ASSESSING THE SUCCESS OF SWIFT FOX REINTRODUCTIONS ON THE BLACKFEET INDIAN RESERVATION, MONTANA

by

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B.S. University of Montana – Missoula, 2003

presented in partial fulfillment of the requirements

for the degree of

Master of Science, Wildlife Biology

The University of Montana – Missoula

December 2005

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Ausband, David E., M.S., December 2005 Wildlife Biology

Assessing the success of swift fox reintroductions on the Blackfeet Indian Reservation, Montana

Chairperson: Dr. Kerry R. Foresman

Reintroductions have been used to conserve species around the world with a variety of results. Beginning in 1998, the Blackfeet Tribe and Defenders of Wildlife reintroduced 123 captive-raised swift fox (*Vulpes velox*) to the Blackfeet Indian Reservation, Montana. I used two success criteria, a population growth rate (λ) $\geq$ 1.0 and an index count $\geq$ 100 foxes, to determine if the reintroduction was successful.

I radiocollared 23 adult and 35 juvenile swift fox from 2003 – 2005 to estimate survival and fecundity. The swift fox population grew at a rate of 16% during 2003/04 and 14% in 2004/05. In addition, field crews observed 93 foxes in 2005. A breeding pair with kits was discovered 110 km south of the release site in Augusta, Montana in 2005.

Predation comprised the majority (79%) of swift fox mortality and it appears that populations can sustain a high proportion of mortalities from predation yet continue to grow.

The swift fox population reached one, and nearly both, of my success criteria. In light of available habitat I was unable to survey and swift fox sign, I believe there were at least 100 foxes present in 2005. Based on the population growth rate, the number of foxes counted and the fortunate discovery of swift fox in Augusta, Montana, I consider this reintroduction a success. The Blackfeet Tribe and Defenders of Wildlife have attained their goal of restoring a culturally important species to Tribal lands and have even initiated a comeback of swift fox along the Rocky Mountain Front.

At the outset of this research project there was potential that additional swift fox releases would be recommended. I trapped small mammals during 2004 and 2005 to delineate areas of high prey abundance that may be suitable as release sites. Small mammal densities were relatively low throughout the areas I trapped and I was unable to detect patterns that could serve as a guide for future release sites. Deer mice (*Peromyscus maniculatus*), Richardson's ground squirrels (*Spermophilus richardsonii*), and sagebrush voles (*Lemmiscus curtatus*) were the most commonly captured species. Deer mice were the most ubiquitous of all species captured.

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ACKNOWLEDGEMENTS

This research was funded by Defenders of Wildlife, a TWG grant through The Blackfeet Fish and Wildlife Department, a SWG grant through Montana Fish, Wildlife and Parks, and a grant through Sigma Xi.

I want to express sincere thanks to my advisor, Dr. Kerry R. Foresman. As an advisor, Kerry continually went above and beyond the norm of what any graduate student should expect. He went to bat for me in difficult situations and I will not forget that. Thanks Kerry. In addition, I thank my committee members, Dr. Daniel Pletscher and Dr. L. Scott Mills. Both of these bright scientists have been mentors in every sense of the word. Dan, you have known me from day one of my arrival in Missoula and have always had time to give me advice and help me correct my wrongs. I thank you deeply for that.

I should also thank Minette Johnson at Defenders of Wildlife for hiring me several years ago as a technician on the swift fox project and for having the faith and confidence in me to allow the project to morph into my graduate research. Dan Carney with Blackfeet Fish and Wildlife was a big help and I certainly appreciated all of his numerous contributions to the project.

Blackfeet Fish and Wildlife biologists, Adrian Costel and Spencer Momberg were invaluable doing fieldwork and tracking radiocollared foxes in my absence. I am indebted to their perseverance in the prairie wind and their ability to work well independently.

Many folks helped me with field work and data analysis, project design and general advice. In no particular order I say thanks to Brian Giddings (MTFWP), Stella Cappocia (MTFWP), Dr. Axel Moehrenschlager (Calgary Zoo), Keith Gibson (Calgary Zoo), Dale Salois, Amy Joyce, Matthew Hogan, Carol Ausband, Rafal Zwolak, Jason

Davis, Dr. Matthew Kaufman, Edward Schauster, Dr. Jay Shepherd, Dr. Michael Schwartz (USFS), Dr. A.J. Kroll, Dr. David Naugle, Dr. Jack Ward Thomas, G. Ross Baty, Larry and Mary Ann Davis, Keven Heinle, Nathan Schwab, all those who reported swift fox sightings and Matthew Bell, who after finishing his service in the Army joined me on a road trip that would change the course of my life forever. I am glad we flunked 8th grade together.

I would be negligent in not thanking my father for taking me to look for red fox in the little patch of hardwoods near my house when I myself was but a pup. Memories from our trips to Algonquin Park have stayed with me and even more than that, have inspired a love for wild country and the animals that reside there that has only grown and strengthened to this day. Maybe now, Dad, I can give back to something that has given the two of us so very much.

And, of course, my wife Elizabeth. Thanks for the diligent field work, meticulous proof reading, positive attitude and general faith in your husband's ability to do good science. I have learned much from you and continue to do so. The future is bright.

Chapter 1. Assessing reintroduction success

INTRODUCTION

Reintroductions have been used as a tool to conserve many imperiled species throughout the world (Griffith et al. 1989; Price 1991; Ginsberg 1994; Biggins et al. 1998; Fisher & Lindenmayer 2000; Sarrazin & Legendre 2000; Ostermann et al. 2001; Tutin et al. 2001; Banks et al. 2002; Wanless et al. 2002). Often the success of these efforts is difficult to determine because research may not be conducted over the time scale necessary to facilitate conclusions about a reintroduced population (Kleiman et al. 1991; Ginsberg 1994). In addition, loosely defined or wholly absent criteria defining project success (Phillips 1990), poor post-release monitoring (Aubry & Lewis 2003), and lack of published results from reintroductions can inhibit determining success (Fischer & Lindenmayer 2000). From 1980-2000, only 26% of species reintroductions were determined successful and 47% had no determination of project success at the time of publication (Fischer & Lindenmayer 2000). Moreover, reintroductions that have made efforts to determine success have used various definitions of success making interpretation and comparisons difficult (Fischer & Lindenmayer 2000). For example, Sanz and Grajal (1998) determined a reintroduction of yellow-shouldered Amazon parrots (*Amazona barbadensis*) was successful after 10 of 12 birds were alive one year post-release and one animal reproduced after 28 months. In contrast, Ostermann et al. (2001) had five explicitly defined success criteria for bighorn sheep (*Ovis canadensis*) reintroductions in California. After obtaining vital rate estimates from the reintroduced sheep population, they compared their estimates to vital rates estimated from other sheep populations and determined the reintroduction was unsuccessful.

Despite the disparities and concerns with monitoring and success determination, reintroductions are a vital component in our efforts to conserve rare species (Griffith et al. 1989). For example, swift fox (*Vulpes velox*) are now present in Montana largely because of reintroductions. Swift fox once inhabited shortgrass and mixed-grass prairies across the western United States and Canada. Records indicate swift fox were present in Alberta, Manitoba, Saskatchewan and south through Montana, North and South Dakota, Wyoming, Colorado, Nebraska, Oklahoma, New Mexico, and Texas (Allardyce & Sovada 2003). Since the late 1800s, swift fox populations have declined throughout their range, possibly due to dramatic changes in the prairie ecosystem associated with the demise of the buffalo (*Bison bison*), conversion of prairie habitat to agriculture, inadvertent poisoning, unregulated trapping, and interspecific competition with red fox (*Vulpes vulpes*) and coyotes (*Canis latrans*) (Carbyn et al. 1994; Allardyce & Sovada 2003; Herrero 2003). The swift fox was declared extirpated in Montana in 1969, although Hoffman et al. (1969) indicate the species was probably not present since 1953.

Canada declared the swift fox endangered in 1978 and began reintroductions of the swift fox in southern Alberta and Saskatchewan in 1983 (Carbyn et al. 1994). Over the following 15 years, Canadian wildlife agencies released 942 captive-raised as well as translocated wild foxes into two native prairie regions along the U.S. - Canadian border. Canadian reintroductions appear to have been successful (Moehrenschlager & Moehrenschlager 2001) with foxes even recolonizing transborder habitats in north-central Montana (Zimmerman 1998). In 1998, the Blackfeet Indian Nation, along with Defenders of Wildlife, a Washington, D.C.-based Non-Governmental Organization, began swift fox reintroductions on the Blackfeet Reservation, Montana. The goal of this project was to establish a self-sustaining population of swift fox on the Reservation. From 1998-2002, 123, mostly juvenile (89%), captive-raised swift fox (54% F, 46% M), obtained from Cochrane Ecological Institute, Canada, were released on tribal lands (Fig. 1) (Waters & Ausband 2002). Subsequent monitoring located natal dens (Fig. 2) and wild-born kits (Fig. 3) every year from 1999 – 2002 (Ausband 2003).

