



Reestablishment of swift fox in north central Montana
by Amy L Zimmerman

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:

Canadian wildlife agencies began a swift fox (*Vulpes velox*) reintroduction program in southern Alberta and Saskatchewan, Canada in 1983. Over the next decade, these reintroduction efforts led to a strong possibility of individuals dispersing into north central Montana and creating a resident population. This study began in the fall of 1996 in northern Blaine County, Montana to confirm the presence of a resident swift fox population. Secondary sites were surveyed in northern Phillips and Valley Counties. The study involved systematic grid trapping by township using live traps and radio collaring any swift foxes captured. Home ranges, food habits, survival, habitat comparisons by township, land ownership/management patterns by township, and the degree of topographical roughness in each township were all investigated. In the spring of 1997, radio collared swift fox were used to locate possible natal den sites and to confirm a resident population. A total of 16 swift foxes were trapped in the fall of 1996 and late summer of 1997. Five of the captured swift foxes were juveniles and 11 were adults. In the spring of 1997, 3 litters were produced in northern Blaine County. These litters were monitored through the summer. Average home range size using the Minimum Convex Polygon method was 10.4 km² and the average using the Adaptive Kernel method was 12.3 km². Survivorship was estimated at 4.6 %. Fecal samples used for food habit analysis were dominated by mammal material, with *Microtus* spp. being the highest in percent occurrence. No relationships were found in the habitat composition, land ownership/management patterns, or topographical roughness in townships with and without swift foxes. The swift fox has reestablished a population in northcentral Montana, and evidence suggests that the population is surviving and reproducing. A wider range of habitat in northcentral Montana needs to be surveyed to determine swift fox distribution and population density.

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MONTANA

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MONTANA STATE UNIVERSITY--BOZEMAN
Bozeman, Montana,

April 1998

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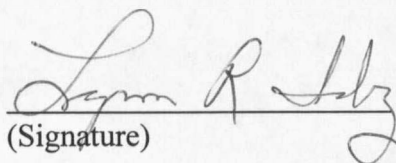
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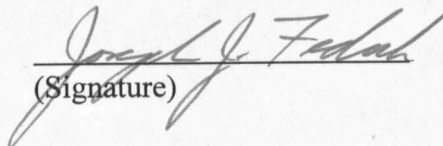
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ACKNOWLEDGMENTS

This project was funded by Montana Fish, Wildlife, and Parks and supported by Montana State University. I would like to thank Dr. Lynn Irby for his guidance in this project. Special thanks also goes to Brian Giddings of Montana Fish, Wildlife, and Parks, for providing materials, guidance, and encouragement. Thanks goes to my committee for assisting with technical support and advice: Bob Garrott, Bok Sowell, and Al Zale. Alisa Gallant and Bo Wilmer were great in helping me with ArcView and ArcInfo applications. Melissa Hart was also key in obtaining digital land cover data. Thanks to Cathy Siebert and Bob Moore for their help in fecal analysis. Kristie Allen, Dan Gustafson, Jay Rotella, and Mark Taper gave much needed advice in data analysis. Thanks to all of the agency folks in Havre and Chinook--Jody Peters, Kent Gilge, Dan Hughbanks, Al Rosgaard, and all of the local trappers. Thanks to the leasees and landowners of my study area for their cooperation and support of this project, especially Earl and Jerry Bahr, the Davies' and Patti Matthews. Thanks to Buttrey's of Havre and Media Works of Bozeman. Christiane Roy, Ludwig Carbyn, and Marsha Sovada gave me advice and support. Thanks to my office mate, Kayhan Ostovar and my emotional advisor, Michele Kastler for their support. Special thanks to my technician Heather Marstall. Much love and thanks to my family, who have always supported me throughout my scholastic career. Finally, thanks to my husband for all of his sacrifice, unconditional love, and support.

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ABSTRACT

Canadian wildlife agencies began a swift fox (*Vulpes velox*) reintroduction program in southern Alberta and Saskatchewan, Canada in 1983. Over the next decade, these reintroduction efforts led to a strong possibility of individuals dispersing into north central Montana and creating a resident population. This study began in the fall of 1996 in northern Blaine County, Montana to confirm the presence of a resident swift fox population. Secondary sites were surveyed in northern Phillips and Valley Counties. The study involved systematic grid trapping by township using live traps and radio collaring any swift foxes captured. Home ranges, food habits, survival, habitat comparisons by township, land ownership/management patterns by township, and the degree of topographical roughness in each township were all investigated. In the spring of 1997, radio collared swift foxes were used to locate possible natal den sites and to confirm a resident population. A total of 16 swift foxes were trapped in the fall of 1996 and late summer of 1997. Five of the captured swift foxes were juveniles and 11 were adults. In the spring of 1997, 3 litters were produced in northern Blaine County. These litters were monitored through the summer. Average home range size using the Minimum Convex Polygon method was 10.4 km² and the average using the Adaptive Kernel method was 12.3 km². Survivorship was estimated at 46%. Fecal samples used for food habit analysis were dominated by mammal material, with *Microtus spp.* being the highest in percent occurrence. No relationships were found in the habitat composition, land ownership/management patterns, or topographical roughness in townships with and without swift foxes. The swift fox has reestablished a population in northcentral Montana, and evidence suggests that the population is surviving and reproducing. A wider range of habitat in northcentral Montana needs to be surveyed to determine swift fox distribution and population density.

INTRODUCTION

Swift fox (*Vulpes velox*) were originally thought to occur widely on the Great Plains from northeastern New Mexico and northwest Texas to southern Alberta and Saskatchewan, Canada (Hall 1981, Johnson 1969). Swift fox were extirpated or experienced population declines in the northern part of the United States (U.S.) and southern Canada early this century, while persisting in the central and southern portions of the range (Warren 1942, Armstrong 1972, Bee et al. 1981). Causes for the decline of swift fox in their northern range (U.S. and southern Canada) were believed to be related to their vulnerability to poisoned baits and traps used for coyote (*Canis latrans*) and wolf (*Canis lupus*) control (Brechtel et al. 1996). Other factors that may have contributed to the decline included the loss of habitat to dryland agriculture, a changing prey base, and increased interspecific competition with medium sized carnivores, such as the coyote and red fox (*Vulpes vulpes*) (Brechtel et al. 1996). In the U.S., the swift fox is currently listed as a (listing is warranted, but precluded) candidate species under the Endangered Species Act of 1973. It has a listing priority of 9 on a scale of 1 (high priority) to 12 (low priority).

Presently, viable populations of swift fox occur in areas of suitable habitat in Kansas, Colorado, and Wyoming (Allen et al. 1995). Kansas classifies the swift fox as a state furbearer with an open harvest season (Roy 1996). Wyoming classifies the swift fox as a nongame species and Colorado has a closed season on swift fox (Kahn and Beck 1996, B. Luce, pers. comm.). South Dakota has listed the swift fox as a state threatened

species, and the swift fox is listed as a state endangered species in Nebraska (Andelt 1995, Dateo et al. 1996). The swift fox is considered a species of special concern in Oklahoma, with a closed season on harvest (Whitaker-Hoagland 1996). Texas and New Mexico classify the swift fox as a furbearer with an open harvest season, but harvest is reported to be minimal due to low trapping intensity (Horner 1995, Schmitt 1995). Closed seasons for swift fox harvest exist in Montana and North Dakota (Allen 1995, Giddings 1996).

