Assessing Restoration of Swift Fox in the Northern Great Plains

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Abstract: Swift foxes (Vulpes velox) *are listed as threatened in South Dakota, and thus the state is mandated to "manage, protect, and restore" the species. We assessed potential for restoration of swift fox in South Dakota following the International Union for the Conservation of Nature guidelines. We reviewed the taxonomic status of swift foxes in the northern Great Plains; reviewed previous reintroductions; assessed features of reintroduction sites; examined social, economic, and legal considerations; and developed methods for translocation. In cooperation with the U.S. Fish and Wildlife Service; U.S. Forest Service; South Dakota Department of Game, Fish and Parks; Wyoming Department of Game and Fish; Colorado Division of Wildlife; and the Lower Brule Sioux Tribe, we will translocate approximately 30 foxes a year for 6 years from Wyoming and Colorado. Coyote* (Canis latrans)*-caused mortality of swift foxes is a primary limiting factor in fox population expansion, thus we will reduce coyote populations in the area during releases to maximize fox survival. We will work with local people to ensure optimization of fox management and restoration. We will monitor foxes during reintroduction to measure the project's success and to identify influencing factors.*

Since the settlement of the Great Plains of North America, swift fox (*Vulpes velox*) have disappeared from 60–90% of their historic range (Swift Fox Conservation Team [SFCT] 1997). The viability of fox populations especially in the northern half of their range (north of the North Platte River in Wyoming and Nebraska; Hall and Kelson 1959) where they exist in small, scattered, isolated patches remains in question. South Dakota lists the species as threatened and is thus mandated to "manage, protect, and restore" the species. Swift fox status in states bordering South Dakota is similarly tenuous (SFCT 1997).

Over 75% of swift fox habitat is on private property (SFCT 1997) and, as such, innovative plans will be needed to restore populations. As private land managers in South Dakota (Turner Endangered Species Fund and Turner Enterprises), we are developing a cooperative project with state, federal, and other private entities to restore swift foxes in South Dakota. We hope to demonstrate by example that stewardship of biodiversity is economically sustainable and enhances the long-term value and conservation of private "working" lands. We hope to show that private ranchers and farmers can produce public "environmental goods" or "conservation commodities" in conjunction with food and fiber (National Governors Association 2001). These and other efforts on private and federal lands are critical steps toward removing swift foxes from the state's threatened list and assuring the long-term viability of fox populations.

We developed a study plan (Kunkel et al. 1999) based on criteria set out by International Union for the Conservation of Nature Species Survival Commission (IUCN/SSC Re-introduction Specialist Group 1998) and the SFCT to assess the feasibility of reintroducing foxes. Results from that study indicate that ecologically, the Turner-owned Bad River Ranch (BRR) in western South Dakota was suitable for a swift fox reintroduction effort (Kunkel et al. 2001). Reintroduction addresses the first of 6 primary considerations identified by the SFCT (1997; p. vi) to develop a successful conservation strategy for foxes: "expanding the distribution of swift fox where ecologically and politically feasible." Additionally, the reintroduction project addresses critical research, management, and education needs identified in that document.

We believe that the most direct and immediate way to achieve swift fox recovery is to actively expand the distribution of swift foxes in the Great Plains. We believe that fox range will remain restricted without reintroductions because swift foxes are similar to kit foxes (*V. macrotis*), a species that has poor survival during dispersal along the edges of occupied habitat (Koopman et al. 2000). Coyote-caused mortality in areas of low fox-coyote ratios is especially significant for foxes dispersing into unfamiliar areas (no experience with escape terrain; edge effect of predation; Wilcove et al. 1986, Paton 1994, White and Garrott 1999). Reintroducing foxes greatly advances swift fox recovery by directly enhancing population abundance and distribution and by providing insights into swift fox ecology through experimentation.

Objectives

1. Establish a self-sustaining population of swift foxes on and around the BRR.
2. Establish a population that serves as a source for swift fox recovery and expansion in South Dakota and neighboring states and assists in removing foxes from threatened status in South Dakota.
3. Establish a population that enhances the long-term

survival of the species, restores natural biodiversity to the area (as part of the restoration of a full array of native species), and promotes prairie conservation awareness.

4. Collect and disseminate information on reintroduction techniques and the ecological requirements for successful swift fox restoration.

5. Collect and disseminate information on the ecology of swift foxes.

Reintroductions are relatively lengthy, complex, risky, and expensive conservation endeavors (IUCN/SSC Re-introduction Specialist Group 1998). We are prepared to expend the resources and to work with stakeholders and cooperators to achieve success in this project. This assessment, along with our feasibility study, ensures that we have taken the necessary steps to achieve our objectives. The topics, timeline, and responsible parties for this project follow the recommendations in the IUCN Guidelines for Re-introductions (1998) and those specifically for swift foxes by Mamo (1987) for Canada, by Sharps and Whitcher (1984) for South Dakota, and by FaunaWest (1991) for Montana.

