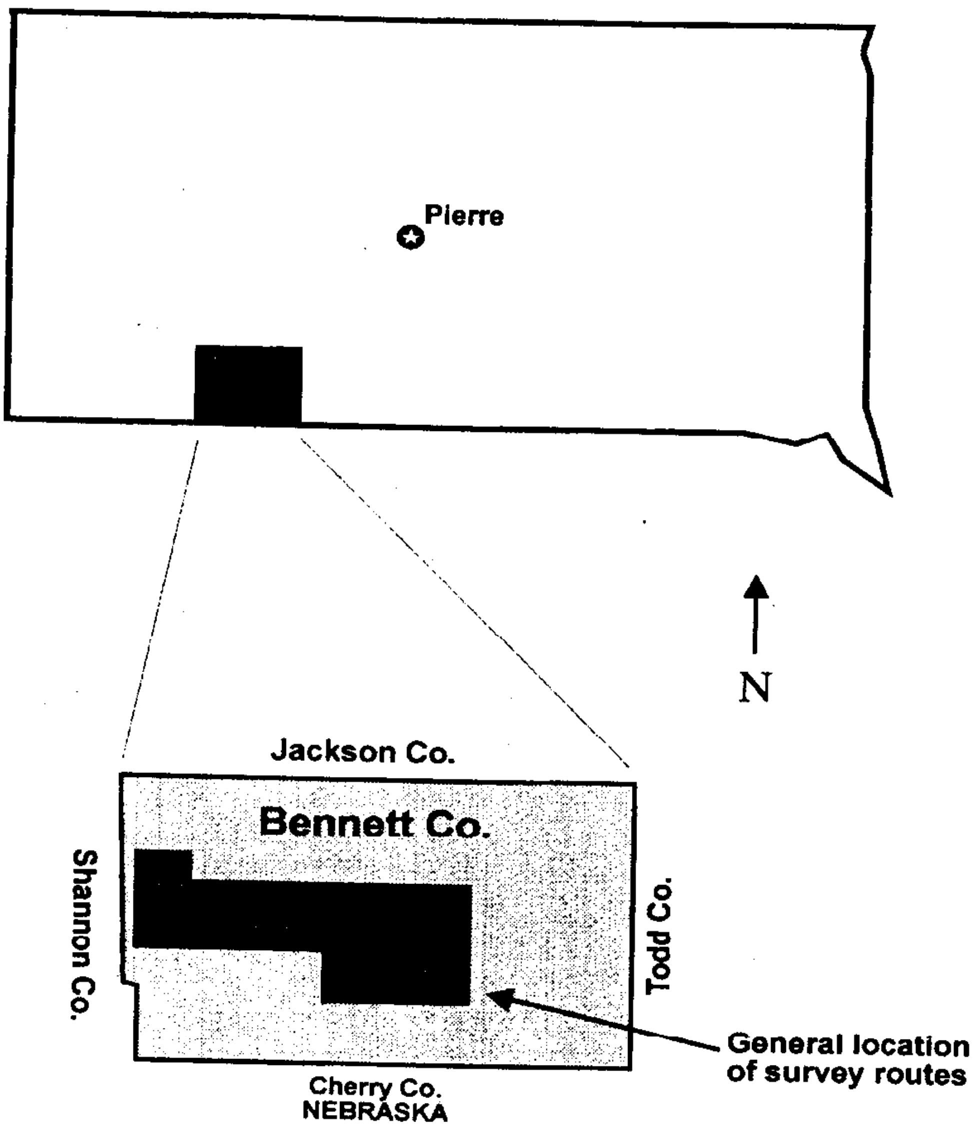
Fig. 1. General location of swift fox survey area in Bennett Co., South Dakota.



SWIFT FOX SURVEY EVALUATION, PRODUCTIVITY, AND SURVIVORSHIP IN SOUTHEAST WYOMING

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ABSTRACT

This state report is an edited version of the information presented in Olson et al. (1997). The probability of detecting 1 swift fox (*Vulpes velox*) of a pair using tracking plate transects was estimated, in Albany county, Wyoming, for the purpose of monitoring swift fox population status in the state. Detection probability was estimated to be 0.66 in late June and 0.88 in late August. Estimated detection probability near active dens was 1.0 in early July. We measured a significant increase in the detection rate of foxes from late June to late August. Average litter size was 5.25 pups, and estimated adult survivorship was 43% from March 1996-November 1997. We conducted distribution surveys to confirm the presence of swift fox in three areas of Wyoming: 1) northern and central Campbell county; 2) Bighorn Basin; and 3) Green River Basin. No swift fox were detected in the areas sampled.

INTRODUCTION

Efforts to increase our knowledge of swift fox ecology have accelerated since the swift fox was proposed for listing as an endangered species in 1992. In June of 1995, the US Fish and Wildlife Service concluded that listing of the swift fox was warranted but precluded, giving affected states the opportunity to gather additional data on the species. The Swift Fox Conservation Team was formed to develop conservation objectives for the species and drafted a conservation plan (Kahn et al. 1996) to identify steps to be taken to ensure swift fox survival. Reliable techniques to monitor current swift fox population status are needed to address these conservation objectives (Luce and Lindzey 1996).

