demographic and ecological research in both natural and anthropogenically modified landscapes.

Occurrence in captivity

No captive breeding efforts are currently being conducted for kit foxes. Facilities such as the Arizona-Sonora Desert Museum in Tucson, Arizona, California Living Museum in Bakersfield, California, and several zoos keep live kit foxes for display and educational purposes. Also, Humboldt State University in Arcata, California maintains a small number of kit foxes for research and education.

Current or planned research projects

R. List (Institute of Ecology, National University of Mexico) is currently assessing the abundance of kit foxes in the prairie dog towns of north-western Chihuahua to compare the densities to those in 1994 to 1996. He is also planning to map the current distribution in Mexico using GIS.

B. Cypher, D. Williams, and P. Kelly (California State University-Stanislaus, Endangered Species Recovery Program – ESRP) are conducting a number of investigations on the San Joaquin kit fox, including ecology and demography in agricultural lands and urban environments, use of artificial dens, kit fox-red fox interactions, highway impacts, pesticide effects, and restoration of retired agricultural lands.

K. Ralls and colleagues (Smithsonian Institution, Washington D.C., USA), in collaboration with the ESRP, are conducting range-wide genetic analyses for the San Joaquin kit fox and investigating the use of tracker dogs (to find scats) in gathering information on kit fox presence and ecology.

Two working groups of the National Center for Ecological Analysis and Synthesis (University of California, Santa Barbara, USA) are conducting population modelling studies and investigating conservation strategies for the San Joaquin kit fox.

The California State University, San Luis Obispo and the California Army National Guard are investigating the effects of military activities on the San Joaquin kit fox and monitoring kit fox abundance on military lands in California.

R. Harrison (University of New Mexico, Albuquerque) is investigating kit fox ecology in New Mexico.

The U.S. Army is sponsoring an investigation of military effects and kit fox ecology on the Dugway Proving Grounds in Utah.

Gaps in knowledge

In general, demographic and ecological data are needed throughout the range of the kit fox so that population trends and demographic patterns can be assessed. In Mexico, information available on the kit fox is scarce. The most important gaps in our knowledge of the species are the present distribution of the species and population estimates throughout its range. General biological information is needed from more localities in the Mexican range of the kit fox. In the United States, information is required on the San Joaquin kit fox including assessing the effects of roads and pesticides on kit foxes, investigating dispersal patterns and corridors, determining metapopulation dynamics and conducting viability analyses, developing conservation strategies in anthropogenically altered landscapes, assessing threats from non-native red foxes, and range-wide population monitoring.

Core literature

Cypher *et al.* 2000; Egoscue 1962, 1975; McGrew 1979; O'Farrell 1987; Spiegel 1996.

Reviewers: Mauricio Cotera, Patrick Kelly, Ellen Bean.
Editors: Claudio Sillero-Zubiri, Michael Hoffmann, Deborah Randall.

4.6 Swift fox
Vulpes velox (Say, 1823)
Least Concern (2004)

A. Moehrenschlager and M. Sovada

Other names

French: renard véloce; **German:** flinkfuchs; **Indigenous names:** senopah (Blackfeet Tribe, Canada and USA).

Taxonomy

Canis velox Say, 1823. James, Account of an Exped. from Pittsburgh to the Rocky Mtns, 1:487. Type locality: "camp on the river Platte, at the fording place of the Pawnee Indians, twenty-seven miles below the confluence of the North and South, or Paduca Forks."

The swift fox is phenotypically and ecologically similar to the kit fox (*Vulpes macrotis*) and interbreeding occurs between them in a small hybrid zone in west Texas and eastern New Mexico (Rohwer and Kilgore 1973; Mercure *et al*. 1993; Rodrick 1999). Some morphometric comparisons and protein-electrophoresis have suggested that these foxes constitute the same species (Ewer 1973; Clutton-Brock *et al.* 1976; Hall 1981; Dragoo *et al.* 1990; Wozencraft 1993). Conversely, other multivariate morphometric approaches (Stromberg and Boyce 1986), as well as mitochondrial DNA restriction-site and sequence analyses (Mercure *et al.* 1993; Rodrick 1999) have concluded that they are separate species. Swift and kit foxes are most closely related to Arctic foxes (*Alopex lagopus*), and this genetic association is the closest among the *Vulpes*-like canids (Wayne and O'Brien 1987), although Arctic foxes are classified in a different genus.

