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DISTRIBUTION OF THE SWIFT FOX (*VULPES VELOX*) IN TEXAS

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ABSTRACT—Swift foxes (*Vulpes velox*) once occupied ca. 79 counties in Texas, but surveys in 1997–1998 indicated the range of the species was reduced to two counties. We used scat-transects and live-trapping during 2005–2007 to assess current distribution of the species in Texas. Our results indicated that distribution of the swift fox in Texas remains significantly reduced from the historical distribution and that population densities are low where the species currently exists.

RESUMEN—El zorro del desierto (*Vulpes velox*) antes ocupaba ca. 79 condados de Texas, pero muestreos en 1997–1998 indicaron que la distribución de la especie se redujo a dos condados. Se utilizaron excrementos a través de transectos y captura de animales vivos durante 2005–2007 para evaluar la distribución actual de la especie en Texas. Nuestros resultados indicaron que la distribución de el zorro del desierto en Texas sigue siendo significativamente reducida de la distribución histórica, y que las densidades poblacionales son bajas donde la especie existe en la actualidad.

Historically, the distribution of the swift fox (*Vulpes velox*) spanned the Great Plains from southern Canada to eastern New Mexico and northwestern Texas in close association with short-grass and mixed-grass prairies (Egoscue, 1979). Declines in distribution and density of populations led to its candidacy for threatened status under the Endangered Species Act during 1992–2001 (Allardyce and Sovada, 2003). Although currently not a candidate for federal protection, status of the swift fox in Texas remains tenuous (Allardyce and Sovada, 2003). Swift foxes once occupied ca. 79 counties (Fig. 1; J. K. Jones, Jr. et al., in litt.). K. Mote et al. (in litt.) estimated distribution of swift foxes in Texas during 1997 and 1998 by using a combination of track-plates, live-trapping, and spotlight surveys in 25 counties (Fig. 1). Results indicated swift foxes in only Dallam and Sherman counties (Fig. 1). Since surveys by K. Mote et al. (in litt.), researchers have documented a declining presence in these counties (Nicholson et al., 2006). Determining current distribution in Texas is necessary to develop an appropriate management strategy for conservation of swift foxes in Texas.

MATERIALS AND METHODS—We conducted surveys in 35 counties that encompassed the majority of remaining short-grass and mixed-grass prairies within Texas (Fig. 2). The landscape was a matrix of various-sized fragments of native grasslands, croplands, Conservation Reserve Program lands, and a limited urban interface. Native grassland was most prevalent in the northern and western counties and decreased with the increase of agricultural development south of the Canadian River (United States Department of Agriculture, http://www.nass.usda.gov/Statistics_by_State/Texas/Publications/index.asp).

Many methods used for surveying populations of carnivores have been used for swift foxes. These include spotlight-counts (Harrison et al., 2002; Schauster et al., 2002; Schaughnessy, 2003; K. Mote, in litt.), headlight-counts (Harrison et al., 2002; Schauster et al., 2002; K. Mote, in litt.), track-plates (Olson et al., 2003), scent-stations (Harrison et al., 2002; Schauster et al., 2002; Sargeant et al., 2003), mark–recapture surveys (Harrison et al., 2002; Schauster et al., 2002; Finley et al., 2005; A. Moehrenschlager and C. Moehrenschlager, in litt.; K. Mote, in litt.), resighting using infrared cameras (Harrison et al., 2002; Schaughnessy, 2003), an activity index (Schauster et al., 2002), and scat-deposition surveys (Schauster et al., 2002; T. Olson et al., in litt.; M. Sovada and C. Roy, in litt.), sometimes combined with analysis of DNA to confirm identity of species (Harrison et al., 2002, 2004; Cullingham et al., 2010). Additionally, scat-detection dogs have been used successfully in presence–absence surveys of a variety of species, including kit foxes (*Vulpes macrotis*; Smith et al., 2005), although their efficacy for surveying swift foxes has not been evaluated. We were unable to consider using scat-detection dogs for our surveys due to cost of this technique. In an extensive review of multiple survey techniques, Schauster et al. (2002) reported mark–recapture surveys to be the most effective predictor of density of swift foxes (71.1%). However, rates of detection from scat-surveys were similar (69.7%) and