Researchers have used various techniques to detect swift fox presence, such as scent stations with tracking media (Hoagland 1996), tracking plate transects (Woolley et al. 1995, Mote 1996, Dieni et al. 1997), spotlighting (Hillman and Sharps 1978, Woolley et al. 1995, Mote 1996, Dieni et al. 1997), and scat surveys (Sovada and Roy 1996, Dieni et al. 1997), but the probability of detecting swift fox presence with these methods has not been determined.

In order to monitor swift fox population persistence, one needs an effective technique which is capable of detecting swift foxes with a high probability. Dieni et al. (1997) reported that tracking plates run in the fall provided the greatest detection frequency. Tracking plates are also relatively inexpensive, easy to use, and tracks left on a hard surface are readily identifiable, making this technique an attractive detection method. Tracks of the similar San Joaquin kit fox (*Vulpes macrotis mutica*) left on tracking plates were readily distinguishable from other wild canids (Orloff et al. 1993). Precipitation is the main hindrance to using tracking plates, but selecting typically dry time periods (late June through August in Wyoming) to conduct surveys will help mitigate this problem. Knowledge of the likelihood of detecting swift fox when they are present can be incorporated into simulations designed to estimate survey effort needed to detect declines in swift fox distribution, which can be used as an indicator of population persistence.

We had four objectives for research conducted in 1997: 1) estimate the probability of detecting 1 swift fox from a pair using tracking plate transects within their known home range over 2 time periods; 2) estimate the probability of detecting 1 swift fox from a pair using tracking plates near active dens; 3)estimate swift fox litter size and survivorship; and 4) confirm swift fox presence in the far northern portion and/or outside the boundaries of their historic range in Wyoming.

STUDY AREA

Our study area was located on the southern edge of the Shirley Basin in northwestern Albany county, near Medicine Bow, Wyoming (Fig. 1). The study area covered approximately 220 km^2, and elevation averaged 2075 m (6800 ft). Plant communities consisted of sagebrush steppe and mixed-grass prairie. The habitat was primarily grass dominated, interspersed with patches of low-growing (<1 m) sagebrush (*Artemisia*) and taller greasewood (*Sarcobatus vermiculatus*). The topography of the area was mostly flat with numerous dry lakebeds and several saline lakes. The climate of the area was characterized by long, cold, snowy winters and warm, dry summers. Precipitation averaged 26 cm (10.3 in), including 59 cm (23 in) of snow annually (Medicine Bow town office, pers. comm.). Predators present were badgers (*Taxidea taxus*), coyotes (*Canis latrans*), golden eagles (*Aguila chrysaetos*), and ferruginous hawks (*Buteo regalis*). No red foxes (*Vulpes vulpes*) were seen on the study area during the course of study. White-tailed prairie dog (*Cynomys leucurus*) colonies of variable size were found on the study area. Land ownership was mostly private and the primary land use was cattle grazing. Human developments consisted of fences, windmills, stock ponds, and secondary roads.

METHODS

We captured swift foxes using Tru-catch live traps baited with butcher scraps. Foxes captured in 1996 (Dieni et al. 1997) and their mates were targeted for re-capture. Traps were checked twice nightly to minimize the time which any trapped female fox was kept away from new-born pups. Each captured fox was ear-tagged, if needed, fitted with a radio collar (Advanced Telemetry Systems Inc., Isanti, MN), weighed, and released.

We located swift foxes at night using a combination of a roof mounted omni antenna and a hand held "H" antenna. We triangulated from roads traversing the study area, using at least three intersecting azimuths per location. Observer position was determined from US Geological Service 1:24000 scale topographic maps. From our location data and the average activity radii of male swift foxes (plus 1 sd) estimated by Pechacek et al. (unpubl. manuscript, 1997) during the winter of 1996-97 on some of the same study animals, we estimated core use areas and constructed potential home ranges for each pair. We then delineated the area of each pair's potential home range that did not overlap with the home ranges of adjacent pairs.

Detection Probability - Two test trials were run for 7 days each to estimate the probability of detecting 1 fox from a marked pair, using tracking plates. Transects, 1 km (0.6 mi.) in length and consisting of 4 stations separated by 0.3 km (0.2 mi), were placed within or near the core use area of each pair. We purposely avoided areas of overlap with adjacent fox pairs to minimize the number of adult foxes which would likely encounter each transect. Transects were placed in selected locations (e.g., along fencelines, road intersections) to increase the likelihood of fox visitation. Each station consisted of a 61cm x 61cm (2 ft x 2 ft) tracking plate (sheet steel) and an infra-red remote triggered camera (TrailMaster TM 1500, Goodson and Assoc. Inc. Lenexa, KS). Each tracking plate was sprayed with a talcum powder-ethanol mixture, leaving a thin coat of talc on the plate, and baited with approximately 5 g of canned mackerel in the center of the plate (Woolley et al. 1995). We started each trial on a day forecasted to be dry because rain would have washed the tracking medium (talc) off the plates. Mackerel was used as an incentive for the foxes to re-visit the plates. Cameras were triggered when an infra-red beam of light centered across the plates was broken, allowing us to identify foxes (marked or unmarked) that visited plates from photographs. If a photograph showed a marked fox, we assumed the fox was one of the pair in whose core area the transect was located. Tracking plates were checked each morning, and swift fox tracks were measured and recorded. Plates were re-baited later that day (early evening). Number of photographs taken each night was recorded, and film was replaced as needed.