The species was declared extinct in Montana in 1969 because of a 16-year absence of swift fox in fur harvest records (Hoffman et al. 1969). No swift foxes were recorded in Montana until 1978, when a male was trapped in Custer county (Moore and Martin 1980). This animal, however, may have been dispersing from northeastern Wyoming or southwestern South Dakota. In Canada, the last known swift foxes in Saskatchewan and Alberta were collected in 1928 and 1938, respectively (Soper 1964, Banfield 1974). The swift fox was designated as extirpated by the Committee on the Status of Endangered Wildlife in Canada in 1978 because of the lack of observations since 1938 (Brechtel et al. 1996).

A reintroduction program began in southern Alberta and Saskatchewan in 1983-1984, with annual swift fox releases planned through 1998 (Brechtel et al. 1996). The Canadian National Recovery Plan for the Swift Fox has three main objectives. The first is to establish two geographically distinct, yet genetically connected core populations with an average spring density of 5 adults per township. Other objectives are to ensure the long term security of key swift fox habitat in two main areas of the Canadian prairie

and to establish swift foxes in at least 50 percent of the suitable habitat remaining on the Canadian prairies (Brechtel et al. 1996). The plan's overall goal is to establish a target population of 420 foxes by the year 2000.

Three main release areas were established in Alberta and Saskatchewan. One of the release areas lies south of the Cypress Hills along the Alberta-Saskatchewan border, and a second site is on the Wood Mountain Plateau in Grasslands National Park, Saskatchewan (Fig. 1). A third release site is located along the Milk River ridge south of Lethbridge, Alberta (Fig. 2). The population along the Alberta/Saskatchewan border is currently the largest. Releases are a combination of Canadian captive-reared foxes and wild foxes obtained from Wyoming. Seventy to 100 foxes have been released annually since 1983 (Brechtel et al. 1996). In 1993, the wildlife directors of Alberta, Saskatchewan, and the Prairie and Northern Region of the Canadian Wildlife Service decided that the reintroduction effort would continue for another five years (Brechtel et al. 1996). A population assessment carried out in the winter of 1996-1997 estimated the Canadian swift fox population at 289 foxes, with a 95% confidence interval of 179-412 foxes (Cotterill 1997).

Recent observations of swift foxes in Montana have been recorded in northcentral and southeastern Montana (Fig. 3). Observations of swift foxes in portions of northcentral Montana have been increasing in recent years, presumably the result of the Canadian reintroduction program (Giddings and Knowles 1995). Canadian swift foxes dispersed into northcentral Montana throughout the late 1980s and early 1990s (Brechtel et al. 1993). It was not known, however, if these dispersing foxes were surviving and

establishing a resident population in Montana.

The goal of my project was to verify and document the presence of the species in portions of northcentral Montana. One study objective was to document reproduction in Montana by locating and documenting natal den sites. Additional study objectives included an investigation of relative distribution, home range size, reproductive success, survival, and food habits of radio collared swift foxes. Habitat composition, land ownership/management, and the degree of topographical roughness of areas that swift foxes currently occupy in northcentral Montana were also analyzed to determine if these attributes affected the probability of swift fox presence.

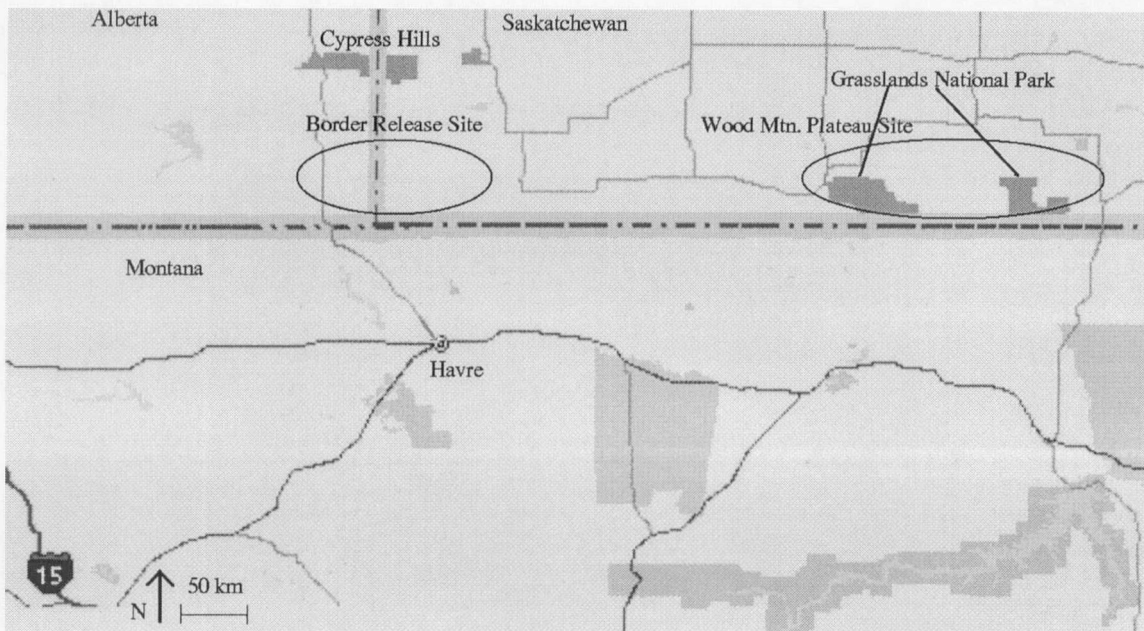


Figure 1. Two swift fox release sites for the Canadian reintroduction program, 1983-1998. The Border release site is located on the border of Alberta, Saskatchewan, and Montana. The Wood Mountain Plateau release site is located near Grasslands National Park in Saskatchewan.

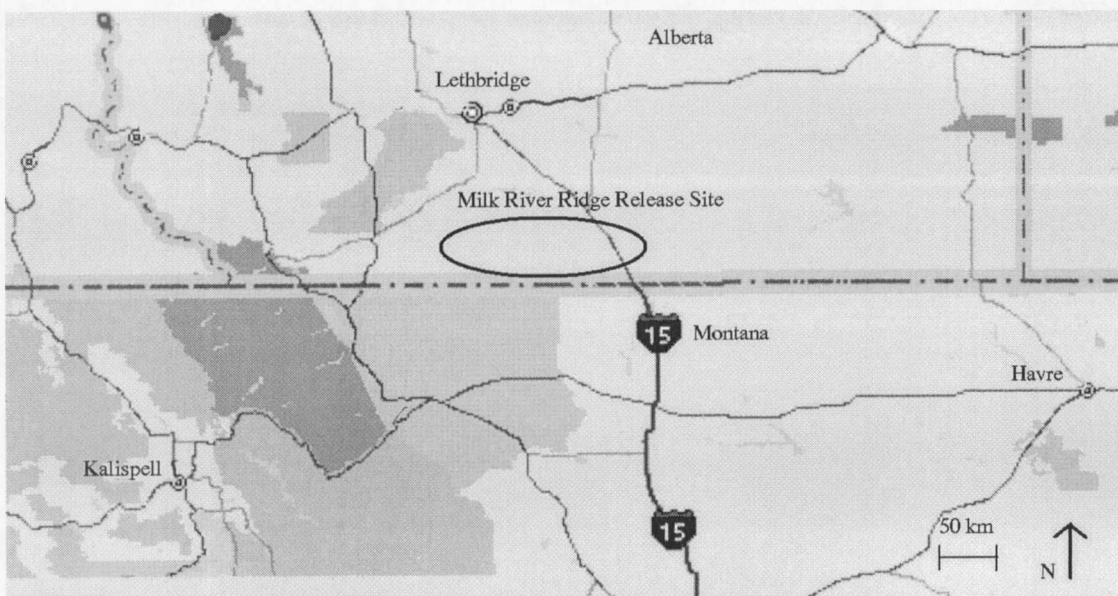


Figure 2. The Milk River Ridge release site for the Candian swift fox reintroduction program, 1983-1998. The release area is located south of Lethbridge, Alberta.