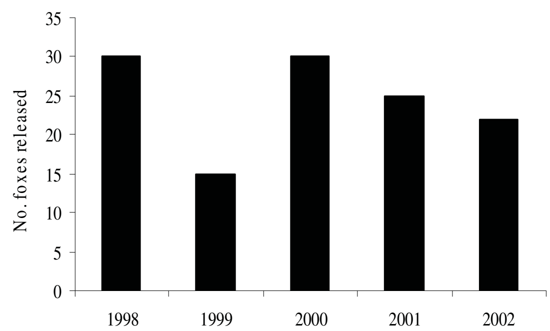

Figure 1. Number of captive-raised swift fox released on Blackfeet Indian Reservation, Montana from 1999 - 2002.

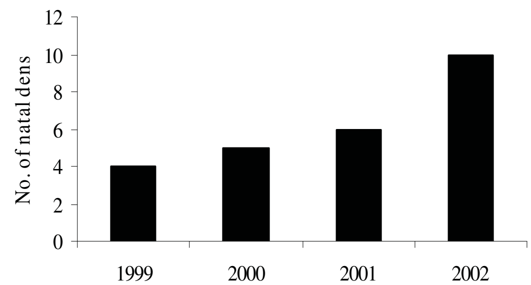

Figure 2. Number of swift fox natal dens found on Blackfeet Indian Reservation, Montana from 1999 – 2002.

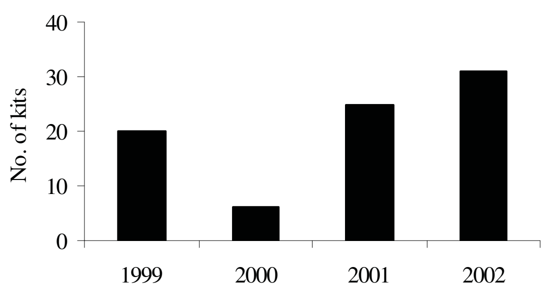

Figure 3. Number of swift fox kits observed on Blackfeet Indian Reservation, Montana from 1999 – 2002.

SUCCESS CRITERIA

After the fifth year of releasing swift fox, the Blackfeet Tribe and Defenders of Wildlife wanted to determine if the population of swift fox on the Blackfeet Indian Reservation was self-sustaining. Because the nearest swift fox population is 240 km (150 mi.) away, the opportunity for foxes immigrating to the Blackfeet Reservation is small, thus the Blackfeet swift fox population can only be considered self-sustaining if it has a long-term growth rate (λ) $\geq$ 1.0. Furthermore, a small population can have a positive growth rate yet be vulnerable to even moderate perturbations or catastrophes, therefore it is necessary to include a target count of foxes in the success criteria. Previous reintroduction studies provide little guidance in determining success criteria and few, if any, have employed an abundance target in the success criteria, even though an abundance target is crucial. Therefore, I considered the reintroductions successful if $\lambda \geq$ 1.0 during both years and an index count was $\geq$ 100 foxes on the Reservation. Although it was not included in my success criteria, I also evaluated facets of juvenile dispersal to provide insight into potential distribution of swift fox on the Reservation.

STUDY AREA

This study occurred on the Blackfeet Indian Reservation, Glacier County, Montana. This land was retained by the Blackfeet people under the Treaty of 1855. Later court decisions declared that this treaty also meant that the federal government recognized the tribe as a sovereign nation, therefore all decisions regarding non-threatened or non-endangered species of wildlife on tribal lands are autonomously dictated by the Blackfeet Fish and Wildlife Department and the Tribal Business Council. The Blackfeet Reservation is 1.5 million acres of mostly grassland habitat lying on the eastern flank of the Rocky Mountains adjacent to Glacier National Park. Blackfeet lands are bordered on the north by Alberta, on the south by Birch Creek, to the west by Glacier National Park, and partially bordered on the east by Cut Bank Creek. Grazing predominates land use on the Reservation with cropland comprising much of the remaining land area. All swift fox were released on the 3,200 ha (8,000 ac.) tribally-owned AMS Ranch located along the Two Medicine River approximately 30 km southeast of the town of Browning, Montana.

Data loggers placed at the release site recorded temperatures ranging from -40° C (-40° F) in January to 41° C (105° F) in July. Yearly precipitation averages 31.8 cm (12.5 in.) and elevation of the grasslands on the Reservation averages 1,200 m. Short-grass prairie vegetation including needle and thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*), and thread-leaf sedges (*Carex filifolia*) dominate much of the Reservation. Similar grassland habitat lies to the south and north of the Reservation.

METHODS

Fox handling, marking and telemetry

I live-trapped adult and juvenile swift fox in box-traps, 109 x 39 x 39 cm (Tomahawk Live Trap Co., Tomahawk, WI) and fitted them with radiocollars (Advanced Telemetry Systems, Isanti, MN) and transponders (AVID ID Systems, Norco, CA). Box-traps were lined with wood and wire mesh to decrease the chance of injury to trapped animals (Moehrenschlager et al. 2003).

Adults were trapped opportunistically year-round with the exception of the summer months if kits were present. I visually monitored adults discovered without kits twice a day for a minimum of seven days. After this time, technicians approached the location and looked for signs of kit presence (kit scat, tracks, tufts of ventral hairs clinging to vegetation, trampling, “fanning” of dirt, multiple entrances). If none of the above signs were observed, technicians then trapped at the site. Juveniles were trapped at natal dens in late August prior to dispersal by placing traps near (< 0.5 km) the late-summer natal den. I set traps at 2200 hr and returned at 0600 hr. I did not trap at temperatures below –20° C, above 32° C, or under other inclement weather conditions.

Captured swift fox were removed from the trap, placed in a sack and weighed. One observer then held and restrained the fox while the second observer placed a sock over the animal's eyes and muzzle, attached a radiocollar, implanted a transponder between the shoulder blades, determined sex, checked ears for tattoos (to determine wild-born versus captive-reared), and recorded tooth wear to estimate age. Observers closely examined the animal for any injuries that may have been sustained during the trapping process. These handling methods followed guidelines of the American Society of Mammalogists.

I located radiocollared foxes weekly by vehicle using a magnetic, roof-mounted antenna for approach and an H-antenna for triangulation. I also conducted telemetry flights as needed to locate missing collars.

Obtaining vital rates

I estimated survival of radiocollared juveniles and adults separately using a staggered-entry Kaplan-Meier formula (Pollock et al. 1989). This staggered-entry procedure allowed for animals to be entered into the survival analysis as I captured them at different times throughout the study. I did not have swift fox die within two weeks after capture, therefore I used all available data and did not include a handling acclimation period (Winterstein et al. 2001).

Survival rates differed at different times of the year for juveniles, but not adults. I calculated juvenile survival for September, October, November, December, and January to June 1 and used the product to obtain a 9-month survival rate. I estimated adult survival from June 2003 – June 2004 and again from June 2004 – June 2005. I also estimated juvenile survival from September 2003 – June 2004 and again from September 2004 – June 2005. Juveniles that were marked in September 2003 and survived to be adults in June 2004 were then included in the 2004 – 2005 adult sample size. Kits were not permanently marked or radiocollared. Therefore, I estimated kit survival by counting the number of kits observed at a natal den upon emergence (typically late May/early June) compared to the number of kits observed at the same den in late August during both 2004 and 2005. I used repeated counts in both early and late summer to increase the accuracy of this visual estimation method. I did not include natal dens discovered after July 1 in my estimate of kit survival because of the potential that kits may have died after July 1, would not be detected and counted, and therefore would incorrectly inflate my survival estimate.

I defined fecundity as the product of litter size (both sexes) and proportion of adult females reproducing annually. Because I did not handle and sex all kits, I also included an assumed sex ratio of 0.50 in my fecundity definition. I obtained the variance for fecundity from estimates of fecundity on the Blackfeet Reservation plus reproductive data from studies of swift fox in Canada (Moehrenschlager et al. 2004) and Wyoming (Olson & Lindzey 2002) and one long-term study of kit fox (*Vulpes macrotis mutica*) in California (Cypher et al. 2000). Litter size was calculated as the number of kits observed at the natal den upon emergence. As with kit survival, I did not include natal dens discovered after July 1 in my estimate of litter size because of the increased potential for kit mortality later in summer as kits begin short forays away from the natal den site. I defined a natal den as a breeding pair and their kits, regardless of how many times they moved in a given summer.

Mortality

I used criteria similar to Disney and Spiegel (1992) to determine the cause of mortality for radiocollared foxes. In addition to Disney and Spiegel criteria, I defined a fox as having been killed by a raptor if feathers were present at the kill site, the carcass had been fed upon extensively, skin and fur were peeled back, tufts of fur were scattered about, the fox had been eviscerated and there were no puncture wounds on the skull.

Juvenile dispersal

I defined juvenile dispersal as the distance that a juvenile fox moved from where it was trapped in late August/early September to where it was located on June 1 of the following year or to where it died, whichever came first. I did not classify a juvenile as having dispersed if this distance was < 2.0 km. Furthermore, because a small number of juveniles dispersed much farther than others, I use the geometric mean (Sokal & Rohlf 1995) when reporting juvenile dispersal distance. The geometric mean provides a better representation of the average dispersal distance juvenile foxes made as a group.