The transect/fox pair was the sample unit, and the proportion of transects detecting presence of marked swift foxes during each trial was considered the detectability estimate. Because of our small sample size, we estimated a 95% confidence interval by constructing a binomial distribution of theoretical population proportions for each detectability estimate (Moore and McCabe 1993). The average number of nights on a transect that detected a swift fox, and the average number of stations on a transect that detected a swift fox each night were compared between trials using a paired-samples Wilcoxon test. Tests were considered significant at a P value less than 0.05. Regression analysis was conducted between the shortest distance from tracking plate transects to active dens, and the number of days until we first recorded evidence (track, photograph, scat) on a transect that a swift fox (marked or unmarked) had visited.

Following trial 1 we also estimated the probability of detecting 1 swift fox from a marked pair near active dens using tracking plates. Tracking plates were placed at the ends of two perpendicular transects (4 plates total), centered over the active den site of each marked fox pair. In all likelihood, foxes which visited the plates were those marked foxes residing in the den. Prior to this test, we observed pups at each active den site to determine how far they ranged from the den. Each plate was placed 100 m from the den to eliminate the possibility of pups visiting the plates. The plates were again coated with talcum powder, but we used 2 types of bait. One transect was baited with mackerel and the other with bacon. After the first night both transects were rotated 45 degrees clockwise around the den.

We surveyed each tracking plate transect for swift fox scat just before the first trial. Two observers walked each transect twice and measured the maximum diameter of each fox scat found. The proportion of transects with swift fox scat present was our detectability estimate. We also collected and measured swift fox scat near active den sites and compared them with red fox scat sizes reported in the literature.

Litter Size - We opportunistically observed dens of radio-collared swift fox pairs and recorded the number of pups seen. We observed dens from a distance using a variable powered spotting scope and/or binoculars. Dens where pups had not previously been seen were emphasized. Initially, we spent an evening at a den until we saw pups, and then returned to the den during different time periods to update the pup count. Number of times a den was observed and the amount of time spent (if more than 5 minutes) were recorded.

Survivorship - Sixteen swift fox were radio-collared on the study site in the spring of 1996 (Dieni et al. 1997). These animals were included in the survivorship calculations along with new foxes captured in 1997. Life status was monitored weekly from March-July 1997, and every 2-3 weeks from August-October 1997. Dead foxes were recovered and cause of death was determined, if possible. If death was undetermined in the field, the carcass was taken to the Wyoming State Veterinary Lab for further examination. We used the Kaplan-Meier product limit estimator to estimate survivorship and a 95% confidence interval (White and Garrott 1990).

Distribution Surveys - We conducted surveys to confirm swift fox presence in three areas of Wyoming: 1) northern and central Campbell county; 2) Bighorn Basin; and 3) Green River Basin. Since 1995, the Wyoming Game and Fish Department has requested information on swift fox sightings from trappers throughout the state, and these three areas had several swift fox sightings reported (Fig. 2). Campbell county lies within historic swift fox range (Fig. 3), although earlier survey efforts by Woolley et al. (1995) failed to confirm species presence. We surveyed transects (Fig. 2) in suitable habitat near the location of recent swift fox sightings using tracking plates and spotlighting. Woolley et al. (1995) suggested that increased sampling effort may be needed in the northern portion of historic swift fox range in Wyoming to detect foxes if they were present at low densities. Therefore, we increased the sampling effort from 2 nights to 3 and decreased tracking plate spacing from 1mi (1.6 km) to 0.5 mi (0.8 km). We surveyed each transect in the Green River Basin for only two nights due to time constraints.

Tracking plates were sprayed with an ethanol-talcum powder mixture, leaving a thin coat of talc on the plate, and a scent tab soaked in a cod liver oil/mackerel mixture was placed in the center of the plate as an attractant (Dieni et al. 1997). Plates were checked each morning, tracks identified, and photographs of tracks taken if species identity was in question. A newly soaked scent tab was placed on the plates each morning. Transects were spotlighted each night between 2100 and 0400 hours using a 50-watt, roof mounted light. After animal eyeshine was observed, we identified the animal using a 15x-60x variable powered spotting scope. A GPS unit was used to estimate animal locations in UTM coordinates.

RESULTS

We captured 18 swift foxes between 9 March and 15 May 1997 which consisted of 10 foxes from 1996 that were re-captured and eight newly captured foxes. These collared foxes formed nine complete pairs. Five foxes died between trials 1 and 2, eliminating one pair and leaving three single foxes.