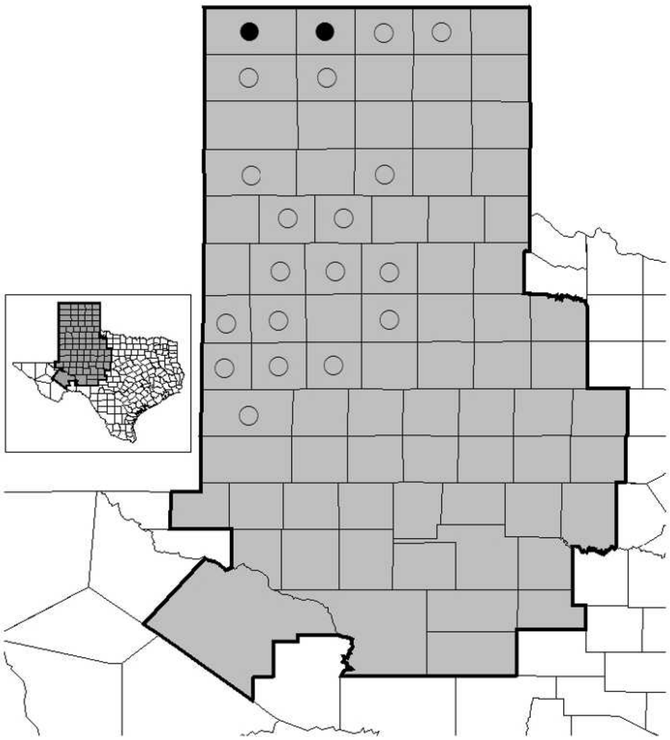

FIG. 1—The shaded area is the historic distribution of the swift fox (*Vulpes velox*) in Texas (J. K. Jones, Jr. et al., in litt.; K. Mote et al., in litt.): ○, the county was surveyed in 1998, but no swift fox was detected; ●, the county was surveyed in 1998 and the swift fox was detected.