Fox index count

Potential swift fox habitat on the Reservation is extensive with large tracts that are difficult and time consuming to access, therefore, I wanted to have assistance from the public in locating swift fox. I placed informative signs with a photograph and description of a swift fox (Appendix A) annually in the same local businesses and government buildings on and around the Blackfeet Reservation in an attempt to collect reports from the public. I also placed advertisements with a photo, description, and den reward information (Appendix B) in the Glacier Reporter newspaper bi-weekly during both years. Defenders of Wildlife offered rewards of $100.00 (US) for reports that led to active, previously undiscovered swift fox natal dens. In addition, we designed and staffed an informative booth annually at the North American Indian Days pow-wow in Browning, Montana in an attempt to reach more of the public and familiarize them with the swift fox, the reintroductions, and our den reward system. I developed an informative pamphlet (Appendix C) to hand out at North American Indian Days and for use in field work when talking with local landowners.

I included a swift fox in a given year's count if it was present on June 1 of that year and was not discovered later than August 30 of that same year to avoid the potential for double counting of individuals. I assumed August 30 was the date after which juveniles may have dispersed from their natal area and thus would have the potential to be counted twice in my total. I report only individual swift fox observed by field crews and the numbers reported should not be viewed as an estimation of total fox abundance.

ANALYSIS

Survival, mortality and juvenile dispersal

I arcsine-transformed survival rates and used *Z*-tests to examine differences in survival rates between years for adults, juveniles, and kits. I used chi-square analyses to test for differences in juvenile survival by season and to test for differences in adult mortality by sex. I also used arcsine-transformed data and a *Z*-test to examine differences in survival between juveniles that stayed within their natal range and juveniles that dispersed from their natal range and to test for differences between raptor predation on juveniles and adults. I log-transformed juvenile dispersal distances and used a t-test to ascertain differences in dispersal distances between 2003/04 and 2004/05.

Population growth and projections

To estimate a growth rate (λ) for the swift fox population, I developed a post-birth pulse matrix based on vital rates obtained from radiocollared animals (Fig. 4).

$$\begin{bmatrix} S_k * S_j * F_1 & S_a * F_2 \\ S_k * S_j & S_a \end{bmatrix}$$

Figure 4. Post-birth pulse matrix for swift fox on the Blackfeet Indian Reservation, Montana where S = survival, F = fecundity. Subscripts represent age classes defined as k = kits (June – August), j = juveniles (Sept. – June), a = adults (June_{200X} – June_{200X+1}), 1 = first year adult breeders, 2 = 2+ year adult breeders.

I estimated asymptotic λ for both 2003/04 and 2004/05 using Matlab 6.0 (The MathWorks, Inc. Natick, MA) and function "eigenall" (Morris & Doak 2002). I then used the delta method (Eq. 1) to construct a 95% CI for λ (Lande 1988; Caswell 2001). The delta method also uses vital rate sensitivities in its calculation and these were obtained using Matlab and running a modified version of program file vitalsens.m (Morris & Doak 2002).

$$V(\hat{\lambda}) \approx \sum_{ij} \sum_{kl} Cov(a_{ij}, a_{kl}) \frac{\partial \lambda}{\partial a_{ij}} \frac{\partial \lambda}{\partial a_{kl}}$$

Equation 1. Equation to estimate variance for matrix-derived λ using the delta method, where ∂ = sensitivity.

I also used Matlab to project swift fox population growth to 2025 for 100 replicates, with each replicate 20-year projection being equally likely. A modified version of program file limitsens.m (Morris & Doak 2002) in Matlab allowed me to randomly construct matrices for each year of a 20-year projection by choosing vital rates from a uniform distribution that was based on the upper and lower bounds of my estimated vital rate confidence intervals for 2005 (Table 1). Choosing from a range of possible vital rate values emulates environmental stochasticity in the population projections. For example, if the program chose the lower bounds of my adult survival and juvenile survival confidence intervals the resulting λ would emulate a poor year for fox growth. These projections did not account for correlation among vital rates between years. The swift fox population on the Reservation was large enough to exclude potential effects of demographic stochasticity in my projections (Morris & Doak 2002).

Table 1. Vital rate values measured from swift fox in 2004 and 2005 used to construct randomly chosen matrices to project swift fox population growth on the Blackfeet Indian Reservation, Montana to the year 2025.

	Mean vital rate	Lower bound	Upper bound
S_k	0.77	0.65	0.89
S_j	0.47	0.32	0.62
S_a	0.60	0.44	0.76
F_1	0.83	0.55	1.20
F_2	2.07	1.20	2.30

RESULTS – Vital rates, mortality and juvenile dispersal

Field crews captured and radiocollared 23 adult (12 F, 11 M) and 35 juvenile (16 F, 19 M) swift fox between 2003 and 2005. Three of the adult foxes were ear-marked indicating they had been captive-reared releases. Survival rates for adults were mostly constant throughout seasons and annual rates did not differ between years ($Z = 1.01$, $p = 0.16$) (Table 2). Juvenile survival was lower in autumn (Sept. – Dec.) during both years ($\chi^2 = 10.9$, df = 3, $p = 0.01$) (Table 3), but did not differ between years ($Z = 0.49$, $p =$

0.31) (Table 2). Survival rates did not differ between years for kits ($Z = -1.07$, $p = 0.14$) (Table 2).

Table 2. Mean survival and 95% CI for swift fox adults, juveniles and kits on the Blackfeet Indian Reservation, Montana.
[a] No. censored refers to foxes that were missing due to either radiocollar failure or dispersal.

	Age class	No. marked	No. censored[a]	$\bar{x}$ survival	95% CI
June 2003 – June 2004	adults	14	2	0.73	0.52 – 0.94
June 2004 – June 2005	adults	24	3	0.60	0.44 – 0.76
Sept. 2003 – June 2004	juveniles	13	4	0.56	0.32 – 0.80
Sept. 2004 – June 2005	juveniles	22	1	0.47	0.32 – 0.62
June 2004 – Sept. 2004	kits	29	0	0.69	0.55 – 0.83
June 2005 – Sept. 2005	kits	39	0	0.77	0.65 – 0.89

Table 3. Juvenile survival rate estimates by month during autumn and remainder of nine month time interval on the Blackfeet Indian Reservation, Montana.

	$\bar{x}$ survival Sept.	$\bar{x}$ survival Oct.	$\bar{x}$ survival Nov.	$\bar{x}$ survival Dec.	$\bar{x}$ survival Jan. - June
Juveniles 2003/2004	0.89	0.88	1.00	0.86	0.83
Juveniles 2004/2005	0.85	0.88	0.94	0.88	0.77

Four of six 2+ year adult females that survived to June 1 reproduced in 2004, whereas five of five that survived to June 1 bred in 2005 (Table 4). One of two first year adult females reproduced in 2004, whereas three of six reproduced in 2005 (Table 4). Average litter size for 2+ year adults was 3.57 in 2004 and 4.14 in 2005. First year breeders averaged 4.00 and 3.33 kits per litter in 2004 and 2005, respectively.

Table 4. Swift fox reproductive estimates and number of natal dens observed on the Blackfeet Indian Reservation, Montana (2003 – 2005).
[a] No. natal dens includes both collared and uncollared animals

	Proportion reproducing		No. natal dens[a]	Avg. litter size
	Adults (1 yr)	Adults (2+ yr)		
2003	N/A	N/A	8	4.75 $\pm$ 0.62 (SE)
2004	0.50	0.67	14	4.00 $\pm$ 0.39 (SE)
2005	0.50	1.00	13	3.92 $\pm$ 0.42 (SE)

Predation accounted for 26 of 33 (78.8%) radiocollared swift fox mortalities (Fig. 5). Vehicle collisions were the cause of five and I was unable to determine the cause of death for two foxes.

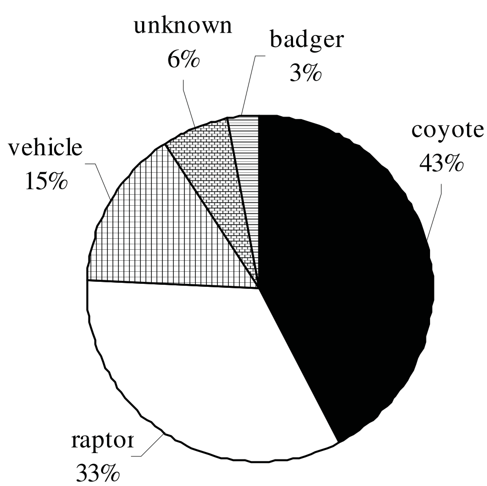

Figure 5. Cause of radiocollared swift fox mortalities from 2003 – 2005 on the Blackfeet Indian Reservation, Montana (n = 33).

Causes of mortality were roughly equivalent between age classes with the exception that predation by raptors was slightly higher for adults (38.9%) than for juveniles (26.7%), but this trend was not significant ($Z = 0.78$, $p = 0.22$) (Fig. 6).

Although the sex ratio of foxes captured did not differ, significantly more radiocollared adult females died than males ($\chi^2 = 4.17$, df = 1, $p = 0.04$).

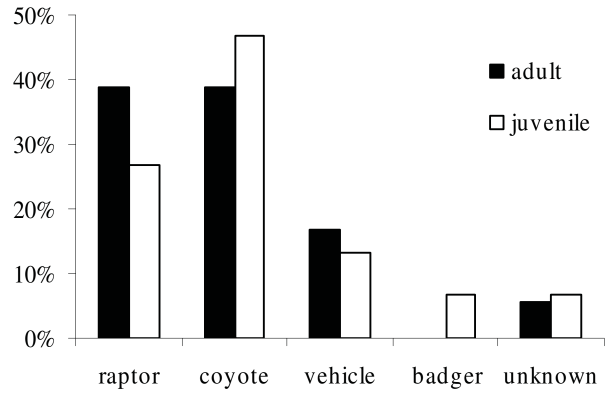

Figure 6. Cause-specific swift fox mortality by age class on the Blackfeet Indian Reservation, Montana, 2003 - 2005 (n = 33).