Detection Probability - We sampled nine transects during trial 1 (27 June-3 July, 1997) and swift fox tracks were recorded on six transects (66%) over 6 days (Table 1, Fig. 4). We recorded tracks of marked swift foxes on three transects during the first 3 days of the trial. Assuming that all tracks left on plates were from marked foxes in whose home range the transect was located, we estimated the probability of detecting at least one fox from a marked pair at 0.66. Photographs of marked foxes were recorded on six of the nine transects; tracks were not recorded on three of these transects. We recorded evidence (tracks, scat found near tracking plates, photographs) that all nine transects were visited by foxes during the trial. Swift fox scat was detected on or near tracking plates on four transects, and photographs of unmarked foxes were recorded on two of the transects.

We sampled eight transects during trial 2 (28 August-3 September, 1997) and tracks of swift foxes were recorded on seven transects (88%) over 6 days (Table 1, Fig. 4). We recorded tracks of marked (adult) swift foxes on seven of eight transects (88%) during the first 6 days. We estimated the probability of detecting at least one fox from a marked pair at 0.88. Photographs of marked swift foxes were taken on all eright transects. Swift fox scat was detected on or near tracking plates on five transects, and photographs of unmarked foxes (presumably young-of-year) were recorded on six of the eight transects.

Trial Comparisons - The average number of nights detecting swift fox tracks on a transect increased significantly from trial 1 to trial 2 (Table 2). The average number of nights recording photographs of marked swift foxes on a transect also increased from trial 1 to trial 2, but the difference was not significant.

The average number of stations on a transect which recorded swift fox tracks each night increased significantly from trial 1 to trial 2 (Table 3). The average number of stations on a transect which detected marked swift foxes each night was nearly the same for both trials. Combining results of the two trials, we detected tracks of marked swift foxes on all nine transects.

When a photograph of a swift fox was taken, we identified a track on the plate 76.9 % (n = 143, trials combined) of the time. We recorded a photograph of a swift fox 33 times when we were unable to detect a track on the plate. Poor tracking medium due to moisture or cattle, and bait being stolen by ground squirrels likely explained the absence of a track on 16 of those occasions. Several photographs showed foxes on plates, but we found no identifiable track due to heavy dew or rain. On 23 occasions we identified a swift fox track, but no photograph had been taken. When we identified swift fox tracks, photographs had been taken 82.7 % (n = 133) of the time.

Swift fox tracks measured on tracking plates during all tests averaged 24 mm wide and 30 mm long (n=158; sd=1.5 mm wide, 2.2 mm long; range=20-29 mm wide, 25-42 mm long; Fig. 5). Orloff et al. (1993) reported that red fox tracks measured on tracking plates averaged 39 mm wide and 47 mm long (n=18; sd=4.2 wide, 5.8 long; range=33-47 wide, 40-56 long).

Shortest distance from tracking plate transects to active dens averaged 740 m (n=9; sd=390; range=175-1350) for trial 1 and 1086 m (n=8; sd=787; range=300-2340) for trial 2. We did not detect a strong relationship between the shortest distance from tracking plate transects to active dens, and the number of days required to detect swift fox presence (Table 4).

Detection Probability Near Dens - We recorded swift fox tracks on tracking plates at all active den sites both nights (13-14 July, 1997) of the trial. An average of 2.1 plates/den site detected tracks the first night and 2.5 plates/den site the second night. We detected little difference in the number of plates visited which were baited with mackerel (22) and bacon (20). Bait was completely eaten on 17 plates baited with mackerel and 19 plates baited with bacon.

Scat Surveys - We detected swift fox scat on six of nine transects (24 June, 1997) using two observers. One observer detected swift fox scat on five of nine transects and the other on six of nine transects, suggesting little difference between the two observers. Assuming that the scats observed were from marked foxes, the detectability estimate would be 0.66. Coyote scats were observed on four of nine transects (observers combined). Swift fox scats collected at active den sites had an average maximum width of 12.6 mm (n=253; sd=2.2; range=8-20). Green and Flinders (1981) reported average red fox scat width to be 14 mm (n=129; range=8-20). Ninety-one percent of red fox scats measured by Green and Flinders (1981) had a diameter of 17 mm or less, and 92% of swift fox scats we measured had a diameter of 15 mm or less (Fig. 6). A fox scat 11 mm wide would have a 15% chance of being that of a red fox.

Litter Size - We saw a total of 42 swift fox pups between 31 May and 23 July, 1997 at the 10 dens observed. No pups were seen at two of the dens, and an average of 5.25 (range=3-10) fox pups were seen at the others. An unmarked adult fox was seen at the den with 10 pups, so it is possible that the pups were from two females. Five of the females collared in 1997 were also collared in 1996, and at least three of these produced pups in 1996. Combined, these three females produced at least seven pups in 1996.

Observation efforts in 1996 were not similar to those in 1997, precluding comparison between years. We initially observed pups above ground on 31 May, 1997, however we did not begin to see pups on a regular basis until 25 June. Initial den observations were done in the evening, and on average, it took 2.8 visits in the evening to see pups for the first time. We observed each den an average of 12 times. When dens known to have pups were visited, we observed pups 53% of the time. Dens of the two swift fox pairs where pups were not seen were observed 21 and 16 times, respectively, during all periods of the day. We also examined the den entrances of these two dens and found no pup sign (small diggings near den, matted grass, abundant scat).