Description

The swift fox is one of the smallest canids, with an average weight of 2.4kg (Table 4.6.1). The winter pelage is dark greyish across the back and sides extending to yellow-tan across the lower sides, legs, and the ventral surface of the tail. The ventral fur is white with some buff on the chest. In summer, the fur is shorter and more rufous. Swift foxes can be distinguished from other North American canids, except the closely related kit fox, by black patches on each side of the muzzle, a black tail tip, and their small body size. Dental formula: 3/3-1/1-4/4-2/3=42.

Subspecies Stromberg and Boyce (1986) concluded that significant geographic variation exists among swift foxes, but Merriam's (1902) classification of swift foxes into northern (*V. velox hebes*) and southern (*V. v. velox*) subspecies is likely unjustified (Stromberg and Boyce 1986; Mercure *et al*. 1993).

Table 4.6.1 Body measurements for the swift fox from specimens at least nine months old in north-eastern New Mexico (Harrison 2003).

HB male	523mm (500–545) n=11
HB female	503mm (475–540) n=10
T male	286mm (250–340) n=11
T female	278mm (250–302) n=10
HF male	121mm (115–127) n=11
HF female	116mm (109–126) n=10
E male	64mm (59–68) n=10
E female	62mm (57–68) n=10
WT male	2.24kg (2.0–2.5) n=18
WT female	1.97kg (1.6–2.3) n=9

Similar species Kit foxes (*V. macrotis*) have longer, less rounded ears that are set closer to the midline of the skull, a narrower snout, and a proportionately longer tail to their body length than swift foxes.

Distribution

Historical distribution The swift fox is native to short-grass and mixed-grass prairies of the Great Plains in North America (Egoscue 1979). On the northern limit of its range, swift foxes were present in the Canadian provinces of Alberta, Saskatchewan, and Manitoba. The southern species boundary was New Mexico and Texas in the United States. Historical records also exist for areas in Montana, Wyoming, North Dakota, South Dakota, Nebraska, Kansas, Colorado, and Oklahoma. Some historical range descriptions mention swift foxes in Minnesota and Iowa; however, there are no verified records of occurrence in either state (Sovada and Scheick 1999). Iowa has one fossil record and several unconfirmed accounts. Minnesota has no records and no account of any merit.

Current distribution Following swift fox extirpation from Canada by 1938 (Soper 1964), reintroduction releases since 1983 have established a small swift fox population in Alberta, Saskatchewan, and Montana which now constitutes the northern extent of the species' range (Moehrenschlager and Moehrenschlager 2001) (Figure 4.6.1). The southern periphery of the range is still central New Mexico and north-western Texas, and, in terms of historic distribution, swift foxes are currently not found in Manitoba or North Dakota. Current estimates for the United States suggest that swift foxes are located in 39–

Juvenile swift fox, approximately 2.5 to 3 months old, sex unknown. Near Shirley Basin, Wyoming, USA, 1998.