More juvenile deaths occurred in autumn (Sept. – Dec.) than expected if predation had been constant throughout the year ($\chi^2 = 10.9$, df = 3, $p = 0.01$) (Fig. 7).

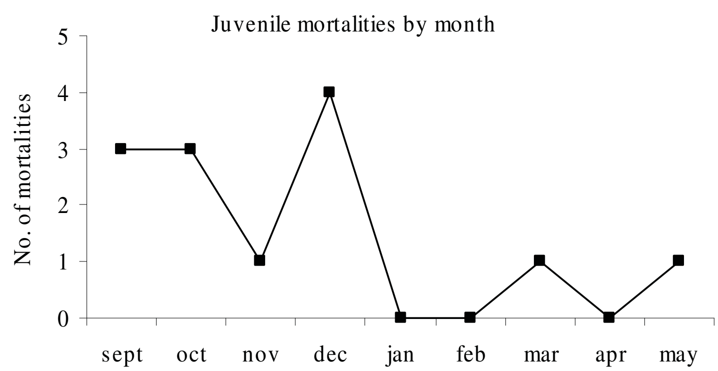

Figure 7. Radiocollared juvenile swift fox mortalities by month on the Blackfeet Indian Reservation, Montana, 2003 - 2005.

Juvenile dispersal averaged 5.2 km (SE = 1.8, range = 2.3 – 12.9 km) for 2003/04 and 9.6 km (SE = 2.8, range = 2.6 – 28.5 km) for 2004/05 and was not different among years (t = 1.55, df = 15, two-tailed $p = 0.14$). For both sexes, one of nine juveniles stayed and bred within its natal range and two of nine died before dispersing from their natal area in 2003/04. In 2004/05, eight juveniles died before dispersing from their natal area and three stayed within their natal area with two of the three having reproduced. For both 2003/04 and 2004/05 combined, juvenile survival for those that did not disperse $\geq$ 2 km from their natal area was 0.36 (0.21 – 0.51, 95% CI), whereas 0.59 (0.41 – 0.77, 95% CI) of juveniles that did disperse survived to become adults the following June (Z = -1.46, p = 0.07).

Fox index count and population growth

The number of swift fox observed increased every year with a high of 93 individuals counted in summer 2005 (Table 5).

Table 5. Number of individual swift fox observed on the Blackfeet Indian Reservation, Montana during summers 2003 – 2005.

Age class	No. individuals
2003 adults	24
kits	38
total	62
2004 adults	39
kits	47
total	86
2005 adults	44
kits	49
total	93

I received 19 natal den reports from the public in 2004 and 14 reports in 2005. Five of the 19 reports in 2004 were separate swift fox natal dens, eight were red fox dens, and I was unable to confirm an additional two reports, although based on habitat I believe these reports were likely red fox. In 2005, four of the 14 reports were swift fox natal dens, although only one of these was previously undiscovered by field crews. An additional seven of the 14 reports were red fox and one was a coyote natal den. I was unable to confirm two of the 14 reports in 2005, but again, based on habitat features I believe these were red fox.

I estimated a λ of 1.16 (0.77 – 1.55, 95% CI) from June 2003 to June 2004 and 1.14 (0.80 – 1.48, 95% CI) from June 2004 to June 2005. Population projections based on empirical vital rates indicated growth over 20 years for all 100 replicates, each equally likely to occur. The arithmetic mean for all 100 replicates was $\lambda = 1.072$ (1.066 – 1.078, 95% CI) (Fig. 8).

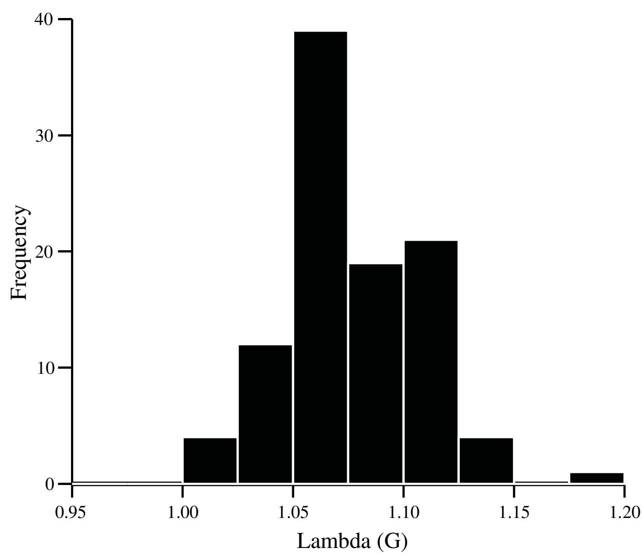

Figure 8. Histogram of λ_G values generated from 100 replicates of 20-year swift fox population growth projections.

All 100 replicates had an initial population size of 93 foxes. Mean abundance in year 2025 was 427 (377 – 478, 95% CI; $\bar{x}_G = 365$) and no replicate went extinct (Fig. 9).

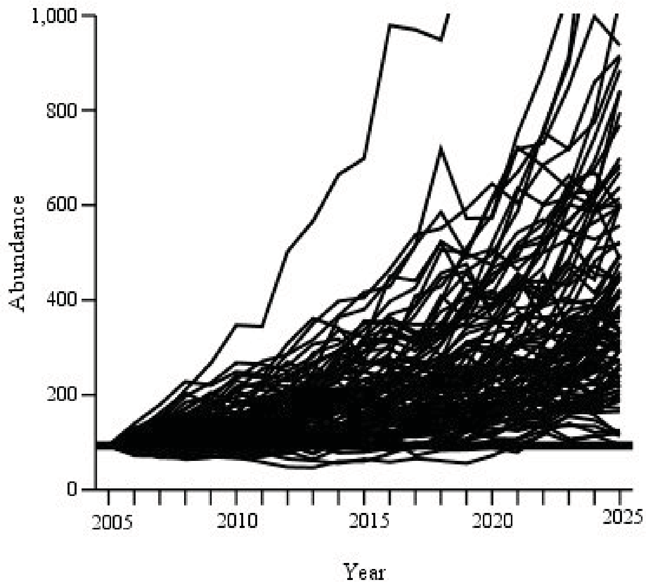

Figure 9. Estimated abundance counts generated from 100 replicate, 20-year swift fox population growth projections. Thick, dark line at abundance of 93 indicates initial population size for all 100 replicates.

DISCUSSION

Vital rates, mortality and juvenile dispersal

Adult survival was comparable to, or higher than, what is reported from several recent studies on swift fox (Table 6). Moehrenschlager et al. (2004) also contains a useful table for comparing vital rates obtained on the Reservation to vital rates obtained in other swift fox studies.

Table 6. Comparison of other studies' survival rate estimates to those obtained on the Blackfeet Indian Reservation, Montana from 2003 – 2005.
[a]value is mean of 3 years, [b] value is mean of 2 years, [c]value is from 6-month survival interval, [d]value is from 6-month survival interval and is mean of 3 years, [e]value is from 4-month survival interval

Blackfeet	$\bar{x}$ survival		Other studies
Adults			
2003/04	0.73	0.64	Kitchen et al. (1999)
2004/05	0.60	0.58	Olson & Lindzey (2002)[a]
		0.54	Kamler et al. (2003b)[b]
Juveniles			
2003/04	0.56	0.33	Sovada et al. (1998)[c]
2004/05	0.49	0.60	Kamler et al. (2003b)[d]
Kits			
2004	0.69	0.38	Rongstad et al. (1989)[e]
2005	0.77	0.56	Covell (1992)

Comparing juvenile survival to other studies is difficult due to small sample sizes and varying time periods used to define juvenile survival estimates. Sovada et al. (1998) found that average juvenile survival (six month) in Kansas was 0.33. However, the majority of foxes in their estimate inhabited cropland thereby making comparisons to the Blackfeet foxes difficult. In contrast, Kamler et al. (2003b) estimated juvenile survival (six month) in Texas to be approximately 0.60 over three separate years (Table 6). Juvenile survival estimates (9.5 month) for San Joaquin kit fox, a closely related species, averaged 0.14 and never exceeded 0.31 over 12 years in California (Cypher et al. 2000). It appears that juvenile survival estimates from the Blackfeet population are quite high and certainly higher than estimates reported from other studies.