STUDY AREA

The study area was in northcentral Montana, primarily in northern Blaine County, with secondary sites in northern Phillips and Valley Counties (Fig. 3). The landscape consists of gently rolling, glaciated short and mid-grass prairie, interspersed with agricultural areas on upland sites. Moderate relief is created from creek drainages that cut through the prairies. Annual mean monthly temperature ranges from -1.8° C to 13.9° C. Mean annual precipitation is 32 cm and ranges from 19 to 52 cm.

Dominant grasses on the study area were: western wheatgrass (*Agropyron smithii*), prairie junegrass (*Koeleria pyramidata*), blue gramma (*Bouteloua gracilis*), and Sandberg bluegrass (*Poa secunda*). Some localized areas have been seeded to crested wheatgrass (*Agropyron cristatum*). The main shrub occurring on the prairie is silver sagebrush (*Artemisia cana*). Dominant forbs include: American vetch (*Astragalus spp.*), scarlet globemallow (*Sphaeralcea coccinea*), fringed sagewort (*Artemisia frigida*), cudweed sagewort (*Artemisia ludoviciana*), toadflax (*Linaria spp.*), plains clubmoss (*Selaginella spp.*), and prickly pear (*Opuntia spp.*). Upland sites in the study area were characterized by loam or clay loam soil surfaces and clay or clay loam subsoil types (National Cooperative Soil Survey 1976). Elevation on the study area ranged from 670 to 2,103 meters. Twenty-eight percent of the study area was managed by the Bureau of Land Management (BLM), and 6% was managed by the state of Montana. Sixty-six percent of the study area was in private land ownership.

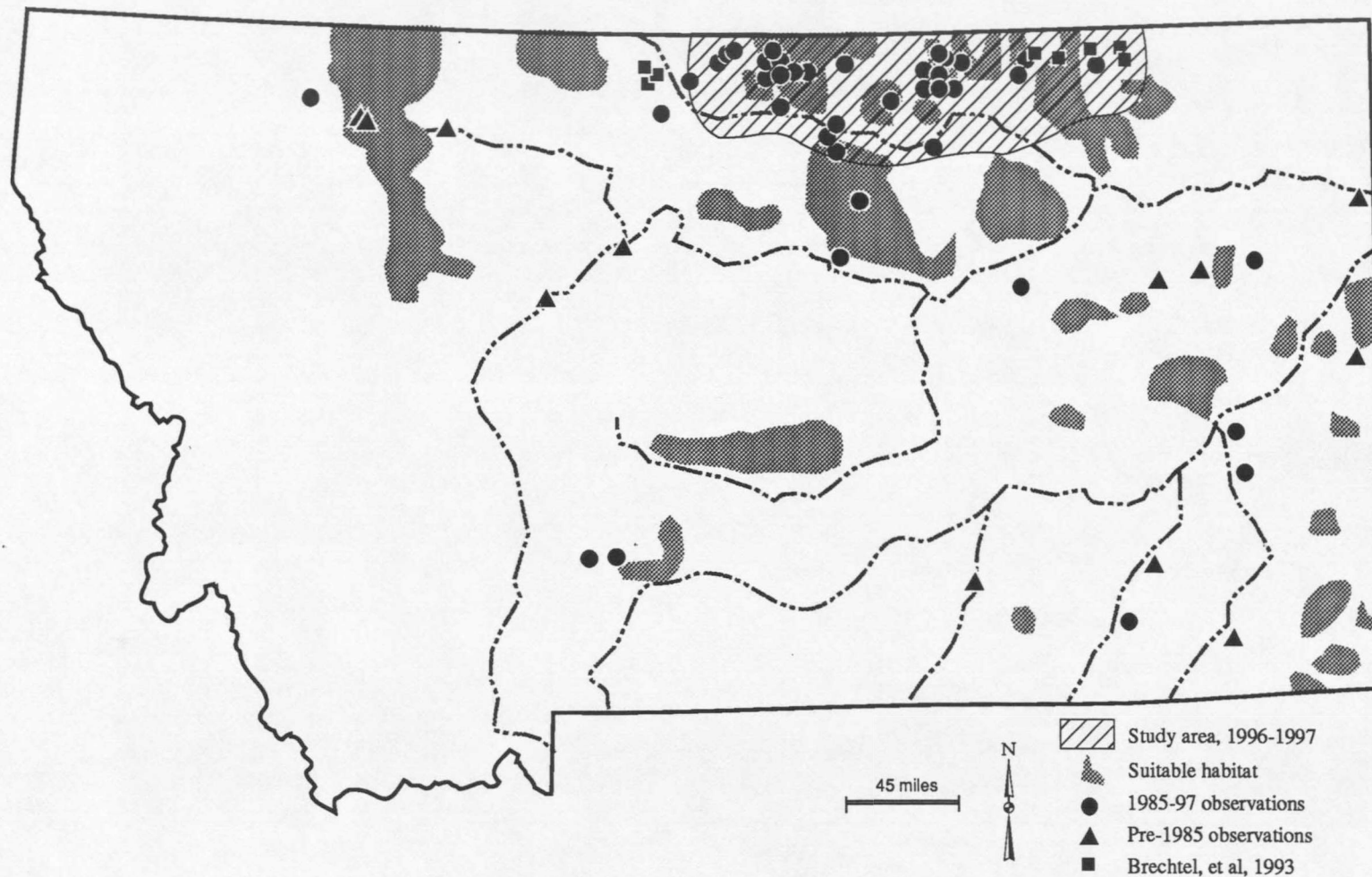


Figure 3. Location of study area and distribution of potential swift fox habitat in Montana based on vegetation and topography (map modified from Montana Natural Heritage Program records) with documented observations of swift foxes. Observations of swift foxes include pre-1985 observations, 1985-1997 observations, and observations from Brechtel et al. 1993.

METHODS

Fourteen townships, each having an area of 92 km², were systematically trapped using Tomahawk live traps placed in a block grid design (Smith et al. 1975). Trap dimensions were 42 x 12 x 12 cm or 32 x 10 x 12 cm. Traps were placed on every corner of each 10- km² area in a township, resulting in a baseline number of 16 trap sites per township. The basic block design for trap placement was modified according to road and trail accessibility for each township so that traps were placed as close to a corner as the road and trail system allowed. This method was used to increase the efficiency and ease of surveying a large area. Loy (1981) found that placement of traps along roads or trails increased the ease of setting and checking traps and proved more successful for capturing swift fox than a random placement of traps over the landscape. Each township was trapped for 3 to 7 days. Traps were checked daily from 0530 to 1000. Trapping occurred from 12 August to 29 November, 1996, and from 7 July to 15 August, 1997. A short-term trapping effort occurred from 12 October to 18 October, 1997. Trapping success was calculated as the number of foxes captured per 100 trap nights of effort.