Travis Olson

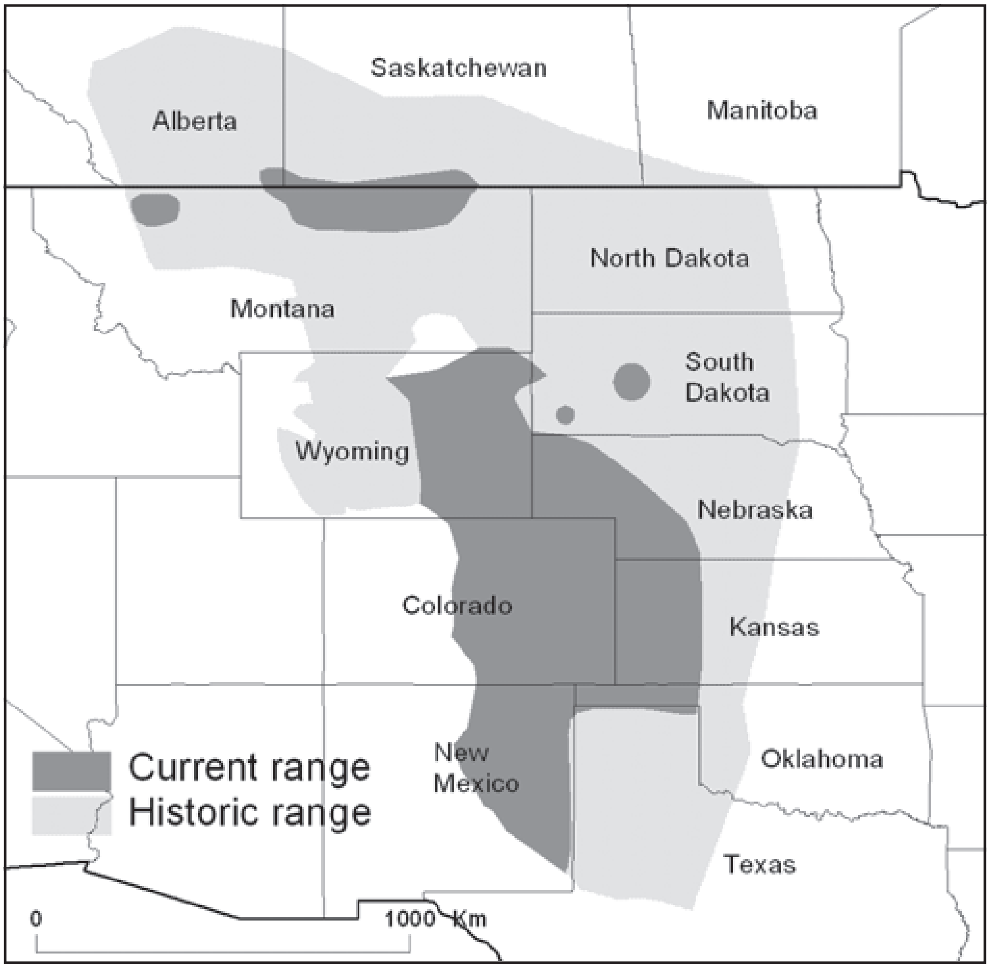

Figure 4.6.1. Current distribution of the swift fox.

42% of their historic range depending on conservative versus liberal estimates of historic range and the time span of records that are considered (Sovada and Scheick 1999). As such, the conservative estimate, based on the relative presence or absence of swift foxes in counties throughout individual states, is that swift foxes are distributed across 505,149km^2 while the liberal estimate is 607,767km^2 (Sovada and Scheick 1999). But in much of the distribution populations are fragmented.

Range countries Canada, USA (Sovada and Scheick 1999).

Relative abundance

Historically, the swift fox was considered an abundant predator of the prairies, but their numbers were severely depleted by the late 1880s and early 1900s. In Canada, the last recorded specimen was collected in 1928 (Carbyn 1998) and a single sighting was made in 1938 (Soper 1964). Zumbaugh and Choate (1985) provided evidence that, in Kansas, swift foxes were extremely abundant in the mid-1800s, but became less abundant by the turn of the 20th century. The species was probably extirpated from Kansas by the 1940s (Black 1937; Cockrum 1952; Hall 1955; Sovada and Scheick 1999). There are similar reports of population declines from other states (see Sovada and Scheick 1999).

Swift fox populations began to recover over portions of their former range beginning in the 1950s (Martin and Sternberg 1955; Glass 1956; Anderson and Nelson 1958; Andersen and Fleharty 1964; Kilgore 1969; Sharps 1977; Egoscue 1979; Hines 1980). In the core of their distribution, in Kansas, Colorado, the Oklahoma panhandle, and New Mexico, populations are considered stable whereas populations in Texas and Wyoming are fragmented and more susceptible to decline. Swift foxes are rare in Nebraska, South Dakota, and Montana, and extirpated from North Dakota (Allardyce and Sovada 2003).

Estimated populations/relative abundance and population trends Following approximately 50 years of extirpation, a swift fox reintroduction programme was initiated in Canada in 1983. By 1997, 942 foxes had been released, primarily utilising captive breeding but also through the use of translocations (Moehrenschlager and Macdonald 2003). Using live trapping, a 1996/1997 census estimated the Canadian population to consist of 289 individuals in two isolated subpopulations. A second census that re-sampled these sites during the same season in 2000/2001 also expanded the survey area into Montana (Moehrenschlager and Moehrenschlager 2001; Moehrenschlager *et al.* 2004). The results showed that swift fox population size in Canada had increased three-fold since 1996/1997, the total known distribution including Montana spanned at least 17,500km^2, the combined population size was approximately 877 individuals, and that 98.6% of the population is now wild-born. This population is considerably isolated from the contiguous swift fox range in the United States and needs to be considered separately in terms of population viability.