Study Area

The reintroduction area (10,160 km^2; Fig. 1) is situated within the Pierre Hills physiographic region (Johnson et al. 1995). Soils are primarily clays derived from Cretaceous Pierre Shale. Topography consists of flats cut by intermittent drainages, including the Bad River, and gently rolling hills. Elevation ranges from approximately 590 m to 727 m above sea level. The climate is temperate with average temperatures ranging from -4°C in winter to 23°C in summer. Mean annual precipitation is 46.0 cm/year with most occurring in June and March. Kuchler (1975) characterized the area as a western wheatgrass (*Agropyron smithii*)-needlegrass (*Stipa viridula*; dominant cool season grasses) community within the typical mixed-grass prairie community region. Buffalo grass (*Buchloe dactyloides*) is the dominant warm season grass. Deciduous woodlands dominated by plains cottonwood (*Populus deltoides*) follow the Bad River valley floodplain and tributaries in the northern floodplain forest region.

Fort Pierre National Grasslands (FPNG) is a 470-km^2 grassland in Stanley, Jones and Lyman counties in west-central South Dakota. It is administered by the Nebraska National Forest and managed as a wildlife emphasis area. FPNG consists of 59 allotments and 210 pastures managed as one unit for multiple use. Deferred and rest rotation grazing is dominant between May and October.

BRR is approximately 570 km^2 and managed by Turner Enterprises for bison (*Bison bison*) production and

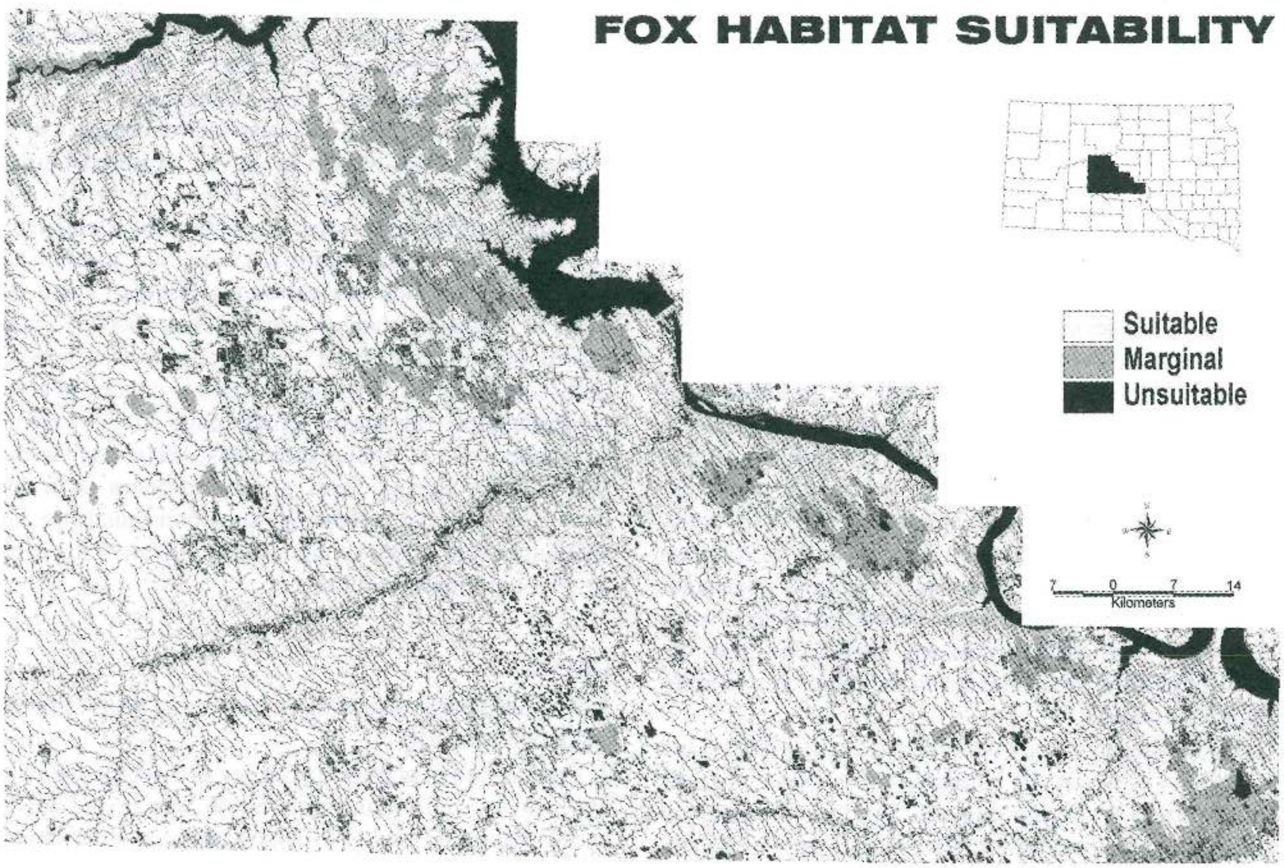

Figure 1. Relative suitability of landscape of west-central South Dakota for swift foxes based on a model of physiography and land cover.