To my knowledge, only two studies have estimated kit survival. Rongstad et al. (1989) estimated that 0.24 and 0.52 of kits survived (emergence to October 1) during 1986 and 1987 in Colorado. Although, kit survival estimates from the Blackfeet population are much higher than those reported from Colorado, comparisons are difficult as no kit survival sample sizes are provided in the Rongstad et al. (1989) report. Covell (1992) estimated kit survival for swift fox in southeastern Colorado to be 0.56. Clearly, my estimates of kit survival during both 2004 and 2005 were higher than those reported by Covell (1992) and Rongstad et al. (1989). Fortunately, many studies have estimated litter size and average litter sizes on the Blackfeet Reservation (Table 4) compare favorably with other summary papers on swift fox ecology (Moehrenschlager et al. 2004; Stephens & Anderson 2005). In addition to litter size, another component of fecundity is the proportion of adult females that breed annually. Again, this metric was comparable to, or higher than, what is reported by Olson & Lindzey (2002) (0.79, adults), Moehrenschlager & Macdonald (2003) (0.33 and 0.60, adults (2+ yr) and adults (1 yr), respectively), and estimates from a summary table in Moehrenschlager et al. (2004). I should note that when comparing vital rates from the Blackfeet population to other populations of swift fox I am comparing a presumably expanding population to established, resident populations. For example, vital rates may be higher in the Blackfeet population because foxes are expanding into optimal, vacant habitat whereas other populations of swift fox are already at carrying capacity making their vital rates more reflective of a growth rate at or near 1.0.

Coyotes were the primary cause of mortality for swift fox on the Reservation. Coyotes have been implicated as a major source of swift and kit fox mortality in numerous other studies as well (Cypher & Scrivner 1992; Sovada et al. 1998; Kitchen et al. 1999; Olson & Lindzey 2002; Kamler et al. 2003a). Researchers even suggest that coyotes may have a large enough impact on swift and kit fox that they suppress fox population growth (Cypher & Scrivner 1992; Kamler et al. 2003a). A substantial proportion of swift fox on the Reservation were presumed to be killed by raptors (33%). Other studies have recorded sporadic and negligible amounts of raptor predation on swift fox (Covell 1992; Olson & Lindzey 2002), and I have not discovered another study with the same level of raptor predation I observed. While it is true that some of these foxes may have died from other causes and were only then fed upon by raptors, most raptor species observed on the Reservation do not typically eat carrion (Elphick et al. 2001).

As expected, most juveniles died in autumn when parental care dwindled and some juveniles dispersed from their natal range. Juvenile dispersal in autumn was also recorded by Kamler et al. (2004) and increased mortality during this dispersal period was recorded in kit fox (Koopman et al. 2000). Average juvenile dispersal distance (5.2 km and 9.6 km for 2003/04 and 2004/05, respectively) was similar to juvenile kit fox in California (7.8 km) (Koopman et al. 2000). However, when reporting the arithmetic mean to estimate average dispersal distance, as Koopman et al. (2000) do, the Blackfeet juvenile swift foxes dispersed farther (10.4 km) for both years combined.

I found more radiocollared adult females died than I would expect had mortality been constant across sexes. Survival between sexes of adults was roughly equivalent during the first year of the study, however, from June 2004 to June 2005 adult females had a survival rate of 0.38 (0.20 – 0.56, 95% CI) whereas adult males had a survival rate of 0.80 (0.58 – 1.00, 95% CI) for the same time period. Moehrenschlager and Macdonald (2003) note that survival for females was lower in translocated foxes and suggest swift fox reintroduction projects should release more females than males to compensate for differential survival. I am unsure what would create differential survival in adult foxes, particularly during just one year of my study. Two of the adult females that died during the 2004/05 year were old judging from severely worn teeth as well as ear tattoos indicating one was from the original 1998 release. If these two female deaths are excluded from the survival analysis, average adult female survival increases to 0.54 (0.32 – 0.76, 95% CI). Identifying factors that would lead to differential mortality between sexes during one year is difficult because survival rate equations can be sensitive to any changes due to the relatively small sample sizes being analyzed.

When coupled with my estimate of population growth, it seems that swift fox populations can grow even under intense predation from both raptors and coyotes.

Fox index count and population growth

Coupled with our outreach efforts, providing monetary rewards for reports of natal dens was effective in obtaining additional swift fox locations. Although some time was spent confirming den reports that were actually red fox or coyote, the benefit of discovering previously unknown swift fox natal dens outweighed the cost of resources used on misidentifications. In 2004, five of 14 natal dens discovered were from public reports. Although only one of the 13 natal dens discovered in 2005 was from a report, some of the radiocollared foxes (n = 5) that produced litters in 2005 were discovered via reports in 2004.

In 2005, the lone report that lead us to a previously undiscovered den in 2005 was from the town of Augusta, 110 km south of the release site. This pair of swift fox produced two kits in 2005, both of which were female. We captured and radiocollared both female kits in late August 2005 and they are currently being monitored by a Montana Fish, Wildlife and Parks volunteer. Two additional swift fox were discovered in the same area in December 2004, one of which was hit by a vehicle and another was inadvertently injured in a trap and has since been moved to a zoo in North Dakota. A large expanse of cropland separates Augusta from the only other known swift fox population in the state near Havre, Montana. In contrast, grassland is contiguous along the Rocky Mountain Front from the release site on the Reservation to Augusta and continuing farther to the junction of Highway 200 (Appendix D). Based on habitat features, these swift fox are likely to have been derived from the Blackfeet Reservation population and it is likely swift fox occupy, at least in part, the habitat between Augusta and the southern Reservation boundary. Future surveys and monitoring - preferably cooperative between the Tribe and state - will provide a clearer picture of what this potential habitat may contain.

My estimate of swift fox population growth admittedly has a wide associated confidence interval. However, when comparing individual vital rates to vital rates obtained from other studies where swift fox are considered stable or growing the Blackfeet vital rate estimates are comparable, or in some cases, higher.

Population projections, each equally likely, based on vital rates obtained from radiocollared foxes provided a range of 377 – 478 swift fox present in the year 2025 and no replicate had a $\lambda_G < 1.0$. While these population projections did emulate environmental stochasticity - good years and bad years - I should note that the population projections in Fig. 9 are based on a minimum number of foxes present in 2005 and it is likely more swift fox were present that were simply undetected by field crews. Furthermore, I do not know the true process variance in this system and the estimated growth rates are based solely on sample variance, which may or may not encompass all variance in the vital rates over time. The projections presented are merely a rough sketch of what could be expected given the vital rates I measured from radiocollared foxes, however, both the Blackfeet Tribe and Defenders of Wildlife should be aware that these projections are very sensitive to initial population size. Furthermore, these projections did not include habitat or territoriality factors, hence, I only used a 20-year projection interval.

CONCLUSION – Reintroduction success

Based on my explicitly defined success criteria, I believe this reintroduction of swift fox has been a success. The swift fox population on the Reservation is growing, therefore, the first criterion defining success was met. Field crews also very nearly reached the second success criterion of 100 foxes by counting 93 in 2005. This minimum number of foxes does not include the Augusta swift fox. Again, the index count of 93 swift fox is not an estimate of total fox abundance on the Reservation, it is merely a minimum number of swift fox alive during the summer of 2005. I feel confident there were at least 100 swift fox on the Reservation during the summer of 2005 based on potential habitat that was not surveyed, sporadic reports from the public, and swift fox sign in areas where I was unable to observe a swift fox despite being aware of their presence. Also, the fortunate discovery of swift fox reproducing as far south as Augusta lends support to calling this reintroduction a success. Not only have the Blackfeet Tribe and Defenders of Wildlife reached their goal of restoring an extirpated species to Tribal lands they have also potentially initiated a comeback of swift fox along the Rocky Mountain Front in Montana.

I should note that all of the animals used to initiate this reintroduction effort were from the captive colony at Cochrane Ecological Institute, Canada. While Cochrane has taken great care to maintain genetic diversity in their captive animals, the Tribe should be aware that genetic concerns have not been directly addressed through my research. While we have witnessed no morphological defects consistent with inbreeding in any of the foxes observed in the wild, the population on the Reservation is small and isolated enough to merit attentiveness to the possibility of inbreeding depression (Mills & Allendorf 1996). However, with swift fox as far south as Augusta and more foxes likely occupying the habitat between the Reservation and Augusta, the realized population may, in fact, be large enough to assuage concerns about inbreeding. Should future monitoring demonstrate that this is not a contiguous Rocky Mountain Front swift fox population or DNA analysis shows low heterozygosity, the Tribe, as well as the state, may want to consider supplementing the population with 5-6 adults every other year until inbreeding concerns dissipate. I suggest 5-6 adults because survival of captive-reared swift fox is low (Carbyn et al. 1994) and 5-6 animals may be needed to ensure at least one survives to breed. The number of foxes recommended for release could be decreased to 3-4 if wild-born foxes are used. Researchers suggest even a small amount of gene flow can greatly enhance heterozygosity within a population (Mills & Allendorf 1996; Flagstad et al. 2003; Vila et al. 2003). Animals may be obtainable through personnel associated with the Swift Fox Conservation Team or from zoos who have teamed with the Conservation Team to maintain colonies of genetically diverse swift fox specifically for the purpose of reintroductions (Swift Fox Conservation Team, pers. comm.).

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Chapter 2. Small mammal distribution

INTRODUCTION

The first step in species reintroductions should be the feasibility phase (Price 1991). The feasibility phase includes estimating the carrying capacity of the release area, assessing habitat and forage quality, and determining potential mortality risks (Kleiman 1989; Tutin et al. 2001; Wanless et al. 2002). As a part of feasibility studies, swift fox reintroduction projects in South Dakota and on the Blood Reserve, Canada assessed prey and relative predator densities in their prospective release areas (Kunkel et al. 2001; C. Smeeton, Cochrane Ecological Institute, pers. comm.; S. Grasley, Lower Brule Sioux Tribe, pers. comm.). Knowles (1998) conducted a feasibility study prior to the release of swift fox on the Blackfeet Indian Reservation. He assessed habitat quality and relative prey densities by placing small mammal trap transects and ATV survey transects throughout the 3,200 ha tribally-owned AMS Ranch. Based on these surveys, Knowles concluded that sufficient prey existed on the potential swift fox release site.