In the United States, swift fox populations are believed to be stable in Texas, New Mexico, Oklahoma, Colorado, and Kansas. The population in Wyoming is relatively stable but fragmented. Less is known about the population in Nebraska, but there appear to be four disjunct populations of unknown status. In South Dakota, populations are small and fragmented; some are considered stable. Swift foxes are extinct in North Dakota. Reintroductions of swift foxes are being implemented at two sites in South Dakota. The Turner Endangered Species Fund began reintroducing foxes in 2002 in the Bad River Ranch south-west of Pierre. Reintroduction to the Badlands National Park began in 2003. The Defenders of Wildlife are currently supporting (1998–present) a swift fox reintroduction in northern Montana's Blackfeet Reservation.

Habitat

The swift fox is predominately found on short-grass and mixed-grass prairies in gently rolling or level terrain (Kilgore 1969; Hillman and Sharps 1978; Hines 1980). In Kansas, swift foxes have been found to den and forage in fallow cropland fields such as wheat (Jackson and Choate 2000; Sovada *et al.* 2003). Survival rates (and reproductive rates, although sample sizes were small; Sovada *et al.* 2003) between foxes in grassland and cropland sites were not significantly different suggesting that swift foxes may be able to adapt to such habitat in some cases (Sovada *et al.* 1998). Notably, the distribution and density of dens are considered important components of swift fox habitat requirements (Herrero *et al.* 1991), particularly in terms of evading coyote predation or red fox competition (Tannerfeldt *et al.* 2003).

Food and foraging behaviour

Food Swift foxes are opportunistic foragers which feed on a variety of mammals, but also birds, insects, plants, and carrion (Kilgore 1969; Hines 1980; Cameron 1984; Uresk and Sharps 1986; Hines and Case 1991; Zimmerman 1998; Kitchen *et al.* 1999; Moehrenschlager 2000; Sovada *et al.* 2001b). Leporids have been reported as a primary prey item in several studies (Kilgore 1969 [winter]; Cameron 1984; Zumbaugh *et al.* 1985). In South Dakota, mammals accounted for 49% of prey occurrences with prairie dogs (*Cynomys ludovicianus*) as the primary prey item (Uresk and Sharps 1986). Sovada *et al.* (2001b) in Kansas, and Hines and Case (1991) in Nebraska, found that murid rodents were the most frequently occurring prey in swift fox diets. Several studies have reported a high frequency of insects, but insects likely constituted a small portion of biomass (Kilgore 1969). Birds and bird eggs have been identified as a food of swift foxes (Kilgore 1969; Uresk and Sharps 1986; Sovada *et al.* 2001a). Swift fox studies typically have reported a relatively high frequency of plant materials found in samples, but most often in relatively small amounts per sample. However, several studies identified prickly pear cactus fruit, wild plums, and sunflower seeds as a food resource (Kilgore 1969; Hines and Case 1991; Sovada *et al.* 2001b).

Foraging behaviour Swift foxes are mostly solitary hunters, foraging throughout the night. They also exhibit some crepuscular activity and will hunt diurnal species such as birds and ground squirrels during the summer. Caching of food by swift foxes has been observed (Sovada *et al.* 2001b).

Damage to livestock and game There is no evidence that swift foxes significantly impact game or livestock populations.

Adaptations

Swift foxes can run at speeds of up to 60km/hr, which helps to elude predators, and facilitates the hunting of fast prey such as jackrabbits. Predominantly nocturnal activity and diurnal use of dens reduces water loss.

Social behaviour

The typical social group consists of a mated pair with pups. Occasionally, the social group is a trio or group of two males and two or three females, with one breeding female and non-breeding helpers (Kilgore 1969; Covell 1992; Sovada *et al.* 2003; Tannerfeldt *et al.* 2003). Pups remain with the parents until dispersal, which commences in August or September in Oklahoma (Kilgore 1969), September/October in Colorado and Kansas (Covell 1992; Sovada *et al.* 2003) and August in Canada (Pruss 1994). Moehrenschlager (2000) reported that only 33% (n=12) of juveniles had left natal home ranges at 9.5 months of age while all recaptured individuals aged 18 months or older had dispersed (n=7).