conservation of biodiversity. The Lower Brule Reservation in Lyman and Stanley counties is 890 km² of primarily pasture land of which 1/4 is deeded property. Natural resources on the reservation are managed by the Lower Brule Sioux Tribe (LBST) Department of Wildlife, Fish, and Recreation to conserve and enhance the wildlife, fish and recreational resources of the reservation for the cultural, social, political and economic well being of the Lower Brule Sioux Tribe.

Biological Feasibility Study and Background Research

Taxonomic Status

Stromberg and Boyce (1986) found no justification for subspecific classification of northern (as described by Merriam 1902 and Hall and Kelson 1959) and southern swift fox but indicated that significant geographic variation among specimens may reflect genetic differences. They suggested for maintenance of genetic variability (i.e. ensure maintenance of genetics of rarer northern populations of swift fox), reintroduction in northern areas use foxes from northern areas. They cautioned that southern foxes or offspring from southern and northern crosses might not be able to endure the rigors of northern climates. Dragoo and Wayne (2002) supported this recommendation (but expanded northern areas to include Colorado) based on work by Crandall et al. (2000). There is no evidence that "southern" foxes (from southern Colorado) reintroduced into Canada have had lower survival than northern foxes (Carbyn 1998). We will reintroduce swift foxes from Wyoming and northern Colorado (latitude and climate similar to South Dakota).

We have obtained information on the history and ecology of potential source populations (Leberg 1990, Olson 2000, B. Luce, Wyoming Game and Fish [WDGF], unpublished report). We modeled various reintroduction strategies to maximize population performance (Haig et al. 1990, Kunkel et al. 2001). We will collect blood and hair samples for DNA analysis from all foxes to be released.

In order to retain >95% of the heterozygosity and allelic diversity found in the source population, we will reintroduce >25 individuals (½ males and ½ females) per year for at least 5 years (Leberg 1990). This should ensure that we have >25 founders in the population. We will maximize spacing of our traps in the source population to limit captures of related individuals to be released on BRR.

Effect of Reintroducing Foxes on the Ecosystem

Our swift fox reintroduction feasibility assessment (Kunkel et al. 2001) indicated that reduction of coyote densities on and around BRR would likely be necessary to assist in swift fox establishment. Initially (first 5 years), one primary impact on the ecosystem subsequent to the swift fox reintroduction will be a reduction in coyote density resulting from our control efforts (Henke and Bryant 1999). Coyote control will be terminated if it is not effective in assisting the establishment of swift foxes or when it is deemed no longer necessary for fox restoration (see below).

A restored population of foxes will have some level of impact on their prey (potentially reduced densities or behavioral changes in small mammals, birds, and insects). There are no reports from other occupied habitats assessing these impacts. Foxes prey to varying degrees on upland gamebirds. However, most studies indicate that birds make up a relatively small part of fox diets; in South Dakota birds comprised <6% of fox diets, thus their impact on mortality is likely relatively small and compensatory (Uresk and Sharps 1986).

Previous Reintroductions

South Dakota conducted the first recorded reintroduction of swift foxes. Eight captive-reared foxes were released in Haakon County (70 km west of BRR) in 1980 (Sharps 1984). Of these, 3 foxes died (1 shot, 1 trapped, 1 killed by car), radio contact with 3 foxes was lost within about 40 days of release, and one pair remained in the release area and raised pups. Sharps and Whitcher (1984) listed the following as criteria for site selection for fox release: open, gently rolling terrain; short/mid-grass prairie; black-tailed prairie dog (*Cynomys ludovicianus*) towns; permanent water; absence of poisoning; absence of trapping; release site >24 km from a road; and low densities of red fox (*V. vulpes*) and coyotes.

The Canadian reintroduction program released 942 swift foxes from 1983–1997 (Carbyn et al. 1994). There are now more than 300 foxes in about 58 townships in southern Alberta and Saskatchewan (Carbyn 1998). The majority of the current population are wild-born offspring of released animals. One year after release, soft-released foxes survived better than hard-released foxes (31% alive vs. 17% alive; Carbyn et al. 1994). However, 2 years post release, survival rates were similar. Coyote predation was the most significant cause of mortality (32%) for released foxes from 1987–1991 (Carbyn et al. 1994). One year post release, wild-born foxes had higher survival rates than captive-born foxes (47% alive vs. 14% alive). Captive-born foxes released in fall survived better after 1 year than foxes released in spring (14% alive vs. 4% alive). Wild-born foxes dispersed farther ($\bar{x}$ = 19.2 km) than captive-born foxes ($\bar{x}$ = 12.6 km) and all foxes dispersed farther in spring than in fall (Carbyn et al. 1994).