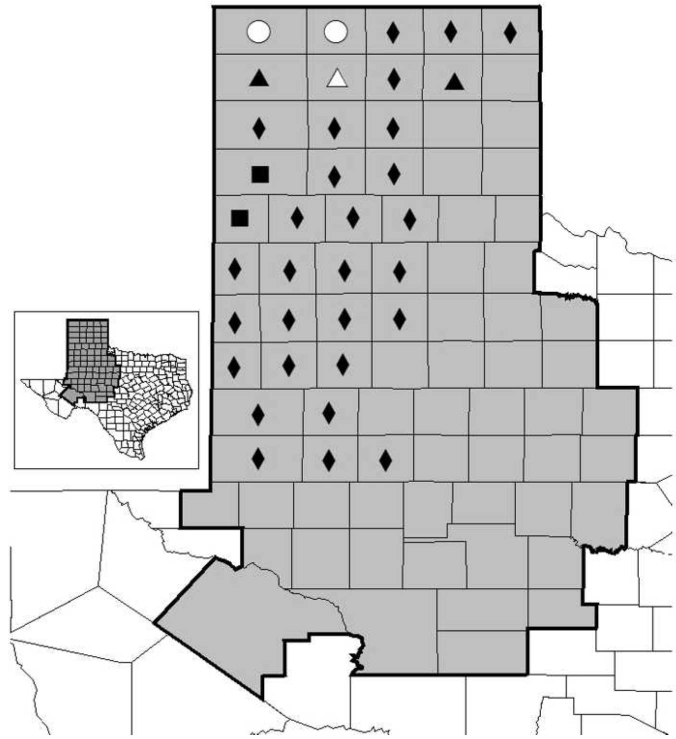

FIG. 2—Area surveyed in search of the swift fox (*Vulpes velox*) in Texas during 2005–2007: ○, swift foxes were detected with scat-transects and live trapping during 2005, 2006, and 2007. Methods used when surveys were conducted in counties where the swift fox was not detected: ◆, scat-transects during 2005–2006; Δ, scat-transects and live trapping during 2005; ▲, scat-transects and live trapping during 2006–2007; ■, scat-transects and live trapping during 2005–2007.

were not statistically different from mark–recapture rates. In a similar review, Harrison et al. (2004) found scat-surveys combined with analysis of DNA to be the best method of detection, with 100% rates of detection in known and presumed home ranges of swift foxes, and 62–67% rates of detection at individual sites. Based on these results, we chose to use live-trapping and scat-transects to assess current distribution of swift foxes in Texas.

We used methods described by Harrison et al. (2002) for conducting scat-transects. We established 93 16-km transects along roads that had maximum contact with native grasslands and minimal contact with unsuitable landcovers (e.g., cropland, Conservation Reserve Program, urban development). Some transects were truncated because of limited access; ultimately, 550 km of roadways were surveyed. We searched for scats along each transect at conspicuous locations (e.g., intersections of trails, roads, and fences, cattle guards, gates) that often are used by canids for territorial marking (Kleiman, 1966; MacDonald, 1980; Barja et al., 2004). Each transect was surveyed once per year during July–November 2005 and July 2006. The order in which transects were surveyed was reversed between years.

Overlap in size has been reported among scats of various canids (Green and Flinders, 1981; Danner and Dodd, 1982). We collected scats with a diameter ≤20 mm to reduce likelihood of disregarding scats of swift foxes. Individual scats were stored in a paper bag and labeled with a unique identification code. In 2005, scats were frozen the day of collection and kept frozen for ≤6 months, then dried at 61.7°C for 1 week. In 2006, scats were dried at 61.7°C for 1 week beginning the day of collection. Once dried, scats were stored at room temperature in a dry location until analysis.

Analyses were conducted by Wildlife Genetics International (Nelson, British Columbia, Canada). Mitochondrial DNA was extracted from scats with Qiagen's QIAamp Mini Stool Kit (Qiagen, Inc., Valencia, California) per instructions of manufacturer. To identify depositing species, we used a sequence-based analysis of the 16S rRNA mitochondrial genome as described by Johnson and O'Brien (1997). We used a dedicated room for handling and storing amplified DNA during analysis to control for contamination. Contamination was monitored routinely by including both negative and positive controls with every analysis.