Published estimates of swift fox home ranges are quite variable and difficult to compare because different techniques and criteria have been used to estimate home-range size (Tannerfeldt *et al.* 2003). Hines and Case (1991) reported an average home range size of 32.3km^2 (range=

7.7–79.3km²) for seven swift foxes in Nebraska using the minimum convex polygon method, but four animals were followed for fewer than five nights in winter or very early spring. Andersen *et al*. (2003) reported a similar average MCP home-range size of 29.0km² (range=12.8–34.3km²) on the Pinon Canyon Maneuver Site in south-eastern Colorado (1986 to 1987) for five swift foxes with >34 locations over a minimum period of seven months. A slightly smaller estimate (MCP) of average home range, 25.1km² (SE=1.9, range=8.7–43.0km²), was determined for 22 swift foxes with >60 locations in western Kansas (Sovada *et al.* 2003). Zimmerman *et al*. (2003) estimated average MCP home-range size of 10.4km² (range=7.3–16.9km²) for five swift foxes in Montana. Using the 95% adaptive kernel method, Kitchen *et al*. (1999) reported average home-range size of 7.6km² for foxes (with >60 locations per season) on the Pinon Canyon Maneuver Site during 1997 to 1998. In western Kansas, Sovada *et al*. (2003) reported a mean ADK estimate of 19.5km² for 22 foxes (SE=1.4). Pechacek *et al*. (2000) estimated mean 95% ADK home range sizes of 11.7km² and 100% MCP estimates of 7.7km² for 10 swift foxes in south-eastern Wyoming.

Early studies suggested that swift foxes were not territorial (Hines 1980; Cameron 1984), although more recent data have provided evidence of territoriality. Andersen *et al*. (2003) reported nearly total exclusion of an individual swift fox's core activity area to other same-sex individuals. Pechacek *et al*. (2000) and Sovada *et al*. (2003) found areas used by mated pairs had minimal overlap with areas used by adjacent pairs, and core areas were exclusive. In Canada, Moehrenschlager (2000) reported swift fox home ranges overlapped by 77.1% among mates and 21.4% between neighbours.

Avery (1989) described the vocal repertoire of the swift fox from recordings made of captive foxes. He identified eight different vocalisations: courting/territorial call, agonistic chatter, submissive whine, submissive chatter, precopulatory call, growls, excited yip/bark, and social yips.

Reproduction and denning behaviour

Swift foxes are primarily monogamous (Kilgore 1969) although additional females that act as helpers in raising pups are occasionally observed at den sites (Kilgore 1969; Covell 1992; Olson *et al*. 1997; Sovada *et al*. 2003; Tannerfeldt *et al*. 2003). Also, a male has been seen with litters of two different adult females on the same day (Moehrenschlager 2000). Swift foxes are monoestrus and the timing of breeding is dependent upon latitude (Asa and Valdespino 2003). Breeding occurs from December to January in Oklahoma (Kilgore 1969), from January to February in Colorado (Scott-Brown *et al*. 1987; Covell 1992), from February to early March in Nebraska (Hines 1980) and in March among wild and captive Canadian foxes (Pruss 1994; Moehrenschlager 2000). The mean gestation period is 51 days (Schroeder 1985). Average litter sizes of 2.4–5.7 have been reported based on counts of pups at natal dens (Kilgore 1969; Hillman and Sharps 1978; Covell 1992; Carbyn *et al*. 1994; Schauster *et al*. 2002b; Andersen *et al*. 2003). In Colorado, litter sizes were greater for mated pairs with helpers than for those without (Covell 1992). Pups open their eyes at 10–15 days, emerge from the natal den after approximately one month, and are weaned at 6–7 weeks of age (Kilgore 1969; Hines 1980). Both members of the pair provide for the young and young foxes remain with the adults for 4–6 months (Covell 1992), which is longer than other North American canids.

Swift foxes are among the most burrow-dependent canids and, unlike most others, depend on dens throughout the year (Kilgore 1969; Egoscue 1979; Hines 1980; Tannerfeldt *et al*. 2003). Swift foxes will excavate their own dens and modify the burrows of other species. Dens serve several functions, such as providing escape cover from predators, protection from extreme climate conditions in both summer and winter, and shelter for raising young.