In fall 1998, Defenders of Wildlife and the Blackfeet Tribe hard-released 13 juvenile female and 17 juvenile male captive-reared foxes onto the Blackfeet Reservation in northwestern Montana (M. Johnson, Defenders of Wildlife, Missoula, Montana, personal communication). Protective shelters were placed and left at fox release sites for 4 days to enhance fox security (Smeeton and Weagle

2001). None of the foxes were radiocollared but surveys in 1999 indicated survival was relatively high and >1 litter had been produced. Twelve adult pairs and 3 captive-reared pups were released in August 1999; 8 of these foxes were radiocollared. Five of the radiocollared foxes remained alive in May 2000. Three litters were found in 2000. Thirty-one captive-reared foxes (16 radiocollared) were released in August 2000. At least 3 litters were produced in 2001.

Choice of Release Site and Type

The SFCT (1997) recommended expanding swift fox populations to occupy >50% of their historic range (suitable habitat). They recommended promoting dispersal or reintroductions in states that have no or severely limited swift fox population distribution. South Dakota, North Dakota, Montana, and Nebraska are the 4 states that meet this criterion. BRR is entirely within the historic range of the swift fox (SFCT 1997). Kunkel, Honness, Phillips, and Carbyn (2001) and a review of the fox sighting database for South Dakota indicate no foxes are present in the area.

Long-term Protection

All of the BRR can best be classified as "status 3 lands" (South Dakota Cooperative Wildlife and Fisheries Research Unit GAP analysis, unpublished data): "Areas having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area." The Turner Foundation holds the BRR in trust in perpetuity. While the legal language of this classification has not been formalized, the practical application is underway: the conversion of nearly 40 km^2 of cropland back to native vegetation, the replacement of all livestock with bison, and the restoration of >10% of BRR to prairie dog colonies. Ft. Pierre National Grasslands are also classified as "status 3 lands." Together BRR and FPNG form a nearly continuous protected block of approximately 1,000 km^2. We will work to secure conservation agreements with the state and private landowners in the restoration area.

Evaluation of Reintroduction Site

Number of Foxes Reintroduction Area Can Support

Based on his observation and research in western South Dakota, Sharps (USFWS 1994) suggested that to maintain a viable fox population in South Dakota, a minimum of 1,500 individuals (250 family groups; 2 adults, 4 pups) in 10 different populations would be needed. He suggested such a population would require 1,295 km^2 of which 20–25% should contain prairie dogs. While we believe prairie dogs will be an important food base for foxes and will be actively managing for them (present prairie dog population on BRR occupies 3 km^2; Kunkel, Honness, Phillips, and Carbyn 2001), we think the evidence for the necessity of prairie dogs to foxes is less than compelling. Foxes forage on a wide variety of prey (Kilgore 1969, Sharps 1984, Kitchen et al. 1999, Sovada et al. 2001) and there is no evidence that prairie dogs are preferred. Successful reintroductions into Canada have been into regions with insignificant populations of prairie dogs (Carbyn 1998). We do, however, agree that higher densities of prey, including prairie dogs, would support higher densities of foxes.

Approximately 7,848 km^2 (77%) of the project area is suitable and 1,162 km^2 (11%) is marginal for swift foxes based on our habitat suitability model (Kunkel, Honness, Phillips, and Carbyn 2001; Fig. 1). Density of holes that can be used to escape coyotes is well above thresholds in other swift fox study areas (Kunkel, Honness, Phillips, and Carbyn 2001). Extrapolations of fox density based either on leporid availability, small mammal availability, or mean home range size (from fox populations in areas nearest BRR) in the BRR area including FPNG and the Lower Brule Reservation yielded a minimum expected density of approximately 0.10–0.25 foxes/km^2 (200–1,000 foxes) in the proposed reintroduction area with a relatively low reproductive rate (Kunkel, Honness, Phillips, and Carbyn 2001). When prey availabilities are combined, and other prey added (insects and birds), we would expect somewhat higher minimum densities and reproductive rates. Such a population, while not exceptionally large, would likely be self-sustaining especially if mortality by coyotes is not excessive.