We were unable to live-trap in all 35 counties due to logistic and financial constraints. Instead, we selected counties based on proximity to known populations of swift foxes and amount of remnant native grasslands. We used Landsat 7 Thematic Mapper imagery (United States Geological Survey, Sioux Falls, South Dakota) to identify fragments of native grasslands in each county. We randomly numbered each fragment and selected the first 50 fragments as potential sites to survey. We did not include fragments <129.5 ha in size, because this area was <10% of the reported size of home ranges of swift foxes in our study area (Kamler et al., 2003*c*). If we were unable to gain access to a given fragment, it was replaced by the next numbered fragment. Number of fragments varied per year of survey pending identification and participation of landowners. We surveyed 27, 41, and 39 fragments in 2005, 2006, and 2007, respectively. Each fragment was surveyed for 2 consecutive nights/year with live traps (Tomahawk Live Trap, Tomahawk, Wisconsin) baited with a piece of black-tailed prairie dog (*Cynomys ludovicianus*), black-tailed jackrabbit (*Lepus californicus*), cottontail (*Sylvilagus*), mule deer (*Odocoileus hemionus*), or pronghorn (*Antilocapra americana*). Canned mackerel and O'Gorman Powder River Scene Lure (Minnesota Trapline Products, Pennock, Minnesota) also were used at each trap as a long-distance scent-lure. We placed traps at ca. 0.4–0.8-km intervals along fences and interior roads. We chose trapping sites to optimize potential trapping success; therefore, spacing between traps and number of traps per fragment varied depending on size of fragment and presence of optimum sites (e.g., cattle guards, fence corners, game trails, intersections of roads and fences, windmills). Minimum number of traps set on a fragment in one night was 11 and maximum was 43. We opened traps 1–2 h prior to sunset, and checked and closed traps about sunrise the following morning. Traps that were robbed of bait, closed without a capture, or with nontarget species were excluded from total trap-nights. Captured swift foxes were removed from the trap and physically restrained. Morphometric measurements were gathered and a microchip was inserted under the skin at the back of the neck to allow identification of each swift fox. Processing time typically was < 20 min. We released swift foxes at site of capture immediately after processing. Nontarget species were released without handling. Our protocol was approved by the Texas Tech University Institutional Animal Care and Use Committee (protocol 05019-04). We calculated probability of detection and estimated occupancy for each year we surveyed using program Presence 2.0 (United States Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland). Our surveys spanned the late pup-rearing and early dispersal phases of life history; probabilities of detection are likely to differ between phases; thus, we used the single-season, survey-specific P model (MacKenzie et al., 2002) to estimate probability of detection separately for each phase.

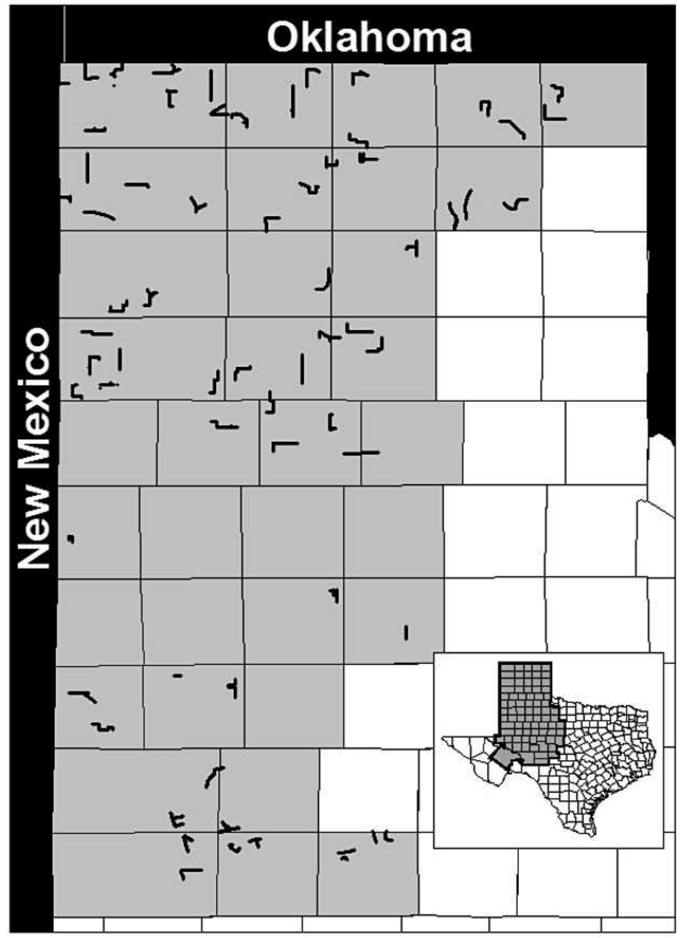

Fig. 3—Distribution of scat-transects (lines among counties) conducted during searches for the swift fox (*Vulpes velox*) in Texas, 2005–2006; study area is shaded.