Competition

Predation by and interspecific competition with coyotes (*Canis latrans*) and expansion of red fox (*Vulpes vulpes*) populations may be the two most serious limiting factors to swift fox recolonisation of suitable habitat identified within the species' historic range (Moehrenschlager *et al*. 2004). Coyote killing of swift foxes significantly affected the reintroduction efforts of swift foxes in Canada (Scott-Brown *et al*. 1987; Carbyn *et al*. 1994). Since coyotes frequently do not consume swift foxes, their killing may primarily be a form of interference competition (Sovada *et al*. 1998). Since red foxes and swift foxes have greater dietary overlap than swift foxes and coyotes in sympatric areas of Canada (A. Moehrenschlager unpubl.), the potential for exploitative competition is highest between the two fox species. Moreover, contrasted to coyotes, red foxes tend to be found in higher densities, with smaller home ranges, and they move as individuals rather than as pairs or groups. Therefore, in sympatric populations there is greater chance of red fox-swift fox encounters than coyote-swift fox encounters. Preliminary results from an experimental study examining the swift fox-red fox relationship suggest that red foxes can be a barrier preventing swift fox populations from expanding into unoccupied, but suitable areas (M. A. Sovada unpubl.). In Canada, red fox dens were significantly closer to human habitation than coyote dens while swift fox dens were found at all distances (Moehrenschlager 2000). As coyotes avoid high human activity areas, red foxes may utilise these sites to begin their invasion of swift fox home ranges. While coyotes reduce swift fox numbers through direct, density-dependent killing within the swift fox range, red foxes could potentially exclude swift foxes through a combination of interference and exploitative competition.

Mortality and pathogens

Reported annual mortality rates range from 0.47 to 0.63 (Covell 1992; Sovada *et al*. 1998; Moehrenschlager 2000; Schauster *et al*. 2002b; Andersen *et al*. 2003), and those of translocated foxes have been similar to those of wild residents in Canada (Moehrenschlager and Macdonald 2003).

Natural sources of mortality Coyotes have been identified as the principal cause of swift fox mortality (Covell 1992; Carbyn *et al*. 1994; Sovada *et al*. 1998; Kitchen *et al*. 1999; Moehrenschlager 2000; Andersen *et al*. 2003). Other predators of swift foxes that have been identified include golden eagles (*Aquila chrysaetos*) and American badgers (*Taxidea taxus*) (Carbyn *et al*. 1994; Moehrenschlager 2000; Andersen *et al*. 2003).

Persecution Mortality factors associated with human activities include poisoning, shooting, and trapping (Kilgore 1969; Carbyn *et al*. 1994; Sovada *et al*. 1998).

Hunting and trapping for fur Swift foxes formed an important part of the North American fur trade. Records of the American Fur Company's Upper Missouri Outfit (near the confluence of the Big Sioux and Missouri Rivers) from 1835 to 1838 included 10,427 swift fox pelts compared to 1,051 red fox pelts and 13 gray fox (*Urocyon cinereoargenteus*) pelts received during the same period (Johnson 1969). Alexander Henry's journals noted the take of 117 "kit" foxes from 1800 to 1806 in north-eastern North Dakota with an additional 120 "kit" foxes received from the Hudson's Bay Company at Pembina in 1905–1906 (Reid and Gannon 1928).

Currently, swift foxes are legally protected under State laws in all 10 states and are protected from harvest through laws or regulations in seven of these. Colorado, Montana, North Dakota, and Oklahoma list swift fox as furbearers but the harvest season is closed all year. Nebraska lists swift fox as "endangered," and in South Dakota they are "threatened." Wyoming lists swift fox in their non-game regulations, and only incidental harvest is allowed to provide additional distribution data. States that do provide harvest opportunities, Kansas, New Mexico, and Texas, regulate harvest by season length and monitor harvest numbers annually. Harvest is minimal (e.g., 181 foxes harvested in Kansas in 1994–2001), and largely incidental captures by coyote trappers. In Canada, where swift foxes are federally listed as 'endangered', swift foxes cannot be legally harvested; however, incidental injuries or mortalities occur in traps or snares set for other species (Moehrenschlager 2000).

Road kills Collisions with automobiles are a significant mortality factor for young animals in some landscapes (Sovada *et al*. 1998).

Pathogens and parasites No significant disease outbreaks have been documented in swift fox populations to date; however, Olson (2000) reported deaths of two swift foxes to canine distemper. Swift foxes host a variety of internal and external parasites (Kilgore 1969; Pybus and Williams 2003). Fleas (*Opisocrostos hirsutus* and *Pulex* spp.) are the most common and abundant ectoparasite. Kilgore (1969) suggested that the large numbers of fleas found in swift fox dens might be a reason for the frequent changes in dens used by foxes. Other parasites include hookworms (*Ancylostoma caninum, Uncinaria* sp.) and whipworms (*Trichuris vulpis*), as well as miscellaneous protozoans and ectoparasites (Pybus and Williams 2003).