While there is no fox recovery plan or objectives for the state of South Dakota, a population of >200 foxes in west-central South Dakota would increase the likelihood of recovery and removal from threatened status in the state. Based on population modeling, Ginsberg (1994) estimated that a population of roughly 200–600 jackals (*Canis* spp.) or foxes (i.e., asocial canids) would be required to maintain 80–90% of starting heterozygosity over 100–200 years. Restoration of foxes in west-central South Dakota can lead to a larger metapopulation in the west-central and southwestern portion of the state that connects to the contiguous population of foxes in southeastern Wyoming and northwestern Nebraska (Kunkel et al. 1999) and could expand into Montana and North Dakota, increasing the prospects for long-term viability of foxes in the northern Great Plains.

Elimination of Threats

Swift foxes and coyotes have persisted sympatrically likely since the formation of the Great Plains biome. Foxes have evolved strategies to persist with coyotes including heavy reliance on dens for escape and the ability to exploit a wide array of prey items (Kitchen et al. 1999). However, coyote predation appears to be a primary factor limiting fox population growth (Kunkel, Honness, Phillips, and Carbyn 2001), especially populations of low density that may initially require a reduction of coyote density to improve their chances of increasing to a sustainable population (Kitchen et al. 1999, White and Garrott 1999, Kunkel, Honness, and Phillips 2001). We will attempt to reduce coyote densities by >50% during reintroductions and continue control until the fox population reaches a density that allow persistence despite coyote predation.

We initiated a coyote population reduction program in late winter 2001 on the BRR and surrounding buffer areas (other private land) that will likely continue through the reintroductions following our approved animal care and use plan (Kunkel, Honness, and Phillips 2001). After killing approximately 280 coyotes on 260 km^2 in northern Texas, fox survival rates and juvenile density increased compared to pre-control and non-control areas (Kamler 2002). It appeared these control efforts turned a small, marginal sink population into a population with a surplus of dispersers. Evidence from southeastern Colorado indicates similar results after coyote control (E. Gese, Utah State University, personal communication). Predator control programs even for enhancement of endangered species are controversial both ethically and scientifically. We believe any control work must be thoroughly justified and meet stringent ethical and scientific standards (Hecht and Nickerson 1999).

Control work will consist primarily of aerial gunning during late winter. We will contract with the South Dakota Game Fish and Parks (SDGFP) Division of Animal Damage Control for this effort. Trapping and shooting from the ground will be done by local trappers and project personnel following approved protocols under the direction of a Turner Endangered Species Fund (TESF) biologist. We will attempt to target resident breeding pairs. We will intensify coyote control efforts if coyote predation remains high, and then discontinue it if this greater effort appears ineffective. Age, sex, and condition of all coyotes killed will be determined. Blood samples will be collected for disease profile analysis related to impacts on fox. We will also collect stomachs from coyotes for diet analysis.

We will estimate the percent of foxes that die due to coyote predation annually to determine the effectiveness of the predator management plan. We will measure coyote population trends via scat transects, scent station surveys, and spot light surveys (Kunkel, Honness, Phillips, and Carbyn 2001). Our goal will be to reduce and maintain coyote densities at <50% of pre-control abundance (approximately 0.20–0.40 coyotes/km^2; Kunkel, Honness, Phillips, and Carbyn 2001) or 0.10 coyotes/km^2 and to maintain coyote-caused mortality rates on foxes at <25%. This would likely mean killing approximately 50–100 coyotes/year. Coyote predation rates on foxes should decline annually as coyote densities decline due to control efforts and the swift foxes gain experience eluding the remaining coyotes. We will stop coyote control when it appears that fox density has reached a level to maintain a viable fox population capable of withstanding coyote predation (fox density >0.10/km^2), or if we have not maintained a viable fox population in 10 years. We concur with Hecht and Nickerson (1999) that "the best overall predator management strategy is an adaptive approach that monitors many factors, considers a full array of management techniques, continually appraises their potential and actual effectiveness, and makes appropriate adjustments."

Public trapping of furbearers is prohibited on BRR. We will work with local trappers to prevent incidental take of swift foxes in surrounding areas and to retrieve and release any foxes caught in traps. Habitat protection is assured by management paradigms used at BRR and on the grasslands (see above).

Surrounding landowners may use rodenticides to control prairie dogs. While zinc phosphide has been widely used to control prairie dogs, there is little indication this poses a hazard to foxes (Bell and Dimmick 1975). Schitoskey (1975) indicated kit fox survived after feeding on kangaroo rats (*Dipodomys* spp.) killed with zinc phosphide.

Diseases reported in swift foxes include plague, distemper, and mange; however, there are no confirmed cases of these diseases impacting population levels significantly (Miller et al. 2000, Pybus and Williams 2002). Plague has never been reported in western South Dakota and our sampling indicates mange levels appear low. We will continue to monitor these diseases in carnivores in the BRR area and manage appropriately (see below).