Survivorship - Sixteen swift fox were captured in March 1996 (Dieni et al. 1997), and eight new swift fox were captured in the spring of 1997. Twelve of the foxes died by the end of October

1997, and we lost radio contact with one other at the end of August 1997. Nine deaths occurred during the spring and summer of 1996 and 1997 combined (May-August), two during the winter of 1996 (November-December) and one in the fall of 1997 (October). Predation by coyotes was the confirmed cause of death in three instances and the other nine causes are unknown. We estimated adult (> 1 year) survivorship at 43 % (n=24; 95% CI=23-63%) from March 1996-November 1997.

Distribution Surveys - We completed 246 miles of spotlight and tracking plate transects from 30 July to 22 August, 1997 with a total of 600 miles spotlighted (61 hr.) and 776 effective (tracking medium undisturbed) tracking plate nights (Table 5). No swift fox were detected in the areas sampled. We recorded 40 carnivore observations while spotlighting and 28 carnivore detections with tracking plates. Carnivores that were detected included red fox, coyote, badger, striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), raccoon (*Procyon lotor*), and domestic cat (*Felis domestica*). Observations of mountain plover (*Charadrius montanus*), burrowing owl (*Athene cunicularia*), and upland sandpiper (*Bartramia longicauda*) were also recorded. The most frequently detected carnivores were red fox (37%) and striped skunk (37%).

DISCUSSION

Detection Probability - Surveys to detect swift fox presence will be more productive in late than early summer. Estimated detection probability of marked adult swift fox using tracking plates increased, but not significantly, from late June (0.66) to late August (0.88). The average number of nights that tracks were detected on each transect, and the average number of stations detecting tracks on a transect each night increased significantly from trial 1 to trial 2. Work done by Dieni et al. (1997) corroborates that detection rates with tracking plates increase in the late summer and fall. We expected to detect more foxes in late summer as young-of-the-year became independent, but the number of transects that detected marked (adult) foxes increased as well, even though five marked swift foxes died between trials.

We expected the probability of detecting a swift fox to depend on: 1) whether the fox encountered the tracking plate; and 2) whether it chose to step on the plate once encountered. We examined the contribution of encounter rates and behavior to estimated detection rates by placing tracking plates near active dens where we assumed they would be encountered, but outside the movement radii of pups. Swift fox tracks were detected on plates the first night at each den site, suggesting that, at least in the area of the dens, swift fox are likely to step on a tracking plate once encountered. We do not know whether swift fox exhibit different behavior toward tracking plates in areas away from dens; however, we expected encounter rates of tracking plate transects, and thus detection rates, to increase with time. Maximum detection rates were achieved on day 7 and day 6 of the two trials, respectively. It appeared that 6-7 days were required in the Medicine Bow study area to ensure that transects were encountered. We do not know whether additional days would have increased the encounter rate and thus the detection probability. Although detection rates were 100% in the den area, where we were confident plates would be encountered, not all foxes left a track on transect tracking plates, even though photographic records and scat showed that they had encountered the plates. Swift fox behavior (likelihood of stepping on a plate) may differ in different parts of their home range.

This test needs to be replicated with a different swift fox population to further establish the precision of the tracking plate survey technique. A possible bias in our results is that all of the adult foxes on our study area had been exposed to tracking plates the previous year. Whether or not these "educated" foxes exhibited different behavior than foxes which had never been exposed to tracking plates before is unknown. We also do not know what affect the cameras had on whether or not a swift fox would step on a tracking plate. It is possible that the camera flash may have scared foxes away from a plate before they stepped on it. Tracking plates placed near den sites without cameras yielded a 100% detection rate. If the camera flash did scare foxes away, then our estimated detection rates will be underestimates of the true detection rates of the population.

Trials were designed to reflect how tracking plates may be used in future swift fox population persistence monitoring. Using short transect lengths (1 km) minimized the number of swift fox home ranges that overlapped each transect. Study design dictated that transects be placed in areas of non-overlap with adjacent swift fox home ranges. This restriction biased transect locations toward active dens, compared to what may be encountered when this technique is applied. Due to our small sample size, confidence intervals are quite wide, and replication elsewhere is needed to enable us to make an inference about swift fox detection rates beyond our study area. Future surveys, conducted on a regular basis in late summer, may reflect changes in pup production, but the resident adult breeding population should still be detected with high probability.

The remote-triggered cameras detected marked swift foxes on more transects than did the tracking plates, indicating that cameras may actually be a superior monitoring tool. Cameras have several advantages over tracking plates. First, cameras can be used during rainy weather with no adverse effects, whereas tracking plates can only be used effectively during dry weather. Another advantage of the camera system is the elimination of the need to positively identify tracks; with a photograph you can actually see the animal that visited and not have to rely on trace sign of animal presence. However, camera systems are expensive ($600/unit, film and battery costs).