Results—We collected 102 scats in 2005 and 64 in 2006. At least one scat was collected in each of 22 counties (62.9%) surveyed in 2005 and 20 counties (57.1%) surveyed in 2006. We successfully generated identifications of species for 55 of 102 (53.9%) and 51 of 63 (79.7%) scats in 2005 and 2006, respectively. In 2005, 2 of 102 (1.9%) scats were identified genetically as swift foxes. In 2006, 6 of 64 scats (9.4%) were identified genetically as swift foxes. We detected swift foxes in 1 of 35 counties where scat-transects were conducted (Fig. 2).

We conducted live-trapping surveys in six counties in 2005 and five counties in 2006 and 2007, although counties surveyed differed between years (Fig. 2). We completed 991, 1,558, and 780 trap-nights in 2005, 2006, and 2007, respectively. We excluded an additional 221, 154, and 49 trap-nights from the per-year totals of trap-nights because of capture of nontarget species, theft of bait, or malfunction of traps. We captured 18 (10 males, 8 females) swift foxes in 2005, 21 (12 males, 9 females) in 2006, and 31 (13 males, 18 females) in 2007. Of the 70 swift foxes captured, 63 were adults and 7 were juveniles. Two swift foxes were excluded because they escaped prior to handling. We detected swift foxes in two of seven counties with live-trapping surveys (Fig. 2). Overall, probabilities of detection were high, with probability of detection slightly lower during the late pup-rearing phase versus the dispersal phase (Table 2). Overall, our estimates of occupancy were low (Table 2).

Discussion—We detected swift foxes in Dallam County with scat-transects and Dallam and Sherman counties with live-trapping. We captured swift foxes in two areas of Sherman County. Although we also conducted scat-transects in these areas, we failed to detect swift foxes from scats. Scat-transects in both of these areas were on roads with frequent traffic from large vehicles because of proximity to oil fields. Scats could have been destroyed before scat-transects were conducted. Failing to detect swift foxes in areas known to be occupied suggests that use of multiple survey methods or, at minimum,

Table 1—Size of fragments of habitat, trapping effort, and number of individual swift foxes (*Vulpes velox*) captured within counties included in live-trapping surveys in Texas, 2005–2007.

County	Year	Number of fragments	Mean size of fragment (ha)	Number of trap-nights	Mean number of traps/fragment	Number of swift foxes captured
Dallam	2005	11	1,595.2	519	45.0	13
	2006	21	999.0	705	33.6	13
	2007	20	1,023.1	567	28.4	26
Deaf Smith	2005	2	1,068.4	38	19.0	0
	2006	9	848.9	283	31.4	0
	2007	6	1,036.0	192	32.0	0
Hartley	2005	2	1,683.5	95	47.5	0
	2006	0	—	—	—	—
	2007	0	—	—	—	—
Moore	2005	0	—	—	—	—
	2006	4	482.4	181	45.3	0
	2007	4	482.4	138	34.5	0
Parmer	2005	1	906.5	20	20.0	0
	2006	1	1,359.7	67	67.0	0
	2007	1	1,359.7	72	72.0	0
Roberts	2005	5	854.7	151	30.2	0
	2006	0	—	—	—	—
	2007	0	—	—	—	—
Sherman	2005	6	2,719.5	168	28.0	5
	2006	7	2,741.1	322	46.0	8
	2007	7	2,741.1	111	15.9	5
	2005	27	1,471.3	991	36.7	18
Totals	2006	42	1,286.2	1,558	37.1	21
	2007	38	1,328.5	780	35.0	31

establishing scat-transects on low-use roads are important considerations for surveys.

We documented swift foxes in only 2 of 35 counties surveyed. Based on these results, current distribution of swift foxes in Texas is significantly reduced from the historical distribution. Likewise, the few individuals captured suggest small populations in areas where they remain. These two factors indicate that the species may be at risk of extirpation in Texas. Lack of expansion of populations (i.e., K. Mote, in litt.) and likely recent extirpation from a site within the current distribution (Nicholson et al., 2006) lend further credence to this concern.