Beef fat obtained from local grocery stores was used for bait, and a commercial trapping lure (Gary Jepson's Cow Country) was applied to a stick and placed through the top of the trap. Non-target animals were released upon their discovery. A standard protocol was followed when handling captured swift foxes (American Society of Mammalogists Animal Care and Use). A large mesh decoy bag was fitted around the opening of the trap, and foxes were transferred into the bag. Swift foxes were sedated

using a 2:1 ketamine-xylazine mixture at a concentration of 10 mg/kg of estimated body weight (Kreeger 1996). Foxes were then weighed, sexed, and aged (juvenile or adult). Standard length measurements were also taken, including the length of the ear, hind foot, tail and total length. Foxes were tattooed in the left ear and radiocollared. Wildlife Materials (Carbondale, Illinois) and ATS (Advanced Telemetry Systems, Isanti, Minnesota) radio collars were used. Collars weighed 40-50 g and contained a mortality sensor that was activated after 4 (Wildlife Materials) or 8 hours (ATS) of inactivity. Foxes were monitored during their recovery from the drug. I observed them as they moved away from the site of capture until they stopped at a probable den site or traveled out of view.

Animals were located via triangulation four times per week during the primary field seasons (fall, 1996; summer, 1997). I used a bipolar antenna mounted to the roof of a truck and a hand held rubber H-antenna to locate signals. I listened for signals while driving using a bipolar antenna mounted on the truck until a signal was heard. I then stopped to obtain a bearing on the animal using the hand-held H-antenna. Regularly spaced radio telemetry stations were used for stops when available. Radio telemetry stations were designated by wooden stakes that were painted, numbered, and placed along roads and trails in locations where signals were picked up frequently. At least three bearing angles per fox location were obtained using the hand-held antenna. Locations were estimated using program LOCATE II (Nams 1990) and home ranges were estimated using program CALHOME (Kie et al. 1994). Home ranges are reported using the Minimum Convex Polygon (MCP) method (Mohr 1947) and the Adaptive Kernel method

(Worton 1989). Locations were sampled most frequently in the hours of 2030 to 0200 and from 0300 to 0530. Hines and Case (1991) reported that 90 to 96% of swift fox activity occurred between the hours of 2000 and 0400. Thirty known locations of radio transmitters were used to determine the degree of precision of fox location bearings.

Fox locations were also obtained from fixed-wing aircraft. An H-antenna was mounted to one wing strut of a Bellanca Scout 53819. Flights were made during the day, from 0700 to 1400 or from 1800 to 1930. Aircraft were used when a fox could not be located on the ground for four consecutive sampling nights, for locations during the winter, and to locate natal dens in the spring and summer of 1997. Regular flights were made every 10 to 14 days during the winter of 1996-1997 to document movements and survival.

An annual survival rate was estimated using the Kaplan-Meier, or Product Limit procedure, modified for a staggered entry design (Pollock et al. 1989). SAS software was used for the analysis (SAS Institute, Inc. 1989-1996). The staggered entry Kaplan-Meier method allows for new animals to be added after the study has begun and lends itself well to a study where the exact number of individuals to be captured is not known at the beginning of the study. Animals monitored over the course of the study are placed into two categories. If the animal is either alive at the end of monitoring or lost (because of radiocollar malfunction or leaving the study area) it is considered right censored. Right censoring means that the exact time of an animal's death is not known. The animal's survival time is only known to be greater than some value. Mortalities were the second category and were indicated from the mortality signals in the radio collars being

activated. Retrieval of the carcass and/or the collar was then initiated.

Potential natal den sites were located in the spring of 1997 using aerial and ground telemetry. Dens were observed by ground several times per week in the morning or evening until pups were seen outside the den. Swift fox pups emerge from the den at 3 to 4 weeks of age (Kilgore 1969). Natal dens were then observed by ground twice a week through the summer to count the number of pups present. All natal dens were described and measured. Documentation included: number of entrances, dimensions of openings (width and length), opening exposure (N, S, E, W), slope, and distance to the nearest road.

Fecal analysis was used to investigate swift fox food habits in northcentral Montana. Swift fox feces were collected in each township trapped during regular field activities. Fecal searching was concentrated along fence lines, trails, and gates. Feces were also collected from captured animals and at den sites. Complete fecal piles were placed into separate, plastic zip-lock bags, labeled with the date, location, and swift fox frequency number, and frozen within 3 hours. Feces were later placed into a strip of nylon hosiery and washed by hand in a bucket (19 liters) with a tablespoon of laundry detergent. Feces were rinsed until the water appeared clear and were then air dried. Dried feces were placed on a sieve and separated into seven categories: hair, bones, teeth, insect, feathers, vegetation, and other. Teeth were used to identify small mammals to genus. Insects were identified to order; feathers were simply classified as "bird", and plant material was labeled as vegetation. Fecal items were reported in percent occurrence.

The proportion (percent) of habitat types occurring in a 200-m radius around each trap site were recorded during trapping efforts. Habitat types were classified as rangeland, cropland, Conservation Reserve Program (CRP) land, or a mixture of these. Trapping success for each habitat type was recorded as the number of foxes captured per 100 trap nights of effort.

The habitat composition and pattern of land ownership/management of townships where foxes were captured were compared with townships having no captures using a Mann-Whitney t-test (Ott 1988). For the habitat composition analysis, habitat types were classified as either grassland (native) or cropland at the township level. Digital maps showing land cover were obtained from the GAP analysis lab at the University of Montana and brought into the ArcInfo GIS computer program (Environmental Systems Research Institute 1982-1997). Areas of the two habitat types were then summarized for each township. The average area of each habitat type in townships that contained swift fox was compared to the average amount in townships that did not have swift fox captures. Land ownership/management was categorized as private, BLM, or the State of Montana. Areas of land ownership/management were summarized by counting sections using a BLM 1:100,000 scale land ownership map. The average area of each type of land ownership/management was compared between townships with and without swift fox captures. Terrain/relief was indexed as a roughness factor, and was obtained for each township surveyed. The roughness factor index was then compared between the two groups of townships (those with and without swift fox captures). The roughness factor was calculated by the computer program Graphical Locator Custom Mapper using a

digital elevation model obtained from the United States Geological Survey. Local roughness was calculated by taking the standard deviation of the surrounding elevation values within a 125-meter radius of a given random point. Seventy-five random points were generated by a computer random number generator for each township. The average of the 75 values was used for the overall roughness factor for each township. Overall roughness was compared using a Mann-Whitney t-test. An alpha level of 0.05 was used in all Mann-Whitney t- tests. Statistical tests were done on SAS software (SAS Institute, Inc. 1989-1996).

RESULTS

Trapping Success

Fourteen townships were block-trapped over the course of the study, with swift foxes being discovered in 6 townships. A total of 1,205 trap nights resulted in nine swift fox captures in 1996. Trapping success for 1996 was 0.75 foxes/100 trap nights. Trapping efforts in 1997 resulted in seven captures in 511 trap nights, for a trapping success of 1.37 foxes/100 trap nights. The overall mean trapping success for the study was 0.93 fox/100 trap nights.

Nine swift foxes were captured in the fall of 1996, including three adult females, three adult males, and three juvenile males. Seven individuals were captured in the summer of 1997. In July of 1997, an adult male and female were captured in northern Blaine county. Additional captures occurred in northern Phillips and northwestern Valley County in 1997. In northern Phillips County, an adult male, an adult female and two female pups were captured just north of Whitewater, Montana. These animals were not radio collared but were tattooed, measured, and released. An adult male swift fox was captured in August of 1997 in northwestern Valley County, 30 miles east of Whitewater, Montana. This male was the only swift fox captured that had been previously marked, indicating that it had been released from the Canadian reintroduction project (the tattoo "VZ 25" was imprinted in its left ear). This swift fox originated out of the captive breeding program at the Valley Zoo in Edmonton, Alberta. It was born in May of 1995 and was released in the fall of 1995 in the east block of Grasslands National Park by

Mankota, Saskatchewan (Figure 1) (A. Moehrenschlager, pers. comm.). This fox had dispersed about 26 km from its initial release to its capture location.