The scat survey in late June 1997 detected swift fox presence on the same number of transects that tracking plates did. Scat surveys to detect swift fox presence are easy to implement, inexpensive, and more weather resistant than tracking plates, but this approach is limited at present by the lack of criteria to positively identify swift fox scat. Assuming that the data from Green and Flinders (1981) are representative of red foxes in Wyoming, swift fox scat differentiation from red fox based on maximum scat width would be difficult, limiting the applicability of scat surveys for swift fox detection. Bile acid analysis (Major et al. 1980) and DNA analysis may be viable approaches to identify swift fox scat in the future.

Confusion of swift fox tracks with red fox should be very limited. The range of red fox track lengths overlaps slightly with what we measured for swift fox, but on average red fox tracks measured off tracking plates are 15 mm wider and 17 mm longer than swift fox tracks. Orloff et al. (1993) also report that differences in palm pad shape and vertical compression can be used as distinguishing features between fox species.

We failed to detect a strong relationship between distance from transects to active dens and the number of days until we first detected swift fox visitation. The distances which the transects were located from active dens did not significantly influence encounter rates, assuming that when a swift fox encountered a plate it left evidence of presence (track, photograph, scat).

We recommend that tracking plate transects 1 km in length (4 plates/transect) be used in late summer for a 6 day time period to maximize the probability of detecting the presence of adult swift fox. Late summer is also preferable because the likelihood of detecting a swift fox is increased due to the addition of independent young-of-the-year foxes. This time of year is normally dry in Wyoming, decreasing the chance of tracking plates being disturbed by rain. We do not recommend using scat surveys to detect swift fox presence in areas where they may be sympatric with red fox.

Litter Size - Average litter sizes for swift fox reported in the literature are fairly consistent at: 3.4 (Kahn and Beck 1996; n=8), 4.0 (Hillman and Sharps 1978; n=5), 3.6 (Fitzgerald et al. 1983; n=16), 1.6 (Fitzgerald and Roell 1995; n=9), and 3.4 (Rongstad et al. 1989; n=5). Bee et al. (1981) reported that swift fox litter size ranged from 3 to 6 and averaged 5. Sharps and Whitcher (1984) reported that a pair of reintroduced swift foxes raised a litter of eight pups in central South Dakota. The average litter size we observed (5.25/den) is larger than others reported in the literature. However, this is only a single year estimate, and litter size likely varies considerably from one year to the next.

Survivorship - Our survival rate of 43% over 1.5 years is similar to other survival rates reported for swift fox. Rongstad et al. (1989) reported annual adult survival to be 52% in southern Colorado, and Fitzgerald and Roell (1995) reported 47% (12 months) and 55% (5 months) survivorship on two study sites in northern Colorado. Sharps and Whitcher (1984) were able to confirm that 23% of reintroduced swift foxes were still alive after two years. Coyote predation may be the most important mortality factor for swift foxes (Roy 1996). Coyote predation was the cause of mortality in at least 25% of the swift fox deaths we recorded.

Distribution Surveys - Woolley et al. (1995) recorded 0.9 swift fox detections/100 tracking plate nights and 0.9 swift fox observations/100 miles of spotlighting. In Oklahoma, 3.7 swift fox detections/100 scent station nights were reported (Hoagland 1996). Mote (1996) reported 1.1 swift fox detections/100 plate nights and 1.3 swift fox observations/100 miles of spotlighting in Texas. We spotlighted 600 miles and completed 776 tracking plate nights without a swift fox detection.

We can not be certain that swift fox were not present in the areas we sampled. However, comparing swift fox detection rates of other researchers with our survey efforts, it appears that we should have detected swift foxes if they were present at similar densities found in other parts of the species range. If swift fox are present in northern and central Campbell county, the Bighorn Basin, and the Green River Basin, their densities are likely low.

We detected red fox and coyotes in all of the areas we sampled. Coyote predation on swift foxes has been well documented in Colorado (Kahn and Beck 1996), as well as on our study area, and in California, both red foxes and coyotes are known to be predators of kit foxes (Ralls and White 1995). Presence of these larger canids in the areas we sampled may be indicative of areas less suitable for swift foxes than the Medicine Bow study area, where we did document coyotes, but no red foxes.

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Table 1. Tracking plate transects detecting swift fox during late June (trial 1) and late August (trial 2) 1997, near Medicine Bow, WY.

Evidence of swift fox presence	Proportion (95% CI) Trial 1 (n=9)	Trial 2 (n=8)	Days[1] Trial 1	Trial 2
Photograph of marked fox and track	0.33 (0.12-0.65)	0.88 (0.52-0.99)	3	6
Photograph of marked fox with or without track	0.66 (0.35-0.88)	1.00 (0.66-0.99)	6	6
Track with or without photograph of marked fox	0.66 (0.35-0.88)	0.88 (0.52-0.99)	7	6
Track or scat[2]	0.77 (0.44-0.93)	0.88 (0.52-0.99)	7	6
Track, scat[2], or photograph of marked fox	1.00 (0.69-0.99)	1.00 (0.66-0.99)	7	6

1 number of transect days required to achieve maximum proportion

2 swift fox scat found near tracking plate stations

Table 2. Trial comparison of the average number of nights detecting swift fox on a transect (n = during each 7 night trial period (late June, late August 1997), near Medicine Bow, WY.