In the event that the population had not reached my two success criteria (Chapter 1) and more reintroductions would be recommended, I estimated the relative distribution of small mammalian prey on the Blackfeet Reservation to delineate possible future release sites.

METHODS

In 2004, I estimated the relative distribution of prey on a portion of the Reservation by placing two 100 x 100 m trapping grids with 10 m trap spacing in each of two sections within a township. I began trapping in the township of the release site in 2004 and spread clockwise out from that location. In 2005, I placed two 100 x 100 m trap grids in each of two sections based partly on travel time from the release site, the center for swift fox research, and access to the land. As a result, some townships were surveyed twice, though not in the same exact locations. Technicians baited one-hundred 8 x 9 x 23 cm. Sherman folding aluminum live traps (H.B. Sherman Traps, Tallahassee, FL) with rolled oats at each of two grids and checked the traps once in the early morning (0500 hr – 0600 hr) and once in the evening (~2000 hr) for four consecutive nights. Technicians identified, weighed, sexed, aged, determined reproductive status, and marked each captured animal with non-permanent ink in 2004. Because the ink worked poorly as a marking tool, I used aluminum ear tags to mark animals in summer 2005. These handling methods followed guidelines of the American Society of Mammalogists.

ANALYSIS

I used chi-square analyses to test for differences in capture rates between years for the three most commonly captured species. I also used a Mann-Whitney test to examine differences between captures of deer mice in Conservation Reserve Program fields versus pasture fields.

RESULTS

After adjusting for inoperable traps, 19 trap grids and one transect provided 14,990 trap opportunities in 2004 and 22 trap grids provided 16,891 trap opportunities in 2005. I captured eight different species (two Class Aves) in 2004 and nine different species (three Class Aves) in 2005 (Fig. 1).

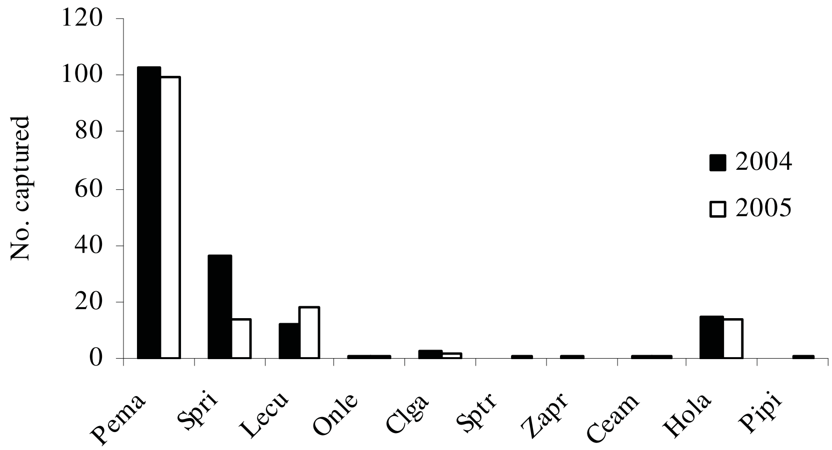
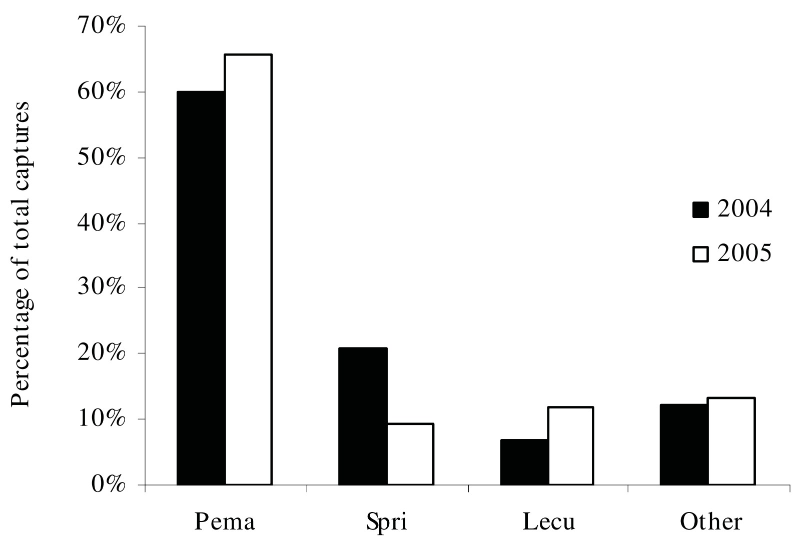


Figure 1. Total animals captured by species at 41 live trap grids and one transect on the Blackfeet Indian Reservation, Montana, summer 2004 and 2005. The three species listed at far right are Aves.

Deer mice (*Peromyscus maniculatus*), Richardson's ground squirrels (*Spermophilus richardsonii*) and sagebrush voles (*Lemmiscus curtatus*) comprised the majority of mammal captures both in 2004 and 2005 (Fig. 2).



. Figure 2. Three of the most commonly captured small mammal species expressed as a percentage of total captures at 41 trap grids and one transect on the Blackfeet Indian Reservation, Montana, summer 2004 and 2005.

The proportion of deer mice captured was roughly equal between years, 58.9% and 65.6% for 2004 and 2005, respectively. I captured a significantly higher proportion of Richardson's ground squirrels in 2004 than in 2005 ($\chi^2 = 10.9$, df = 1, $p < 0.001$). Conversely, I captured a significantly higher proportion of sagebrush voles in 2005 than 2004 ($\chi^2 = 6.9$, df = 1, $p = 0.009$) (Fig. 2).

Small mammal capture rates were insufficient to use an abundance estimator therefore, I report the minimum number alive (MNA) for the three most commonly captured animals at each trap grid (Figs. 3 and 4).

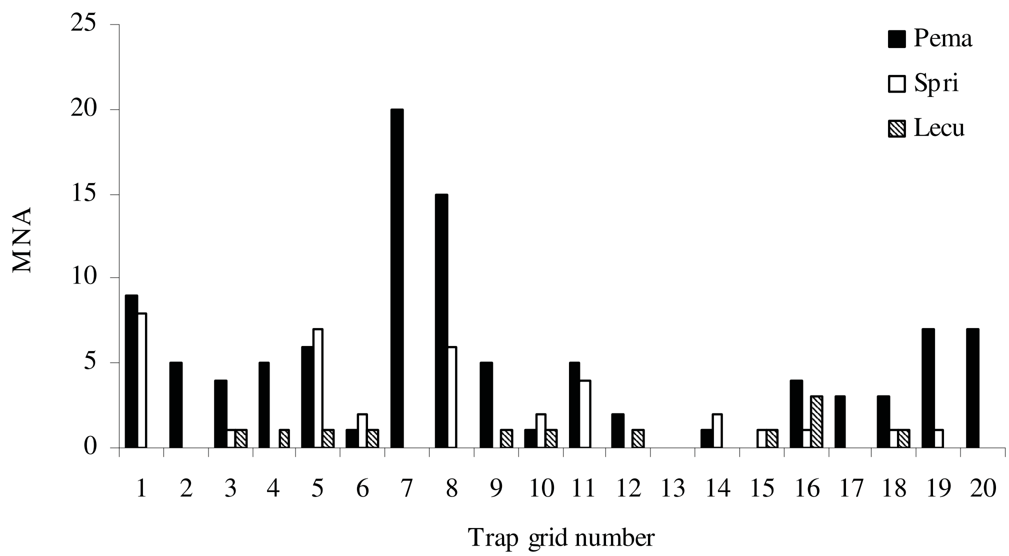


Figure 3. Minimum Number Alive (MNA) for deer mice (Pema), Richardson's ground squirrel (Spri) and sagebrush voles (Lecu) at 19 trap grids and one transect on the Blackfeet Indian Reservation, Montana, summer 2004. Trap sites 7 and 8 were Conservation Reserve Program fields.