Standard Measurements

Captured males weighed slightly more than females (Table 4, Appendix), with the mean weight of males being 2.9 kg compared to 2.7 kg for females. Mean ear lengths were equal for males and females (5.9 cm). Males had longer mean hind foot length, tail length and total body length than females. Mean hind foot length for males was 11.9 cm and 11.7 cm for females. Mean tail length for males was 26.9 cm and 24.9 cm for females. Mean total body length was 72.1 cm for males and 67.9 cm for females (Table 4, Appendix). Standard measurements for juveniles captured in the fall of 1996 were pooled into the adult male and female measurement categories, since juveniles approached adult size in the fall of the year.

Home Range

Annual home range estimates were calculated for five radiocollared swift foxes (Table 1). Four of the nine swift foxes captured in the fall of 1996 were excluded from the home range analysis because of an inadequate number of locations (number of locations ranged from 11 to 20). The number of radio locations per fox ranged from 28 to 72. Home range size ranged from 7.3 km² to 16.9 km² using the Minimum Convex Polygon method and the mean home range size was 10.4 km². Home range size ranged from 8.7 to 20.3 km² using the Adaptive Kernel method, and the mean home range size was 12.3 km². Thirty known locations of radio transmitters were used to determine the degree of precision in fox location bearings. The overall standard deviation of the

Table 1. Annual home range size in km² estimated by the Minimum Convex Polygon Method and Adaptive Kernel Method and time periods tracked of 5 swift fox in northcentral Montana, 1996-1997.

Swift Fox	Sex	Age	Period Tracked	No. Locations	Minimum Convex Polygon Home Range	Adaptive Kernel Home Range
133	M	Juv.	21 Oct. 1996 to 13 Sept. 1997	58	7.4	11.3
826	F	Adult	6 Nov. 1996 to 9 Oct. 1997	63	16.9	20.3
152	F	Adult	8 Oct. 1996 to 9 Oct. 1997	72	8.1	8.7
844	M	Adult	21 Oct. 1996 to 11 Sept. 1997	70	9.4	9.6
272	F	Adult	8 Oct. 1996 to 7 April 1997	28	10.1	11.3

bearing error was 13° ($n = 30$).

Population Dynamics: Survival

Of the nine swift fox captured in the fall of 1996, four foxes died over winter, one fox left the study area, and four foxes (two male, two female) survived to mate and reproduce in the spring of 1997. Two foxes were added to the survival analysis in the summer of 1997. The mean number of days survived in 1 year for the 11 radio collared swift fox was 212 days (± 140 days). Number of days surviving ranged from 28 to 399 days (Table 2). The Kaplan-Meier survival function is based on the probability of an individual animal surviving x units of time from the beginning of the study (Pollock et al. 1989). The mean annual survival rate was 46% with a standard deviation of 13%. My estimates were based on all nine foxes captured in the fall of 1996 and the two adult foxes collared in the summer of 1997. Of these, eight were adults and three were juveniles (young of the year).

Den Characteristics and Reproduction

Eleven separate natal dens were documented in the study. Two of the swift fox pairs had four different natal dens through the summer, and the third pair occupied three separate dens. All natal dens were located less than 500 meters from a road or two-track trail. All natal dens were located in areas with slopes $< 15^\circ$, and 73% were located in areas with slopes of $0-5^\circ$. Of the 11 natal dens, five had two den entrances, three of the natal dens had three entrances, two had four entrances, and one had only one den entrance. The mean dimension (width, length) for all den entrances was 24.6 cm x 42.0 cm ($n=34$, standard deviation= 6.8 cm x 17.8 cm). Over half (54%) of den entrances

Table 2. Dates captured, fates, and number of days surviving for 11 swift foxes during 1996-1997 in northcentral Montana. Sex: M=Male, F=Female; Age: A=Adult, J=Juvenile; Fate: D=Dead, C=Right censored.

Swift fox	Sex	Age	Beginning Date	End Date	Fate	Total Days
033	M	A	24 Sept. 1996	17 Feb. 1997	D	147
133	M	J	27 Sept. 1996	30 Oct. 1997	C	399
272	F	A	27 Sept. 1996	7 April 1997	D	193
073	M	A	3 Oct. 1996	19 Jan. 1997	D	109
793	M	J	5 Oct. 1996	4 March 1997	C	151
152	F	A	8 Oct. 1996	30 Oct. 1997	C	388
113	M	J	16 Oct. 1996	31 Dec. 1996	D	77
844	M	A	20 Oct. 1996	30 Oct. 1996	C	376
826	F	A	5 Nov. 1996	30 Oct. 1996	C	360
834	M	A	10 July 1997	23 Oct. 1997	C	106
350	F	A	14 July 1997	10 Aug. 1997	C	28
Mean						212
Standard Dev.						140

were exposed to a south/southeast direction. A north/northeast exposure was the next most common at 36%. One den site had an entrance toward the southwest, but no entrances were exposed to the west or northwest. Both of the two pairs of radio collared swift fox that survived the winter of 1996-1997 produced offspring. One pair produced a litter of 5, and the other had a litter of 3. The swift fox pair captured in July of 1997 produced a litter of 7 pups. Two pups were captured in northern Phillips county, indicating that reproduction had occurred there also.

Food Habits

Mammals were the most common item in the diet of swift fox. Mammal remains were found in 91% (n=59) of the 65 feces analyzed. The next most common item was insects, occurring in 66% (n=43) of the feces. Vegetation occurred in 48% (n=31) of the feces and birds occurred in 32% (n=21) of the feces. Seven of the 65 feces contained unidentified mammal material (11%).

The most common mammals occurring in feces were *Microtus* spp. (68%), followed by *Peromyscus* spp. (18%), *Spermophilus richardsoni* (9%), *Perognathus* spp. (3%), and *Sorex* spp. (2%). *Microtus*, *Peromyscus*, and *Perognathus* often occurred in feces in combination. *Spermophilus richardsoni* was usually found alone in a fecal sample. Only one instance of *Sorex* spp. was encountered in the 65 samples.

Insect material was mainly composed of the classes Coleoptera (beetles) and Orthoptera (grasshoppers). Coleopterans were found in 49% (n=32) of the feces, and Orthopterans were found in 43% (n=28) of the feces. Seven different families of beetle were identified in feces, including: tiger beetle (Cicindelidae), weevil (Curculionidae),

pill beetle (Byrrhidae), dung beetle (Scarabaeidae), ground beetle (Carabidae), darkling beetle (Tenebrionidae), and carrion beetle (Silphidae). Two families of Orthoptera were identified in feces: Acrididae (grasshopper) and Gryllidae (cricket). Formicidae (ants), of the order Hymenoptera, occurred in 14% of the feces. A few fecal samples contained material from the order Hemiptera (stink bug), Lepidoptera (caterpillar skins), and Odonata (damselfly adults).

Mammals were represented evenly throughout the three seasons (Table 3). Insects occurred in all three seasons, peaking in the fall at 75% occurrence. Vegetation occurrence was highest in the summer (65%) but was present in feces in all three seasons. Bird occurrence was highest in the spring (60%), was present in feces through the summer (39%), and dropped off in occurrence in the fall (20%).