Evidence of swift fox presence	Mean Nights/Transect Trial 1	Trial 2	SE of Diff.	P value[1]
Tracks: Marked or unmarked foxes	2.3	4.0	0.861	0.046
Photographs: Marked Foxes	2.4	3.0	0.925	0.277
Photographs: Marked or Unmarked foxes	2.5	4.6	1.008	0.037

1 one-tailed

Table 3. Trial comparison of average number of stations on a transect (n=8) visited by swift fox each night during each 7 night trial period (late June, late August 1997), near Medicine Bow, WY.

Evidence of swift fox presence	Mean Stations/transect/night Trial 1	Trial 2	SE of Diff.	P value[1]
Tracks	0.68	1.34	0.277	0.034
Photographs: Marked Foxes	0.64	0.61	0.283	0.500
Photographs: Marked and Unmarked foxes	0.79	1.41	0.353	0.070

[1] one-tailed

Table 4. Relationship between the shortest distance from tracking plate transects to active dens, and the number of days until we first recorded evidence on a transect that a swift fox (marked or unmarked) had visited, for late June (trial 1) and late August 1997 (trial 2), near Medicine Bow, WY.

Trial	N	R^{2*}	P
1	9	0.27	0.08
2	8	0.05	0.28

* Adjusted R^2

Table 5. Survey effort in the 3 areas of Wyoming sampled during swift fox distribution surveys between 30 July and 22 August 1997.

Area	Miles spotlighted	Tracking plate nights[1]
Campbell County	237 (40%)	348 (45%)
Bighorn Basin	176 (29%)	252 (32%)
Green River Basin	187 (31%)	176 (23%)