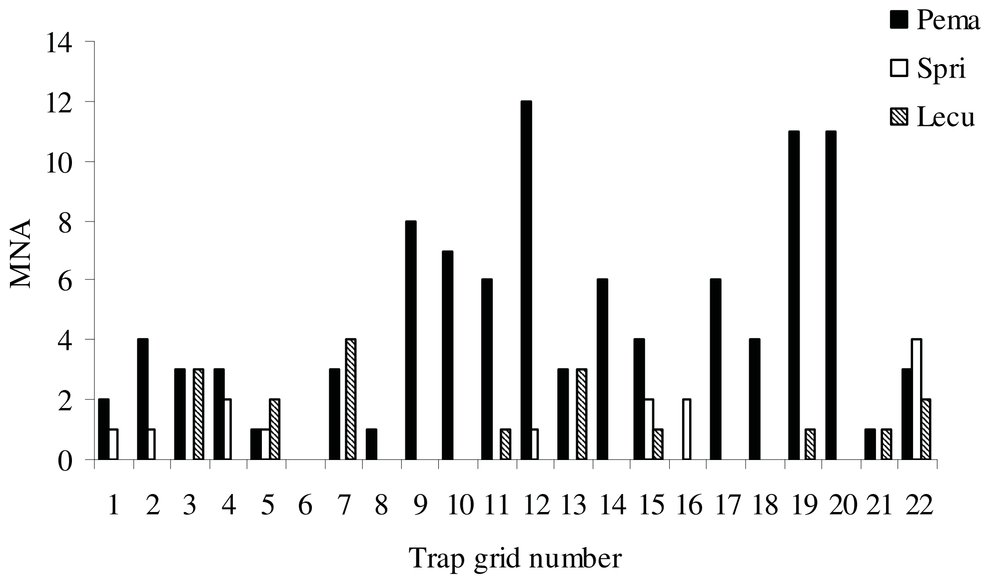


Figure 4. Minimum Number Alive (MNA) for deer mice (Pema), Richardson's ground squirrel (Spri) and sagebrush voles (Lecu) at 22 trap grids on the Blackfeet Indian Reservation, Montana, summer 2005. Trap sites 19 and 20 were Conservation Reserve Program fields.

The number of deer mice within Conservation Reserve Program fields was significantly higher than at trap grids on native prairie sites for both years ($Z = 3.19$, $p < 0.001$).

DISCUSSION

The distribution of small mammals on the Reservation was somewhat uniform, but species were typically at low densities during the summers of 2004 and 2005. Deer mice were the most ubiquitous species and were particularly abundant in Conservation Reserve Program (CRP) fields. While it is true that swift fox avoid tall, dense vegetation (Sovada et al. 2001; Hoagland 2002; Harrison & Schmitt 2003; Harrison & Whitaker-Hoagland 2003), such as that found in CRP fields, translocating foxes into areas with some CRP fields may not be unreasonable as there are abundant prey both within the CRP and presumably dispersing from the CRP. I did note a radiocollared fox that typically foraged along the edge of a CRP field on the AMS Ranch. Perhaps this animal was taking advantage of the abundant deer mice in the CRP without actually foraging in the field itself.

A possible explanation for the discrepancy in Richardson's ground squirrel capture numbers between 2004 and 2005 may have been the relatively mild winter of 2004/05. According to data loggers I had placed on the AMS Ranch during the winter of 2004/05, the daily high regularly reached 16° C (60° F) after mid-January and temperatures continued to remain relatively warm through spring. These conditions may have allowed the ground squirrels to emerge earlier in the spring and also enter into hibernation earlier the following summer, thereby making them unavailable for trapping for a large part of the summer of 2005. The majority of ground squirrels were caught before late June in 2005 (71%), whereas only 50% of ground squirrels captures occurred before late June in 2004.

We captured significantly more sagebrush voles in the summer of 2005. In addition to the previous winter being relatively mild, the spring of 2005 was one of the wettest on record for Glacier County (National Climatic Data Center). This increased precipitation during the spring could have resulted in favorable conditions for voles because they prefer fairly dense cover (Klausz 1997) and are known to show increases in abundance after mild winters and wet springs (Foresman 2001). My personal observations and those of local landowners noted the increased height and lushness of the vegetation during the summer of 2005.

Small mammal capture rates were quite low on the Reservation during the summers of 2004 and 2005 when compared to forested ecosytems (Campbell & Clark

1980), but were similar to capture rates Knowles (1998) reported at the release site. CRP fields consistently had a higher abundance of deer mice, however, this is based on a sample of only four fields. While a healthy distribution of small mammals is important for swift fox, I should note the diet of swift fox can be quite varied and during certain parts of the year small mammals may not even be the largest component (Zumbaugh & Choate 1985; Hines & Case 1991; Lemons 2001; Harrison 2003).

If the Tribe decides to release more swift fox in the future, I would recommend placing foxes in the region north of Highway 2 and west of Meriwether Road. This northern region was not surveyed for swift fox thoroughly nor did I receive many fox reports in this area. In 2005, I had three radiocollared foxes within 0.5 km of Highway 2 but two of them died from vehicles and one juvenile female eventually dispersed 28.5 km to the southeast. Specific areas within this northern region would probably be chosen as release sites based on land access and surrounding available swift fox habitat. Small mammal densities, while relatively low throughout the areas I trapped, were somewhat uniform with no evident patterns that could serve as a guide to delineate sites with high small mammal densities.

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Appendix A. Flyer

$100.00 REWARD!

Swift fox have been reintroduced to tribal lands. We need your help in finding them. If you can provide the location of a new, active, swift fox den with pups we will give you $100! It’s that simple. Below is a photo and key features of the swift fox. **Please note we will not pay for red fox dens, only swift fox.** All reports will be confirmed by a biologist prior to payment. Good luck!
To report locations: Call Dave at 531-2633.

Identification: The swift fox averages 5 pounds and measures 3 feet from head to tail. It is about the size of a house cat. The color is orangeish-tan to gray on the back, fading to a light tan on the belly. The **tip of the tail is black** and there are **black spots on the muzzle**. The swift fox is about one-half the size of the red fox. The red fox has a white-tipped tail.

5	5	5	5	5	5	5	5	5	5	5	5
3	3	3	3	3	3	3	3	3	3	3	3
1	1	1	1	1	1	1	1	1	1	1	1
-	-	-	-	-	-	-	-	-	-	-	-
2	2	2	2	2	2	2	2	2	2	2	2
6	6	6	6	6	6	6	6	6	6	6	6
3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3

Appendix B. Newspaper advertisement

WE NEED YOUR HELP!

Swift fox have been reintroduced to tribal lands. We need your help in finding them. If you can provide the location of a new, active, swift fox den with pups we will give you $100! It's that simple. Below is a photo and key features of the swift fox. **Please note we will not pay for red fox dens, only swift fox.** All reports will be confirmed by a biologist prior to payment. Good luck!

To report locations: Call Dave at 531-2633 or Blackfeet Fish and Wildlife.

Identification: The swift fox averages 5 pounds and measures 3 feet from head to tail. It is about the size of a house cat. The color is orangeish-tan to gray on the back, fading to a light tan on the belly. The **tip of the tail is black** and there are **black spots on the muzzle**. The swift fox is about one-half the size of the red fox. The red fox has a white-tipped tail.

Appendix C. (page 1 of 2)

Swift foxes were once common throughout the grasslands of eastern Montana. In 1998, Defenders of Wildlife and the Blackfeet Tribe collaborated to bring swift fox back to their native lands on the Blackfeet Reservation. Over the next 5 years 123 captive-raised swift fox were released on tribal lands. Monitoring since 1998 has found wild-born kits every year.

Currently there is a research project underway to determine if more reintroductions are needed. One of the main goals of this research is to find dens with kits. **BUT WE NEED YOUR HELP!** The Reservation has nearly 1 million acres of potential swift fox habitat and locating as many natal dens as possible is critical to determining the project's success. That is why we are offering $100 for reports of previously undiscovered, active swift fox dens with kits. We will not provide rewards for red fox dens and all reports will be confirmed by a biologist prior to payment.

To report sightings please call the number below or the Tribal Fish and Wildlife Department.

Blackfeet Fish and Wildlife Department
Box 850 Browning, MT 59417
(406)-338-7207

Defenders of Wildlife
114 West Pine Street
Missoula, MT 59802

The University of Montana

Return of the Swift Fox

Swift fox average 5 pounds and measure 3 feet from head to tail – roughly the size of a small house cat. The color is orange-gray on the back to light tan on the belly. The tip of the tail is black and there are black spots on its muzzle. The red fox is about twice the size of the swift fox and has a white-tipped tail and black legs.