Habitat Comparisons

There were a total of 1,716 trap nights over the course of the study. Of these, 1,394 trap nights occurred in rangeland, 43 were in cropland, 8 were in CRP, and 271 were in a mixed habitat. There were 16 individual swift fox captured. Fifteen captures occurred in rangeland, and one occurred in a mixed habitat. No captures occurred in cropland or CRP sites. Trapping success in rangeland was 1.0 foxes/100 trap nights. The Trapping success in mixed habitat was of 0.4 foxes/100 trap nights.

Mann-Whitney t tests indicated no significant difference in the habitat composition of townships with (n=6) and without (n=8) swift fox captures. The mean amount of rangeland was 6,662 ha in townships with swift fox captures and 6,936 ha in townships without swift fox captures, and the mean amounts of cropland were 1,224 ha

Table 3. Percent occurrence and number (in parentheses) of food items found in 65 swift fox feces in the spring, summer, and fall in northcentral Montana, 1996-1997.

	Spring	Summer	Fall	Total
Total No. of Samples	10	23	32	65
Mammals:	90 (9)	91 (21)	91 (29)	91 (59)
Cricetidae	90 (9)	48 (11)	84 (27)	72 (47)
<i>Microtus</i> spp.	80 (8)	43 (10)	81 (26)	68 (44)
<i>Peromyscus</i> spp.	40 (4)	4 (1)	22 (7)	18 (12)
Sciuridae	10 (1)	22 (5)	0	9 (6)
<i>Spermophilus</i> spp.	10 (1)	22 (5)	0	9 (6)
Heteromyidae	10 (1)	0	3 (1)	3 (2)
<i>Perognathus</i> spp.	10 (1)	0	3 (1)	3 (2)
Soricidae	0	4 (1)	0	2 (1)
<i>Sorex</i> spp.	0	4 (1)	0	2 (1)
Unidentified Mammal	0	22 (5)	6 (2)	11 (7)
Insects	50 (5)	61 (14)	75 (24)	66 (43)
Orthoptera	10 (1)	17 (4)	72 (23)	43 (28)
Coleoptera	50 (5)	57 (13)	44 (14)	49 (32)
Lepidoptera	10 (1)	4 (1)	3 (1)	5 (3)
Hemiptera	0	9 (2)	0	3 (2)
Hymenoptera	10 (1)	22 (5)	9 (3)	14 (9)
Odonata	0	0	3 (1)	2 (1)
Vegetation	60 (6)	65 (15)	31 (10)	48 (31)
Bird	60 (6)	39 (9)	19 (6)	32 (21)

and 780 ha, respectively. The area of rangeland and cropland did not differ significantly ($P=0.75$, $P=0.27$) between the 2 groups. The mean amount of private land in townships with swift fox captures was 4,479 ha and 5,363 ha in townships without swift fox captures. The mean amount of BLM-managed land in townships with swift fox captures was 4,225 ha and 2,975 ha in townships without swift fox captures. State managed lands represented a mean of 480 ha in townships with swift fox captures and a mean of 790 ha in townships without swift fox captures. No significant difference existed in the area of private land ($P=1.0$), BLM managed land ($P=0.95$), or State managed land ($P=0.21$) between townships with and without swift fox captures. The mean roughness factor for townships with swift fox captures was 1.0, and for townships without was 0.9. No significant difference was found in the overall roughness factors for the 2 groups of townships ($P=0.40$). Thus, there was no evidence to suggest that the probability of capturing swift foxes would be different for townships of different roughness (Table 5).

DISCUSSION

A small percentage of the potential swift fox habitat in northcentral Montana was surveyed by trapping in this study. There are about 688,000 hectares of prairie in northcentral Montana, primarily in Blaine, Phillips, and Valley Counties (C. Knowles, pers. comm.). The total area surveyed in this study was only 129,024 ha, or 19% of the total estimated area of prairie in northcentral Montana.

In 1996, trapping success was 0.75 foxes/100 trap nights and in 1997, it was 1.37 foxes/100 trap nights. Trapping success in a study in Kansas, where swift fox were considered common, was 1.75 foxes/100 trap nights (Matlack, 1997). If my trapping success rate was representative of the actual density of swift foxes on the study area, swift fox densities in occupied areas may be comparable to those in other areas.

Physical measurements of swift fox in northcentral Montana appeared to be similar to those in other areas. Scott-Brown et al. (1987) and Kilgore (1969) found adult male swift foxes to be slightly larger and heavier than females. Overall, captured swift foxes appeared to be in good body condition, which is also reflected in the healthy litter sizes observed.

Home range information was rather limited in this study. The whip antenna/hand held H-antenna system received signals from a maximum of 1.6 km. This radiotelemetry receiving system was not adequate for the difficult and remote access that was characteristic of the study area. There were circumstances when individual foxes could not be found during a sampling night, probably due to my inability to get close enough to

access the signal. Thus, it could be predicted that the home ranges found in this study were underestimated. Home range estimates in this study averaged 10.4 km^2 and ranged from 7.3 to 20.3 km^2 . Canadian studies have found annual home ranges up to 34.1 km^2 (A. Moehrenschrager, pers. comm.). Using the Minimum Convex Polygon method, average home range sizes were 17.3 km^2 for males and 12.4 km^2 for females in Nebraska (Hines 1980), which is more comparable to the average home ranges found in my study. More recently, larger home range sizes were found (up to 32.3 km^2) in Nebraska and it was speculated that the large home range sizes may have been the result of low population densities or low prey availability (Hines and Case 1991).

The estimated annual survival rate for swift foxes in this study, 46%, was comparable to reported survival estimates. A 50% survival rate among 14 radiomarked swift foxes over 1 year was reported in South Dakota (Sharps and Whitcher 1984). Zumbaugh (1984) also reported a 50% survival rate among adults based on 2 years of harvest data in Kansas. An annual survival rate of 50% is common for swift fox populations across their range. Minimum annual survival rates for wild born Canadian swift foxes have been estimated at 46% for adults and 36% for juveniles during their first year (Brechtel et al. 1993). In my study, adults and juveniles (young of the year) were included to obtain the annual survival estimate. One might expect that the annual survival rate estimate was lowered as a result of including juveniles in the overall analysis. If this was the case, then the overall survival rate indicates that swift fox are surviving rather well on the northern Montana prairie.

Natal den sites in this study were similar to dens described in other ecological

studies. I found that swift foxes located den sites close to roads and trails. Other studies have shown the tendency for den sites to be ≤ 500 m from a road (Hines 1980, Hines and Case 1991, Loy 1981), and Jackson (1997) located den sites < 1 km from a road. Studies have shown a tendency for swift fox to use roads and trails as traveling corridors and to eat road kills of other species, such as jackrabbits (Kilgore 1969, Matlack 1997).

However, the tendency of researchers to use roads themselves may result in bias in den locations. Searches were made in remote areas of South Dakota, and swift foxes were not found (Hines and Case 1991).

Den sites in northcentral Montana were located in open, relatively level areas, often near the top of a small rise or ridge. Other studies have indicated a preference for areas with $< 15^\circ$ slope (Hillman and Sharps 1978, Loy 1981, Jackson 1997). Additional common characteristics include selection for a east or south exposure, a loamy soil, and areas of sparse vegetation (Kilgore 1969, Hillman and Sharps 1978, Hines and Case 1991, Loy 1981, Uresk and Sharps 1981, Jackson 1997). These characteristics were common to den sites in my study also. The number of den entrances seemed to be related to the number of pups in the litter in my study. The smaller litter of 3 usually had only 1 or 2 den entrances. The larger litters of 5 and 7 had 3 and 4 den entrances.