Availability of Suitable Release Stock and Assurance of No Significant Impact to Donor Populations

Wyoming Game and Fish and Colorado Division of Wildlife have conducted population surveys and identified areas with populations of foxes than can sustain the removals we propose (B. Oakleaf, WDGF, unpublished data). Monitoring of these populations will continue as long as translocations are occurring.

Socio-economic and Legal Considerations

Turner Endangered Species Fund has committed the financial resources estimated necessary for re-introduction success as defined above. The states of South Dakota, Wyoming, and Colorado and the U.S. Fish and Wildlife Service, LBST, and FPNG are committed to provide the administrative support (including permits and Memorandums of Understanding) to ensure the success of the project. Handling and collecting permits will be required from the 3 states along with an importation permit and health certificate from South Dakota.

Local support for conservation of native wildlife species is high in South Dakota. About 89% of South

Dakota residents feel that it is very (56.7%) or moderately (32.5%) important that South Dakota preserves as much wildlife as possible (Gigliotti 1998). Most (84.6%) South Dakota residents strongly (51.3%) or slightly (33.3%) agree that, "the diversity of wildlife in an area is a sign of the quality of the natural environment" (Gigliotti 1998). Most (90.4%) South Dakota residents strongly (51.6%) or slightly (38.8%) agree that, "grasslands like native prairie are a sign of the quality of the natural environment" (Gigliotti 1998). A significant majority (87%) of farmers/ranchers agreed with the statement, "the presence of wildlife on my farm is important to me."

Public Planning and Participation

Local support is crucial to conservation efforts. We conducted 4 public meetings, 2 public hearings, and 1 field trip with local residents to provide information on fox ecology and the reintroduction proposal. We stressed the program's responsiveness to the needs, desires, and opinions of the local public and incorporated these into the program. To that end, we will incorporate the following strategy:

1) regularly update local residents by newsletter on the progress of the reintroduction and request their involvement and input.

2) produce news releases and update our website with progress.

3) develop cautionary highway signs indicating presence of swift foxes in area.

4) work with the South Dakota Natural Heritage Program to develop a voluntary swift fox–sighting network.

5) work with Watertown Zoo to disseminate prairie education packets to present to local schools.

6) develop a local organization dedicated to prairie and swift fox conservation and provide information to local ranchers and farm and ranch organizations on techniques to advance prairie conservation and swift fox restoration.

7) develop the South Dakota Swift Fox Conservation Team as a subcommittee of SFCT.

8) disseminate information on the ranges and characteristics of swift foxes to reduce the likelihood of human-caused mortality.

9) work with South Dakota Game, Fish and Parks (SDGFP) to develop swift fox management plans and prairie conservation promotional activities to update local and state political bodies.

10) work with the State, FPNG, tribes, local trappers, and South Dakota Trapper Association to reach agreements to purchase pan tension devices and develop other techniques to reduce likelihood of fox capture in coyote traps, and work with trappers to develop agreements to temporarily reduce trapping if trapping mortality become significant (not expected based on other states).

11) work with local landowners to limit potential impact of M44s ("coyote getters") on foxes.

Translocation

Acquisition Methods

We will work with Wyoming Game and Fish (priority) and Colorado Division of Wildlife to locate the best sites within each state for trapping and removing foxes. We will work with these states to monitor fox populations to ensure no significant impact to donor populations. During late summer 2002, we will set approximately 40 traps (small mesh single- or double-door tomahawk traps and wood liners [Sovada et al. 1998]) in the chosen trapping area. To maximize genetic diversity and reduce local impacts, no more than 2 foxes will be removed from 1 location (area the size of approximately 1 fox home range). We will attempt to capture 15 males and 15 females for each of 6 years from Wyoming and northern Colorado. Traps will be set in the evening and checked at dawn and then closed during the day. We will use a handling bag or blanket to remove foxes from traps. Foxes will be manually restrained and handled by 2 technicians. We will weigh foxes, assess body condition, count and collect parasites; collect blood; and measure the neck, canines, and body length. We will mark foxes with an ear tag and pit tag. If trapping success is high, we will select primarily adults for translocations.