We do not know what factor or combination of factors is causing the limited distribution and density of swift foxes in Texas. Two potential causes include morality related to coyotes (*Canis latrans*) and loss of habitat (Egoscue, 1979; Scott-Brown et al., 1987; Knowles et al., 2003). In our study area, mortalities caused by coyotes, as reported by Kamler et al. (2003*b*) and McGee et al. (2006), was 27–89% and typically were higher than reported in other parts of the range of swift foxes (40–85%; e.g., Covell, 1992; Anderson et al., 2003; Karki et al., 2007; Thompson and Gese, 2007). Thompson and Gese (2007) reported a negative relationship between density of swift foxes and abundance of coyotes. Furthermore, habitat partitioning is common between coyotes and swift foxes (Kamler et al. 2003*a*; Thompson and Gese, 2007) and can lead to exclusion of swift foxes (Kamler et al., 2003*a*). Low population densities, combined with the possibility exclusion of swift foxes by coyotes, might partially explain the inability of swift foxes to reestablish populations in areas with suitable grassland habitats in Texas.

Table 2—Estimates of probabilities of detection (during late pup-rearing and dispersal) and rates of occupancy of fragments of habitat by swift foxes (*Vulpes velox*), with standard errors, for live-trapping surveys conducted in Texas, 2005–2007.

Year	Probability of detection, late pup-rearing (*SE*)	Probability of detection, dispersal phase (*SE*)	Estimate of occupancy (*SE*)
2005	0.70 (0.14)	1.00 (0.08)	0.37 (0.09)
2006	0.89 (0.10)	0.80 (0.15)	0.27 (0.07)
2007	0.80 (0.13)	1.00 (0.00)	0.26 (0.07)

Grassland systems in the Great Plains have undergone rapid and extensive alteration largely via conversion for agricultural purposes (Samson and Knopf, 1994; Whitney, 1994; Allardyce and Sovada, 2003). About 29% of mixed-grass prairie and 52% of short-grass prairie remains (Samson et al., 2004). Swift foxes typically occur in grassland systems and loss of habitat is believed to be a significant source of range-wide declines in populations (Allardyce and Sovada, 2003). Sovada et al. (1998) and Matlack et al. (2000) detected swift foxes in grasslands and croplands in Kansas; thus, agricultural development does not automatically result in exclusion of swift foxes. However, Kamler et al. (2003*c*) determined that swift foxes avoided cropland within our study area. It is unclear why swift foxes do not use croplands in Texas but use croplands in Kansas. Variation in crops, agricultural practices, and size of croplands between Texas and Kansas, as well as their subsequent influence on populations of predators and prey, are all potential reasons, but these relationships require further investigation.

Regardless of cause, current status of the swift fox in Texas warrants increased research and management efforts if extirpation is to be avoided. Several tools are available that could increase population density and distribution of swift foxes in Texas. During surveying efforts, we observed many grasslands potentially suitable for use by swift foxes, but currently overgrown with cholla cactus (*Cylindropuntia*) and honey mesquite (*Prosopis glandulosa*). Restoring grasslands via control of these species would greatly increase amount of grasslands available for swift foxes, as well as for other grassland species in Texas. Kamler et al. (2003*b*) reported increased survival, density, and recruitment of juvenile swift foxes after coyotes were removed. Conversely, Karki et al. (2007) noted that reduction of populations of coyotes did not increase density or reproduction of swift foxes, but did positively influence survival of adults. However, they also concluded that the population of swift foxes in their study was saturated (Karki et al., 2007); this does not appear to be the situation in Texas. McGee et al. (2006) reported that creating artificial escape cover increased survival and relative abundance, and encouraged formation of new territories. This technique is inexpensive and requires little time; thus, it might be a useful tool for increasing distribution and density of swift foxes in Texas. Finally, translocation has proven an effective means of establishing populations of swift foxes in many areas (Smeeton and Weagel, 2000; Knowles et al., 2003; Zimmerman et al., 2003; Ausband, 2005). We surveyed several grasslands historically inhabited by swift foxes that appeared suitable for occupation, but we detected no evidence of swift foxes. The Canadian River separates these areas from the current distribution of swift foxes in Texas and may pose an impenetrable barrier to dispersal, especially in light of inhospitable habitats that surround both sides of the river. It also is possible that these areas are uninhabited by swift foxes because they are unsuitable due to densities of coyotes, availability of prey, or quality of habitat. These areas might be suitable for translocation efforts, but a suitability assessment including surveys of predators and prey, and availability, quality, and connectivity of habitats is necessary before this can be justified. Using a combination of controlling populations of coyotes, providing artificial cover for escape, and translocations to manage swift foxes in Texas might be necessary to increase density, distribution, and long-term viability of the population.