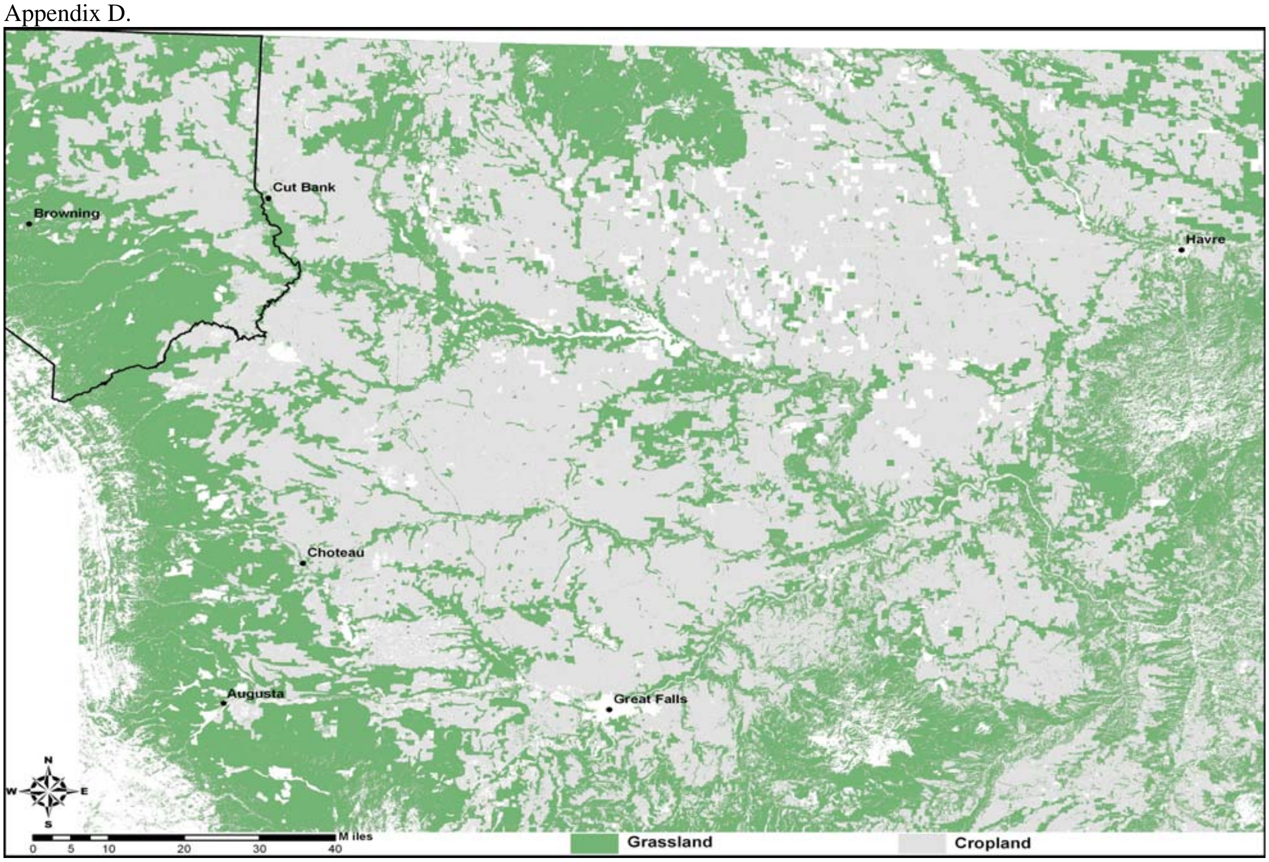
© L. Carbyn

Dens that contain kits are typically identified by the presence of much pup scat and prey remains, multiple entrances, matted vegetation and large fans of dirt projecting from each of the holes. Typically, swift fox will be found in pasture fields and are not commonly located in riparian or cropland areas.

If you locate a den with kits there may be a $100 reward for you! Please report any sightings of swift fox to (406)-531-2633 or call the Tribal Fish and Wildlife Department at (406)-338-7207.

Thanks for your help!

Appendix D.



Cut Bank
Browning
Havre
Choteau
Augusta
Great Falls
N
W
E
S
0 5 10 20 30 40 Miles
Grassland
Cropland

Appendix E.

MONITORING

This monitoring section is a synopsis of available methods for monitoring swift fox populations. I have attempted to concisely state the pros and cons of the various methods available. Another excellent resource when considering possible monitoring methods is Schauster et al. (2002). Also, the time of year when monitoring is conducted can greatly affect results and interpretation. For example, the most conservative monitoring protocol would be a method that employs data collected during winter after most of the young of the year – essentially the non-contributors to growth - have already died. Some suggestions for monitoring and management of swift fox on the Reservation are provided in the latter part of this section.

Swift fox are small, largely nocturnal and fossorial. As a result, monitoring swift fox populations is difficult. Recent developments using DNA derived from scats have shown promise for use as a population monitoring tool (Schauster et al. 2002; Smith et al. 2003; Harrison et al. 2004). However, amplification rates for DNA derived from scats can be low (Harrison et al. 2002) and the cost of associated laboratory work can be high, although when compared to the overall cost of a live-trapping survey, DNA methods may be more economical. Although scat-derived DNA is a non-invasive sampling method, low sample sizes from scat transects may confound the index (Harrison et al. 2004).

Some studies have found that tracking plates coupled with a scented lure are useful for monitoring fox populations effectively and at a relatively low cost (Olson & Lindzey 2000; Schauster et al. 2002; Uresk et al. 2003). However, Warrick and Harris (2001) found that tracking plates were only useful for detecting large changes in population abundance of kit fox. Ralls and Eberhardt (1997) suggest kit fox could be monitored with spotlighting provided there was a high degree of route replication and a continuous dataset. In contrast, Schauster et al. (2002) found that of six methods to estimate kit fox abundance, spotlighting was one of the least effective. Similarly, Uresk et al. (2003) found spotlighting to be an ineffective population estimator for swift fox. As with tracking plates, Warrick and Harris (2001) suggest spotlighting is only useful for detecting large changes in kit fox abundance. A few recent studies have described the use of trained dogs to aid in locating kit fox scats (Smith et al. 2003) and also employing the use of recorded vocalizations to detect swift fox (Darden et al. 2003). More research is needed on the efficacy of recorded vocalizations for use as a monitoring tool. The use of dogs to locate scats was highly accurate, however, scats would still need to be analyzed in the laboratory to extract DNA and the costs of using such trained dogs over a large area is not clear.

Beginning in the winter of 2000/01, Montana Fish, Wildlife and Parks, in conjunction with the Canadian government, initiated a 5-year transboundary swift fox survey that covered townships in north-central Montana and large parts of adjacent Canadian grasslands (Moehrenschlager & Moehrenschlager 2001). This survey will be conducted again in winter 2005/06. The Tribe could consider inclusion in the next survey, projected 2010/11. Joining with agencies that have already established known avenues to resources for conducting such an extensive survey, established methods and protocols, would benefit not only the Tribe, but also swift fox conservation throughout the northern plains because data could be shared more regularly between cooperating parties. This would be especially beneficial between the Tribe and the state of Montana if the assumption of a contiguous Rocky Mountain Front swift fox population bears true in the future.

Because den reports from the public were beneficial in locating swift fox, I suggest that funds be secured annually to offer den rewards and place advertisements (bi-weekly) in newspapers every summer as part of a monitoring tool. Advertisements in the Glacier Reporter cost approximately $50.00 (US) weekly for a 7.5 x 5.0 cm ad with photograph. A reasonable amount to secure for natal den reports would be $1,000.00 (US) per summer. Of course, reports from the public are only useful if personnel confirm whether the reports are valid swift fox natal dens. I suggest the Tribe begin an annual summer swift fox internship available to Tribal students. Some avenues for funding such a position could be obtained through Project IBS-CORE (http://ibscore.dbs.umt.edu/PEER) program at the University of Montana and/or the Project TRAIN program (http://ibscore.dbs.umt.edu/projecttrain/) which is specifically designed to provide Montana's Native American students the opportunity for employment in their future natural resource related field. This intern could confirm den reports from the public, staff an information booth at the pow-wow, and survey areas where swift fox have been located in the past. Maintaining a presence at the annual pow-wow is important for educating the public in proper identification of swift fox and their associated habitat and also to keep the public informed about the current status of the culturally important fox population.

In addition, I suggest the Tribe make a concerted effort to have the county authorities mow the vegetation along the shoulders along Mission Road (Joe Show East) in June. For several years, I have had numerous natal dens within 500 m of this road and kits were frequently seen at night on the roadway. From 2002 – 2005, seven swift fox were killed along this road. Vegetation at the roadside in 2005 was >1.5 m in height along some portions, thereby making visibility of swift fox along the shoulders of the roadway difficult. Also, because there is such a high density of foxes in this area, and in particular close to the roadway, it may be beneficial to obtain cautionary wildlife road signs from the highway department to post along Mission Road.

Another concern frequently cited in the literature regarding swift fox conservation is the loss of their optimal habitat, short-grass prairie (Moehrenschlager et al. 2004; Stephens & Anderson 2005). Based on statistics from the census of agriculture in Montana, Glacier County experienced a 7.9% increase in the acreage of cropland from 1997 – 2002. However, from 1992 – 1997 Glacier County witnessed a 7.1% decrease in total cropland acreage. The amount of acreage under cropland has fluctuated in the past. Tribal wildlife managers should carefully observe the results of the next census, scheduled for 2007, to ascertain whether another increase in the amount of cropland occurred within the county. Swift fox are not known to inhabit cropland in the northern distribution of their range. Furthermore, from 2002 – 2005, I found just two radiocollared animals in cropland, both of them dead.

As a final note, the laboratory costs of DNA analysis have declined dramatically in recent years (S. Mills, University of Montana, pers. comm.) and some states have been using scat-derived DNA to monitor swift fox populations (Harrison et al. 2004; Swift Fox Conservation Team, pers. comm.). The Tribe could use scat-derived DNA for non-invasive monitoring of the swift fox population on the Reservation by establishing permanent transects along which all fox scats are collected and subsequently analyzed.

Scat-derived DNA can provide data that would allow the Tribe to develop time series estimates of abundance for the swift fox population at a cost that would be considerably less than traditional mark-recapture methods. Possible areas for the establishment of permanent scat transects would be the AMS Ranch, Mission Road, Lenoir Road, Mission Lake area, Molly Nipple area, Four Horns Lake area, East Glacier buffalo pasture area, the Walstead Ranch/Kipps Coulee region, and Carlson Ranch/White Calf Coulee region. All of the areas listed above have had swift fox presence since 2004 and most have consistently had swift foxes present since 2002. Any additional permanent transects that could be established would be beneficial as I expect the swift fox population to continue to grow and occupy new areas on the Reservation.

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