Dr. Dave Hunter (Turner Enterprises, Bozeman, Montana) will serve as project veterinarian, providing all oversight and protocols. Parasites and diseases of wild swift foxes have not been well documented. There are no cases of confirmed overt disease in wild populations (Miller et al. 2000, Pybus and Williams 2002). We will follow the recommendations of Miller et al. (2000) and Pybus and Williams (2002) to ensure disease risks during translocation are minimized. Canine parvovirus, canine distemper virus, sylvatic plague, and rabies have been detected in swift fox from southeast Wyoming and we expect some of the foxes we capture will test positive for these diseases (Miller et al. 2000). Foxes that test positive for plague, have very high titers for distemper, or show outward signs of rabies will be returned to the capture site as per WDGF. Any fox that appear in poor condition will be released from traps at capture site. All foxes will be vaccinated for rabies, distemper, infectious hepatitis, adenovirus type 2, parainfluenza and parvovirus (J. Johnson and L. Carbyn, Canadian Wildlife Service, unpublished report). Foxes will receive Duramune Max 5 killed virus with modified live parvovirus, Rabvac 3 killed virus, and be sprayed with Frontline (fipronil) spray. Foxes will then be placed and remain in kennels for <96 hrs and then driven directly to holding pens (3.7 x 7.3 m) on BRR. Pairs of foxes will be placed into each pen (see below), but separated through the quarantine period. Pens will be approximately 4 km apart. Foxes will remain in quarantine in the holding pens for a 14-day health check period.

Release Methods

We will release animals at a number of different locations on and around BRR, including FPNG, Lower Brule and possibly Cheyenne River Reservations, clustered by year. Different locations will be used because foxes may be excluded from some areas due to interspecific competition, but persist in others because of specific behavioral adaptations that have survival value to local conditions ("fugitive" Hutchinson 1951).

As indicated in Kunkel, Honness, Phillips, and Carbyn (2001), adult survival rate is the most important factor affecting the outcome of fox reintroduction. We will strive to maximize survival by focusing on releasing foxes that have the highest probabilities of survival (wild-born adult foxes; Covell 1992, Carbyn et al. 1994, Sovada et al. 1998, Cypher et al. 2000) and through intensive management of released animals. Carbyn (1995) reported that 6 of 108 (6%) captive-raised foxes produced pups while 6 of 19 (32%) of translocated wild foxes produced pups. Additionally, the resident breeding population (as defined by den establishment) in spring 1991 in Canada indicated a roughly 1:1 ratio of captive released to translocated wild foxes despite a 5:1 release ratio (Carbyn 1995). Such patterns have been reported for other species. Stochastic models showed that extinction probabilities for Leadbeater's possum (*Gymnobelideus leadbeateri*; Burgman et al. 1995) or helmeted honeyeater (*Lichenostomus melanops cassidix*; McCarthy 1995) were reduced when adults rather than immature animals were released. Sarrazin and Legendre (2000) developed a demographic model for griffon vulture (*Gyps fulvus*) reintroductions and found that it was more efficient to release adults than juveniles, despite the overall reduction of demographic parameters following release. Caswell (1989) emphasized that the eventual population was larger at any time if the initial population was concentrated in age-classes with high reproductive rates. Adult foxes are more likely to successfully rear pups than are juveniles (Cypher et al. 2000).

Evidence from the Blackfeet and Canadian reintroductions indicates release success of captive foxes can be relatively high (see above; Smeeton and Weagle 2001). More work is needed to assess the relative value of releasing captive-reared animals. Therefore, we will attempt to attain captive animals from the Cochrane Ecological Institute in Alberta or zoos for releases. We will compare success of these releases to success of wild foxes released.

Little information is known on the relative success of soft versus hard releases of foxes. Holding foxes in pens for soft releases will have great information and educational value for local residents (L. Carbyn, personal observation). Observations of foxes will only be allowed from a distance so that stress to foxes is minimized. Additionally, holding foxes through the breeding season will allow pups to be produced in captivity and may thereby increase the survival rate for pups. Therefore, during 2002, approximately 10 wild foxes will remain in the holding pens on and around BRR for release in late May or early June 2003 (soft releases). A pair of foxes will be held in each of 10 pens. Pens will be equipped with den boxes. We will monitor tolerances among foxes and separate any foxes that have conflicts. Foxes will be allowed to breed and rear pups during spring in the holding pens (Carbyn et al. 1994). Pen doors will be locked open for releases so that foxes may continue to use den boxes. Foxes will be gradually weaned off food in the pens. The success of the soft release strategy will be assessed to determine if soft releases will continue to be used in the following years. All soft releases will occur on BRR.

Twenty (approximately 10 pairs) wild foxes will be used for hard releases. These foxes will be placed in quarantine/holding pens with panels to separate each fox. Foxes selected for hard releases will be released immediately from the holding pens after the quarantine period has ended. Some foxes selected for hard releases may be transported from holding pens in kennels to various release sites on BRR, FPNG, and LBR. Kunkel, Honness, Phillips, and Carbyn (2001) indicates escape terrain should not be limiting in the project area. Should we find this not true, we will dig escape holes for foxes in the immediate vicinity of release sites.

Criteria for Measuring Success

Initial success (1–3 years) will be reached when we achieve breeding of the first wild-born generation of foxes in the release area (Kleinman et al. 1991). Short-term criteria (3–5 years) for success will include survival and recruitment rates similar to other wild self-sustaining populations (e.g., Carbyn et al. 1994, Sovada 1998, Schauster 2001) and population growth or $r > 0$.