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Literature Cited

Allardyce, D., and M. A. Sovada. 2003. A review of the ecology, distribution, and status of swift foxes in the United States. Pages 3–18 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

Anderson, D. E., T. R. Laurion, J. R. Cary, R. S. Sikes, M. A. McLeod, and E. M. Gese. 2003. Aspects of swift fox ecology in southeastern Colorado. Pages 139–148 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

Ausband, D. E. 2005. Assessing the success of swift fox reintroductions on the Blackfeet Indian Reservation, Montana. M.S. thesis, University of Montana, Missoula.

Barja, I., F. J. de Miguel, and F. Barcena. 2004. The importance of crossroads in faecal marking behaviour of the wolves. Naturwissenschaften 91:489–492.

Covell, D. F. 1992. Ecology of the swift fox (*Vulpes velox*) in southeastern Colorado. M.S. thesis, University of Wisconsin, Madison.

Cullingham, C. I., M. Curteanu, M. C. Ball, and M. Manseau. 2010. Feasibility and recommendations for swift fox fecal DNA profiling. Journal of Wildlife Management 74:849–859.

Danner, D. A., and N. Dodd. 1982. Comparison of coyote and gray fox scat diameters. Journal of Wildlife Management 46:240–241.

Egoscue, H. J. 1979. *Vulpes velox*. Mammalian Species 122:1–5.

Finley, D. J., G. C. White, and J. P. Fitzgerald. 2005. Estimation of swift fox population size and occupancy rates in eastern Colorado. Journal of Wildlife Management 69:861–873.

Green, J. S., and J. T. Flinders. 1981. Diameter and pH comparisons of coyote and red fox scats. Journal of Wildlife Management 45:765–767.

Harrison, R. L., D. J. Barr, and J. W. Dragoo. 2002. A comparison of population survey techniques for swift fox (*Vulpes velox*) in New Mexico. American Midland Naturalist 148:320–337.

Harrison, R. L., P.-G. S. Clarke, and C. M. Clarke. 2004. Indexing swift fox populations in New Mexico using scats. American Midland Naturalist 151:42–49.

Johnson, W. E., and S. J. O'Brien. 1997. Phylogenetic reconstruction of the Felidae using16S rRNA and NADH-5 mitochondrial genes. Journal of Molecular Evolution 44(supplement 1):S98–S116.

Kamler, J. F., W. B. Ballard, R. L. Gilliland, and K. Mote. 2003*a*. Spatial relationships between swift foxes and coyotes in northwestern Texas. Canadian Journal of Zoology 81:168–172.

Kamler, J. F., W. B. Ballard, R. L. Gilliland, P. R. Lemons, II, and K. Mote. 2003*b*. Impacts of coyotes on swift foxes in northwestern Texas. Journal of Wildlife Management 67:317–323.

Kamler, J. F., W. B. Ballard, E. B. Fish, P. R. Lemons, K. Mote, and C. C. Perchellet. 2003*c*. Habitat use, home ranges and survival of swift foxes in a fragmented landscape: conservation implications. Journal of Mammalogy 84:989–995.