Locating evidence of reproduction was one of the main goals of this study, and I identified litter sizes of 3, 5, and 7 in northcentral Montana. Reports of litter sizes in the Canadian reintroduced population have ranged from 1 to 7 pups, with an average litter size of 3.9 (Brechtel et al. 1993). Litter sizes in northcentral Montana were even above average when compared to other reported litter sizes, however, this sample size is very

small. A record litter of 8 was reported for a pair of foxes on the Canadian prairie in the spring of 1997 (Axel Moehrenschrager, pers. comm.). Covell (1992) recorded the average litter size for swift fox as 2.4 pups for pairs and 4.2 pups for pairs with a helper fox. Larger average litter sizes of 4 and 5 were reported for swift foxes by Hillman and Sharps (1978) and Kilgore (1969), respectively.

Mammals were the most frequent food item found in the feces I collected (91%). Uresk and Sharps (1981) also found mammals to be the most frequent food item (49%) in the diets of swift fox in South Dakota, followed by insects (27%), plants (13%), and birds (6%). Rodents, especially voles, were found to be the most important food item for the swift foxes in north central Montana. Hines (1980) found Cricetidae rodents, especially *Microtus ochrogaster* increased in occurrence in the spring. Hines and Case (1991) also found *Microtus ochrogaster* to be the most common mammal species found in 52 fecal samples in Nebraska. Cameron (1984) reported that rodents were important food items in spring and summer on the Pawnee National Grassland in Colorado.

Leporidae were not found in any of the 65 fecal samples in this study, even though they seemed to be quite abundant on the study area. Cottontails and jackrabbits have been found to be important food items in other studies, especially in winter (Cameron 1984, Hines and Case 1991, Kilgore 1969, Zumbaugh et al. 1985). Hines (1980) and Kilgore (1969) documented that *Leporidae* species decreased in fecal occurrence in the spring but seemed important in the winter and early spring. The feces I collected were from late spring, summer, and fall. This may explain the absence of *Leporidae*.

A high percentage of feces I examined had at least some insect material present. In a study in Nebraska, Hines and Case (1991) found that 56% of the swift fox feces had insect remains, most of which consisted of Orthoptera (37%) and Coleoptera (25%). This result is quite similar to my result of 66% occurrence of insect material in feces. In South Dakota, Uresk and Sharps (1981) reported that insects were found in 27% of feces.

I found that 48% of the feces contained vegetation. Vegetation found in feces was mainly grass and usually in trace amounts, suggesting vegetation may have been ingested incidentally. However, three fecal samples were entirely composed of vegetation. One was composed of grass, one was unidentified, and one was comprised of berries, probably currants or gooseberries (*Ribes spp.*). Other vegetation found in feces included spike moss (*Selaginella spp.*) and nutlets from the family *Boraginaceae*. Hines and Case (1991) found that 54% of feces contained vegetation. Uresk and Sharps (1981) found vegetation in 13% of the feces.

It is not known whether swift fox ingest vegetation as they consume other prey or whether vegetation is consumed purposely. Zumbaugh et al. (1985) found only one stomach sample that contained enough grass to indicate that it had been ingested purposely. Hines and Case (1991) concluded that vegetation was eaten intentionally in some instances. The 3 feces I examined that were entirely composed of vegetation suggests that vegetation was eaten intentionally, but I have no information to suggest why.

Birds occurred in 32% of the feces I examined. Most feathers were found in feces deposited in late spring and into the summer. This is consistent with studies reporting

that both bird and insect remains increased from winter to summer as their availability increased (Hines 1980, Hines and Case 1991). Feathers found in feces were too small to identify easily. However, mallard (*Anas platyrhynchos*) and horned lark (*Eremophila alpestris*) remains were found at den sites in the summer of 1997. On one occasion, a willet (*Catoptrophorus semipalmatus*) was found lying beside the trap when a juvenile female swift fox was captured south of Whitewater Lake (Phillips County).

Based on high trapping success in rangeland compared to other habitat types, the swift foxes in northcentral Montana seemed to be most strongly associated with rangeland. Den site locations and home range locations supported this association. No den sites were found in any habitat other than rangeland, and only one telemetry location out of 291 locations occurred near cropland. The high proportion of trap sites located in rangeland reflects the dominance of range (95,458 ha) over cropland (13,585 ha) in the study area and may indicate that foxes are using habitat in proportion to availability.

No significant differences were found in the habitat composition or land ownership/management patterns between townships with and without swift fox captures. I hypothesized that townships with a greater amount of rangeland may be more attractive to swift fox, and thus, the composition of habitat would influence where swift fox were captured. I also hypothesized that the pattern of land ownership/management may play a role in the presence or absence of swift foxes, in that there may be certain management practices or vegetation cover that attracted swift foxes to different areas based on land management. The data did not support these hypotheses. There are several possible explanations for why habitat composition and land management patterns did not have an

effect on the probability of swift fox presence. One potential explanation was that trapping was not performed over a wide enough area to detect a gradient of swift fox densities that could be attributed to differences in the amount of rangeland versus cropland across townships (or accordingly, the amount of private, BLM or State managed lands across townships). Another reason could be that sampling was simply not intense enough and thus, did not have enough power to detect a difference (power ranged from 5%-29%). A third possible reason is that these attributes do not have an effect on whether swift fox are present or absent in an area. The distribution of swift foxes may also be patchy across the landscape, rather than a random distribution of animals throughout the available habitat. A final reason could be that the population is currently still colonizing the area and simply has not yet filled all of the most desirable habitat. Of these possibilities, it is most likely that the population is in a colonizing state and has not yet filled the available habitat.

Statistical tests of roughness of townships with and without swift fox captures did not indicate any relationship between large scale terrain complexity/relief and presence/absence of swift foxes. I hypothesized that roughness, (coulees and breaks) could affect habitat quality for swift foxes. Swift foxes may avoid rough terrain because of higher coyote densities (Pyrah 1984). Pyrah (1984) found that coyote surveys indicated a consistently higher density of coyotes in breaks habitat as compared to the adjacent prairie in northcentral Montana. Coyotes have been shown to be one of the main causes of mortality for swift fox, both in the Canadian population (S. Black, pers. comm.) and in other swift fox populations within the U.S. range (Covell 1992, Matlack 1997).

MANAGEMENT IMPLICATIONS

The swift fox has proved to be an adaptable and opportunistic species. However, it has been negatively affected by past human activities such as landscape changes, unregulated trapping, predator shooting, and poisoning programs. Thus, the degree to which we impose human activities on the landscape today will ultimately determine whether this recently established swift fox population in northcentral Montana will persist. Potential threats to the viability of the swift fox population in northcentral Montana include poisoning (coyotes and ground squirrels), the possible loss of prairie to agriculture, indiscriminant predator shooting, road deaths, and accidental trappings.

Habitat loss was one of the factors that led to the extirpation of swift foxes in Montana. Currently in northcentral Montana, there is not a large scale trend toward converting prairie habitat into agricultural lands. Historically, there was large scale conversion of prairie to agriculture in some areas in northcentral Montana. There is currently some small scale conversion of prairie habitat in northwestern Blaine County, along the Hill/Blaine County line (Jody Peters, pers. comm.). One positive aspect concerning the habitat in northcentral Montana is that much of the native prairie today exists on public lands. Poisoning programs are not currently in use by Animal Damage Control in northcentral Montana. Animal Damage Control is primarily involved in coyote trapping. The BLM has recently restricted the use of M44 poison baits and snaring near known swift fox locations in northern Blaine County (Jody Peters, pers. comm.). Road deaths, however, may become an important concern as oil and gas

development increases on public lands in northcentral Montana. As more oil and gas structures are created, more roads are developed to service those structures, which may increase the possibility of road deaths for swift foxes (Kilgore 1969, Matlack 1997).