According to Minimum Viable Population studies, Beck et al. (1994) considered 500 free-living individuals as representing criteria for good success. This threshold is considered somewhat arbitrary without taking into account life history traits, habitat quality, or eventual metapopulation structure (Sarrazin and Babault 1996). They recommended using extinction probability estimates that combined population size, growth rate, and growth rate variance as the main criteria. We will estimate these parameters throughout the reintroduction and consider mid-term success (5–10 years) when demographic rates approach self-sustaining levels yielding extinction probabilities over 100 years of <0.20. We follow recommendations of Breitenmoser et al. (2002) and apply the IUCN Red List Categories to assess success and failure at about 10 years after completion of release. Long-term success (>10 years) will be reached when fox populations expand and connect with other populations in the region.

We will assess factors affecting survival and recruitment rates (see below) and thereby determine reasons for not meeting criteria for success. To deal with problems, we will use adaptive management to modify release and management strategies; options include modifying classes of foxes used for releases and the types of releases, intensifying and extending coyote control and supplemental feeding of foxes (e.g., providing bison carcasses; Warrick et al. 1999).

Monitoring and Research Program (Experimental Design)

We agree that reintroduction programs can provide important opportunities for real-scale hypothetico-deductive experiments in ecology (e.g., Stanley Price 1989, Kleinman et al. 1991, Sarrazin and Barbault 1996). Accordingly, we intend to implement this restoration project to maximize gain of knowledge concerning swift fox recovery throughout North America. This reintroduction will be conducted as an experiment so that we gain the most knowledge possible in the most rigorous fashion. For example, this project should provide an opportunity to better understand mechanisms of population extinction and growth. The use of reintroductions as basic experiments for building theory will eventually create better knowledge of extinction mechanisms and thereby limit the need for future reintroductions (Sarrazin and Barbault 1996).

Objectives

1. Estimate fox density annually for 10 years following first release.
2. Estimate reproductive parameters annually for 10 years following first release.
3. Estimate fox survival rates annually for 10 years following first release.
4. Determine fox diet annually for 10 years following first release.
5. Determine fox home range size and resource selection annually for 10 years following first release.

Methods

All foxes released will be fitted with standard VHF radiocollars (Cypher 1997) and ear-tagged. In order to maintain telemetry contact with all foxes, we will capture and radio-collar juveniles in the fall (fit with expandable collars) and again the following year to fit with adult-sized collars (see methods above). For the first 2 months following releases we will attempt to locate all foxes daily; thereafter, we will locate foxes 1–2 times weekly. Tracking will occur primarily by triangulation from the ground but aerial telemetry will be used to locate far-ranging foxes. Dispersing foxes will be located bi-weekly. Foxes will be located at all times of the day.

Radios will be equipped with a mortality sensor. When radios emit mortality signals, we will investigate the fox and the site to determine cause of death following standard protocols (Kunkel 1997). Landscape features at relocations, kill sites, and random sites throughout the release area will be described including slope, aspect, habitat type, vegetation height, viewshed, and percent stalking cover (Kunkel and Pletscher 2001). We will use a Geographic Positioning System to determine latitude and longitude coordinates of the site and upload this data into a Geographic Information System (GIS). GIS will be used to classify landcover (South Dakota Geographic Analysis Project [GAP analysis]), topographic ruggedness (Nicholson et al. 1997), range site (soil type), grazing intensity, distance to roads, water, settlements, and dens. We will determine location of fox den sites and escape holes and measure the same landscape attributes as measured at fox relocation sites (Pruss 1999). We will observe foxes at den sites to measure pup production and survival and attendance by adults.

Survival rates will be determined using MICROMORT (Heisey and Fuller 1985). Cause-specific mortality rates and factors affecting these will be estimated using *z*-tests of survival estimates and Cox proportional hazards models (Sievert and Keith 1985). Because at least initially this will be the only location in North America where we know the precise number of foxes (due to reintroduction), it will present a great opportunity to test population estimation techniques. We will test all the currently employed techniques, including catch per unit effort (Seber 1982), mark-recapture (Rexstad and Burnham 1991), scent stations, scat deposition transects, track plates, and spot light surveys.

We will continue to follow methodology outlined in the feasibility plan to monitor fox, fox prey, and fox predator trends (Kunkel et al. 1999). Swift fox and coyote scats will be collected (at fox source sites [Colorado and Wyoming] and BRR) and analyzed for disease and diet following standard techniques (Kelly and Garton 1997). Fox prey selection will be determined following Manly (1974). We will attempt to observe fox predation sequences to determine success rates and the influence of landscape and prey factors (Gese et al. 1996).

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