Karki, S. M., E. M. Gese, and M. L. Klavetter. 2007. Effects of coyote population reduction on swift fox demographics in southeastern Colorado. Journal of Wildlife Management 71:2707–2718.

Kleiman, D. G. 1966. Scent marking in the Canidae. Symposia of the Zoological Society of London 18:167–177.

Knowles, C. J., P. R. Knowles, B. Giddings, and A. R. Dood. 2003. The historic and recent status of the swift fox in Montana. Pages 41–55 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

Macdonald, D. W. 1980. Patterns of scent marking with urine and faeces amongst carnivore communities. Symposia of the Zoological Society of London 45:107–139.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

Matlack, R. S., P. S. Gipson, and D. W. Kaufman. 2000. The swift fox in rangeland and cropland in western Kansas: relative abundance, mortality, and body size. Southwestern Naturalist 45:221–225.

McGee, B. K., W. B. Ballard, K. L. Nicholson, B. L. Cypher, P. R. Lemons, II, and J. F. Kamler. 2006. Effects of artificial escape dens on swift fox populations in Northwest Texas. Wildlife Society Bulletin 34:821–827.

Nicholson, K. L., W. B. Ballard, B. K. McGee, J. Surles, J. F. Kamler, and P. R. Lemons. 2006. Swift fox use of black-tailed prairie dog towns in Northwest Texas. Journal of Wildlife Management 70:1659–1666.

Olson, T. L., J. S. Dieni, F. G. Lindzey, and S. H. Anderson. 2003. Swift fox detection probability using tracking plate transects in Southeast Wyoming. Pages 93–98 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

Samson, F. B., and F. L. Knopf. 1994. Prairie conservation in North America. BioScience 44:418–421.

Samson, F. B., F. L. Knopf, and W. R. Ostlie. 2004. Great Plains ecosystems: past, present and future. Wildlife Society Bulletin 32:6–15.

Sargeant, G. A., P. J. White, M. A. Sovada, and B. L. Cyper. 2003. The historic and recent status of the swift fox in Montana. Pages 99–106 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

Schaughnessy, M. J., Jr. 2003. Swift fox detection methods and distribution in the Oklahoma Panhandle. Pages 61–70 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

Schauster, E. R., E. M. Gese, and A. M. Kitchen. 2002. An evaluation of survey methods for monitoring swift fox abundance. Wildlife Society Bulletin 30:464–477.

Scott-Brown, J. M., S. Herrero, and J. Reynolds. 1987. Swift fox. Pages 433–441 in Wild furbearer management and conservation in North America (M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors). Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

Smeeton, C., and K. Weagel. 2000. The reintroduction of the swift fox *Vulpes velox* in south-central Saskatchewan, Canada. Oryx 34:171–179.

Smith, D. A., K. Ralls, B. L. Cypher, and J. E. Maldonado. 2005. Assessment of scat-detection dog surveys to determine kit fox distribution. Wildlife Society Bulletin 33:897–904.

Sovada, M. A., C. C. Roy, J. B. Bright, and J. R. Gillis. 1998. Causes and rates of mortality of swift foxes in western Kansas. Journal of Wildlife Management 62:1300–1306.

Thompson, C. M., and E. M. Gese. 2007. Food webs and intraguild predation: community interactions of a native mesocarnivore. Ecology 88:334–346.

Whitney, G. G. 1994. From coastal wilderness to fruited plain. Cambridge University Press, Cambridge, United Kingdom.

Zimmerman, A. L., L. Irby, and B. Giddings. 2003. The status and ecology of swift foxes in north-central Montana. Pages 49–59 in The swift fox: ecology and conservation of swift foxes in a changing world (M. A. Sovada and L. Carbyn, editors). Canadian Plains Research Center, University of Regina, Regina, Saskatchewan, Canada.

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