border	tracks
Fall 1979	Herman Lutzke	73 km on the Flathead Rd	saw a gray wolf
4-9-80	Allen Foster	Middlepass Creek	tracks