Longevity Captive-born and translocated swift foxes in Canada that were marked at the time of release have been recaptured as late as eight years old, with extremely worn teeth (A. Moehrenschlager unpubl.).

Historical perspective

Swift foxes were of cultural importance to many Plains Indian Nations. The Kit (Swift) Fox Society of the Blackfeet Tribe of south-western Alberta and northern Montana ranked high in status and performed sacred functions. Remains of swift foxes have been found in archaeological sites dating back several thousand years.

Conservation status

Threats Since swift foxes are primarily prairie specialists, ongoing conversion of grassland to cropland threatens to reduce population sizes and further fragment populations. The conversion of native grassland prairies has been implicated as one of the most important factors for the contraction of the swift fox range (Hillman and Sharps 1978). We believe that alteration of the landscape likely influences local and seasonal prey availability, increases risk of predation for swift foxes, and leads to interspecific competition with other predators such as the coyote and red fox. Moreover, an increasing trend towards irrigation of crops from the dry-land farming practices of fallow cropland every other year could exclude swift foxes that have adapted to den and forage successfully under the dryland farming rotational practices. The planting of tall, dense vegetation as a part of the United States Conservation Reserve Program, may also negatively impact swift foxes because they avoid these densely vegetated habitats. In Canada, the oil and gas industry is expanding dramatically and previously isolated prairie areas are now targeted for exploration. Associated road developments will potentially decrease the habitat carrying capacity and increase vehicle-caused swift fox mortalities. Greater urbanisation coupled with coyote control may facilitate red fox expansion, which could lead to the competitive exclusion of swift foxes in established prairie areas. In the United States, the 1972 presidential ban on predator toxicant use (e.g., strychnine, compound 1080) on Federal lands may have contributed to swift fox recovery. However, 1080 is currently being legalised in prairie areas of Saskatchewan, Canada, which will likely limit reintroduced swift fox populations. Moreover, landowners that are attempting to protect their livestock from coyote depredation use poisons illegally and swift foxes readily consume such baits (Moehrenschlager 2000).

Commercial use None.

Occurrence in protected areas In Canada, swift foxes are found mainly on unprotected lands, but approximately one-sixth of the population falls within the boundaries of Grasslands National Park. In the United States, there are 24 National Park Service Units (Parks, Monuments, Historic Sites) located in the historic range of swift foxes. Although there are no records of swift foxes in any of these units, 14 have potential for swift fox presence. One unit, Badlands National Park in South Dakota, began a reintroduction in 2003.

Protection status CITES – not listed.
The swift fox has been down-listed from 'extirpated' to 'endangered' in Canada as a result of the swift fox reintroduction programme.

Current legal protection In the United States, the swift fox was petitioned for listing under the Endangered Species Act. In 2001 the U.S. Fish and Wildlife Service determined listing to be unwarranted.

Conservation measures taken

— In Canada, the National Swift Fox Recovery Team is currently revising its national swift fox recovery strategy, which will be implemented through national and provincial action plans as of 2003. The Canadian federal government has just passed the country's first 'Species at Risk Act', which will provide greater legal protection of swift foxes and promote landowner stewardship programmes facilitating local conservation efforts.

— In the United States, the Swift Fox Conservation Team operates under a Swift Fox Conservation Strategy Plan with identified goals up to the year 2005. The team continues to monitor populations, assess critical habitat conditions, review the potential for reintroductions, and provide research support for ongoing projects.

Occurrence in captivity

In Canada, swift foxes are present in the Calgary Zoo, Cochrane Ecological Institute, Kamloops Wildlife Park, and Saskatoon Zoo. In the United States, swift foxes are represented in the Bismarck Zoo, Bramble Park Zoo, Houston Zoo, Lee Richardson Zoo, Living Desert, Minnesota Zoo, Philadelphia Zoo, Pueblo Zoo, Sunset Zoo, Tulsa Zoo, and Wild Canid Center. The Fort Worth Zoo has put forward a petition to manage a swift fox Species Survival Plan on behalf of the American Zoo Association. On behalf of the Canid Taxon Advisory Group, the St. Louis Zoo is currently devising recommendations for swift fox space allocations in the North American programme.

Current or planned research projects

M. Sovada (Northern Prairie Wildlife Research Centre, U.S. Geological Survey, Jamestown, North Dakota, USA) is working in the state of Kansas, where she is developing methodology for long-term monitoring of swift foxes on a landscape scale with spatial smoothing. Preliminary assessments have been conducted for western Kansas and the final model will provide the basis for determining future expansion or retraction of swift fox range.