CRP was not included in the township habitat composition analysis. Although the CRP program creates grassland from former agricultural areas, most often these lands are seeded to non-native grasses. These stands of grasses are taller and thicker than the native shortgrass prairie species present in the swift fox range. It is thought that CRP areas present a visual barrier to swift fox and provide cover for larger predators, such as coyotes. This combination of factors makes CRP a potentially dangerous place for swift foxes.

The influence or importance of any of these threats and habitat changes is unknown because of a lack of information on the distribution of swift foxes in Montana. Thus, additional surveys are needed to determine the extent of swift fox distribution and population density in Montana. My experience indicated that using live-trapping and radiotelemetry would be an expensive and ultimately inefficient means of surveying for swift fox distribution in Montana. Two alternate possibilities would be surveys of landowners and trappers and systematic track/fecal searches by townships. Surveys of landowners and trappers would be cheaper, but these surveys may be ineffective due to low response and unreliability of information. My experience suggests that track and fecal searches would be reliable, quick, and less expensive. A track and fecal search method was used in Kansas as a means of detection and proved to be quite successful (Christiane Roy, pers. comm.).

After distribution has been defined for swift foxes in Montana, other management steps might be taken. My data suggest that the population is currently reproducing and has similar survival rates as other swift fox populations in the U.S. This indicates occupied areas are suitable for swift fox. Specific studies contrasting occupied with unoccupied areas that emphasize relative land cover, human activity type/intensity, and densities of coyotes would help determine if the present distribution represents full occupancy of suitable habitat or just early stages of colonization. Additional population dynamics studies and perhaps augmentation efforts may be needed in the future to ensure the stability of the swift fox population.

It appears that swift foxes have reestablished a population in northcentral Montana that is surviving and reproducing. The area of potential habitat for further colonization is large (688,000 ha of native prairie primarily in Blaine, Phillips, and Valley counties). Much of the area that swift fox currently occupy in Montana are lands managed by the Bureau of Land Management (BLM) or the state of Montana. Public lands biologists, state biologists, and land managers will now have the opportunity to actively participate in the recovery of swift fox in Montana by cooperating with private landowners and considering the impacts of different land management strategies on the habitat requirements of swift foxes.

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APPENDIX

Table 4. 1996-1997 Standard measurements of morphological characteristics of male and female swift foxes captured in northcentral Montana.

Standard Measurements	Males (n=10)	Females (n=8)
External ear length (cm)	6	6
	6.3	5.7
	5.5	6.5
	6.0	5.1
	5.2	6.0
	6.0	6.2
	6.1	5.7
	7.0	6.0
	5.8	
	6.0	
Mean	5.9	5.9
Standard Deviation	0.5	0.4
Hind foot length (cm)	12.2	12.0
	12.1	12.5
	11.5	11.7
	12.5	11.6
	11.5	10.5
	12.0	11.5
	12.3	11.5
	11.8	12.0
	11.2	
	12.0	

Table 4. Continued

Standard Measurements	Males (n=10)	Females (n=8)
Mean	11.9	11.7
Standard Deviation	0.4	0.6
Tail length (cm)	28.0	25.0
	28.0	26.5
	27.0	25.0
	25.0	23.0
	27.0	26.5
	26.5	26.2
	28.0	25.0
	25.0	28.0
	27.0	
	25.5	
Mean	26.7	25.7
Standard Deviation	1.2	1.5
Total body length (cm)	72.0	67.0
	75.5	71.0
	68.5	67.5
	72.5	66.0
	70.0	70.7
	74.0	67.5
	74.0	70.0
	70.0	74.5

Table 4. Continued

Standard Measurements	Males (n=10)	Females (n=8)
	73.5	
	69.0	
Mean	71.9	69.3
Standard Deviation	2.4	2.8
Weight (kg)	3.5	2.5
	3.0	2.6
	2.5	2.5
	3.0	2.5
	2.6	3.0
	3.0	2.8
	3.5	2.5
	2.4	3.0
	2.7	
	2.5	
Mean	2.9	2.7
Standard Deviation	0.4	0.2

Table 5. 1996-1997 Land cover type, roughness, and land ownership for 14 townships surveyed for swift foxes in northcentral Montana.

Township	Land Cover Type (Hectares)		Roughness (SD)	Land Ownership/Management (Hectares)			
	Noncapture	Capture		Private	State	USFWS [#]	BLM*
T37 R18	6730.4	2120	0.8	5168	512	0	3536
T37 R19	8859.2	2.9	0.6	4984	512	0	3720
T37 R20	7005.3	1297.5	0.7	4192	704	0	4320
T37 R21	8183.6	149.5	2.4	4832	512	0	3872
T36 R17	5381.3	0.0	0.4	6320	2800	0	96
T35 R18	5145.1	1512.1	0.6	6464	512	704	1536
T35 R19	6493.0	812.6	0.7	4976	512	0	3728
T34 R20	7688.1	344.8	1.2	5968	256	0	2992
Mean	6935.8	779.9	0.9	5363	790	88	2975
Standard Deviation	1292.2	792.8	0.6	780	821	249	1435
Capture							
T36 R18	6789.1	806.9	0.7	5504	576	192	2944
T36 R19	7211.2	924.6	0.5	5456	512	0	3248
T36 R20	6328.4	2203.5	0.8	6352	512	0	2352

Table 5. Continued
Township

Captures	Land Cover Type (Hectares)		Roughness (SD)		Land Ownership/Management (Hectares)		
	Rangeland	Cropland	Roughness	Private	State	USFWS [#]	BLM [*]
T35 R20	5582.5	2393.1	0.9	6464	256	0	2496
T35/36 R31	7534.2	525.7	1.6	1624	512	0	7080
T35/36 R36	6526.4	491.6	1.5	1472	512	0	7232
Mean	6661.9	1224.2	1.0	4479	480	32	4225
Standard Deviation	688.9	850.2	0.5	2309	113	78	2293

United States Fish and Wildlife Service.

* Bureau of Land Management.

Table 6. Swift fox capture locations based on legal descriptions of townships in northcentral Montana, 1996-1997. Swift fox radio collar number or identification, date, sex (M=Male, F=Female), and age are also included.

Date	UTM		Swift fox	Sex	Age
	Northing	Easting			
24 Sept. 1996	5419000	624000	033	M	Adult
27 Sept. 1996	5419000	624000	133	M	Juvenile
27 Sept. 1996	5415900	620200	272	F	Adult
3 Oct. 1996	5415900	620200	073	M	Adult
5 Oct. 1996	5417300	620150	793	M	Juvenile
8 Oct. 1996	5413000	627400	152	F	Adult
16 Oct. 1996	5414680	630500	113	M	Juvenile
20 Oct. 1996	5416260	630500	844	M	Adult
5 Nov. 1996	5413200	638520	826	F	Adult
Total Trap Nights		1205			
Trap Success		0.75 foxes/100 trap nights			
10 July 1997	5401900	637250	150.834	M	Adult
14 July 1997	5403500	637200	150.350	F	Adult
4 Aug. 1997	5406650	308250	Not Collared	F	Juvenile
5 Aug. 1997	5406650	308250	Not Collared	M	Adult
5 Aug. 1997	5409050	306700	Not Collared	F	Adult
7 Aug. 1997	5406650	308250	Not Collared	F	Juvenile
13 Aug. 1997	5406900	352050	VZ 25	M	Adult
Total Trap Nights		511			
Trap Success		1.37 foxes/100 trap nights			