The Swift Fox Conservation Team, M. Sovada (Northern Prairie Wildlife Research Centre, U.S. Geological Survey, Jamestown, North Dakota, USA) and others are examining swift fox habitat requisites at a range-wide scale. They intend to use location and remote-sensing habitat data, multivariate statistical techniques, and GIS to model swift fox habitat range wide.

R. Harrison and Jerry Dragoo (University of New Mexico, Albuquerque, New Mexico, USA) in conjunction with the New Mexico Department of Game and Fish, are developing a monitoring plan for tracking swift fox relative to population density, range-wide in New Mexico. They are testing scat collection followed by species verification with mitochondrial DNA analysis.

R. Harrison, M.J. Patrick (Pennsylvania State University, Altoona, Pennsylvania, USA) and C. G. Schmitt (New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA) are also identifying and creating voucher specimens of fleas from four fox species in New Mexico (swift, kit, grey, and red foxes).

E. Gese (National Wildlife Research Center, Utah State University, Utah, USA) is continuing a long-term study on swift foxes on the U.S. Army Pinon Canyon Maneuver Site in south-eastern Colorado. Entering the sixth year of this study, over 200 swift foxes have been radio-collared and tracked. Currently, a Ph.D. student is examining the influence of land-use patterns on plant composition and productivity, the small mammal community, and swift fox demographics. An M.Sc. student will be investigating helper behaviour and swift fox pup survival from den emergence to independence.

A. Moehrenschlager (Calgary Zoo and University of Calgary, Calgary, Alberta, Canada), P. Fargey (Grasslands National Park, Parks Canada, Saskatchewan, Canada), and S. Alexander (University of Calgary, Calgary, Alberta, Canada) are developing a predictive GIS habitat suitability model for the reintroduced Canadian/Montana swift fox population.

A. Moehrenschlager (Calgary Zoo and University of Calgary, Calgary, Alberta, Canada) and C. Strobeck (University of Alberta, Edmonton, Alberta, Canada) are testing gene flow and connectivity in the reintroduced Canada/Montana swift fox population using hair samples collected from 1995 to 2001.

A. Moehrenschlager (Calgary Zoo and University of Calgary, Calgary, Alberta, Canada) and A. Aguirre (Wildlife Trust, Palisades, New York, USA) have tested swift fox serology in Canada and will create a serological profile for all sympatric prairie canids (swift fox, red fox, coyote and domestic dog).

Gaps in knowledge

In Canada and the United States assessments of historical distribution and the identification of critical swift fox habitats for legal protection are hampered by the fact that swift fox habitat use is not well understood. Future studies should assess to what degree swift foxes can utilise differing types of habitats, including habitats considered atypical, such as those dominated by cropland. Information is needed to identify why swift foxes are unable to move into areas of apparently suitable habitat. Identification of barriers, both physical and ecological (e.g., competitive exclusion with other canids), to dispersal would improve the ability to manage and ultimately conserve this species. Future investigations should focus on parameters that might affect the range-wide, long-term viability of the populations.

The primary stochastic factor influencing small canid populations around the world is disease (Woodroffe *et al*. 1997; Laurenson *et al*. 1998; Woodroffe and Ginsberg 1999a), and such risks are enhanced when animals are transferred between populations (Woodford and Rossiter 1994). Although the Canadian population was partly established through translocation, swift fox exposure to canid diseases has not been assessed in Canada. The prevalence of disease exposure in different age classes and regions should be assessed in both countries and the likelihood of disease transfer between swift foxes and sympatric coyotes, red foxes, and domestic dogs should be evaluated. In addition, genetic analyses should be conducted to examine bottlenecks, genetic variability, connectivity, and dispersal distances in Canada and within isolated population fragments of the United States. Finally, data on swift fox demography, disease prevalence, genetics, habitat use, and population trends should be incorporated into population viability models to guide conservation planning on a provincial/state or federal basis.

Core literature

Egoscue 1979; Hines and Case 1991; Jackson and Choate 2000; Kilgore 1969; Kitchen *et al*. 1999; Moehrenschlager 2000; Moehrenschlager and Macdonald 2003; Schauster *et al.* 2002a,b; Sovada and Carbyn 2003; Sovada *et al*. 1998, 2001b, 2003.

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