[1] number of plate nights with undisturbed tracking medium

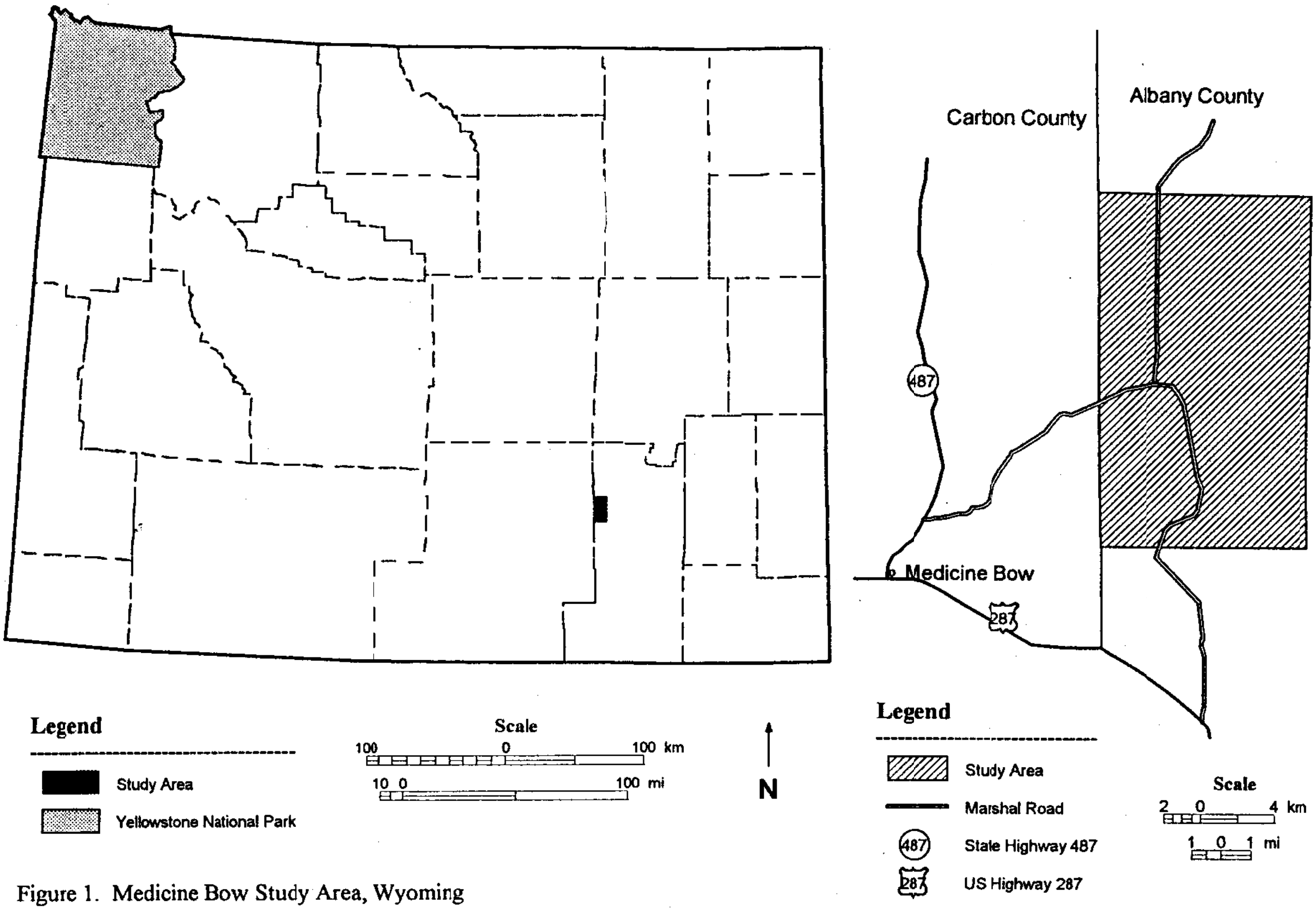


Figure 1. Medicine Bow Study Area, Wyoming

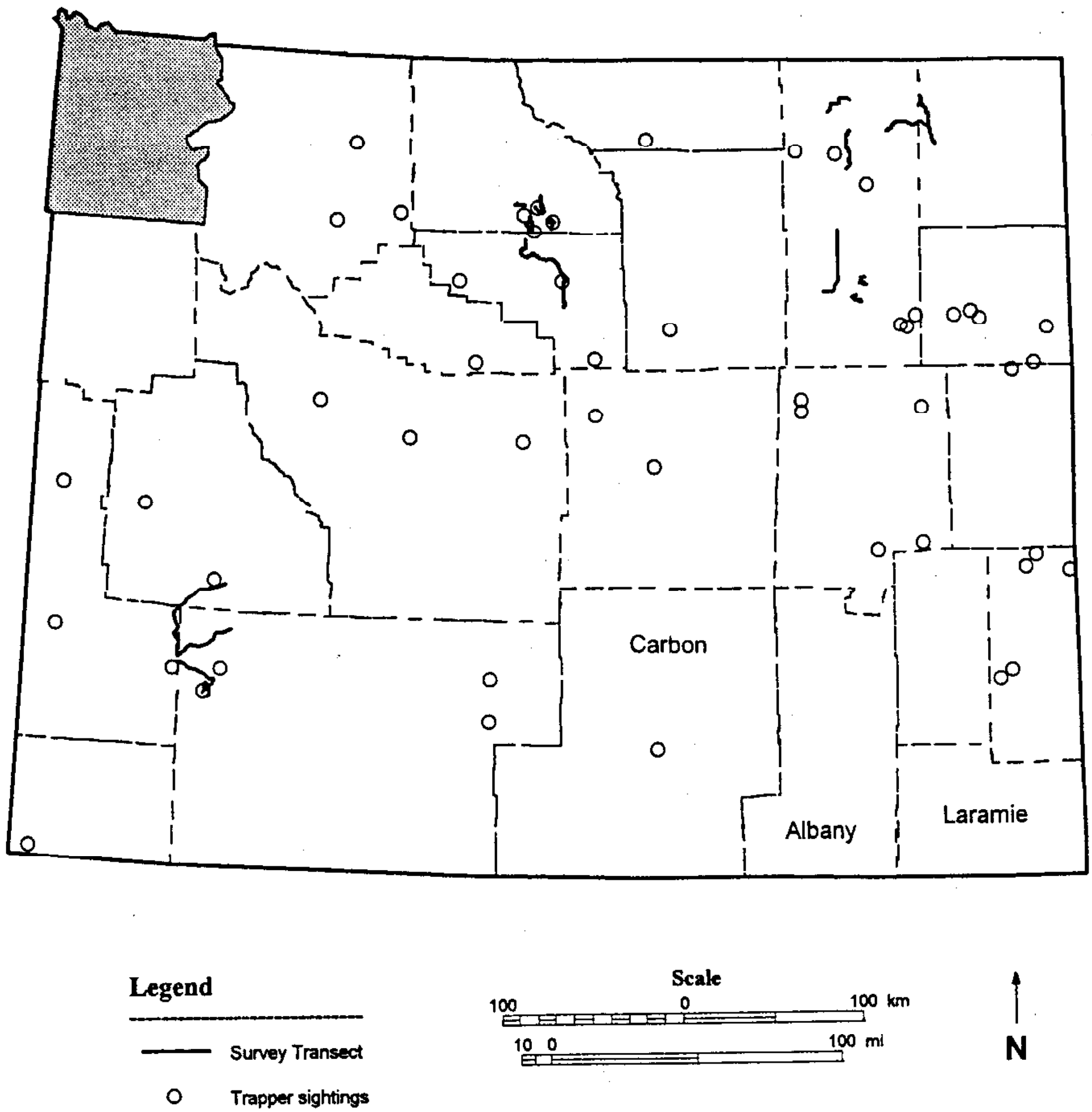


Figure 2. Trapper sightings of swift fox reported to the Wyoming Game and Fish Department, 1994-1997 (sightings in Laramie, Albany, and northeast Carbon county were numerous and are not shown), and survey transects sampled during swift fox distribution surveys 30 July - 22 August 1997.

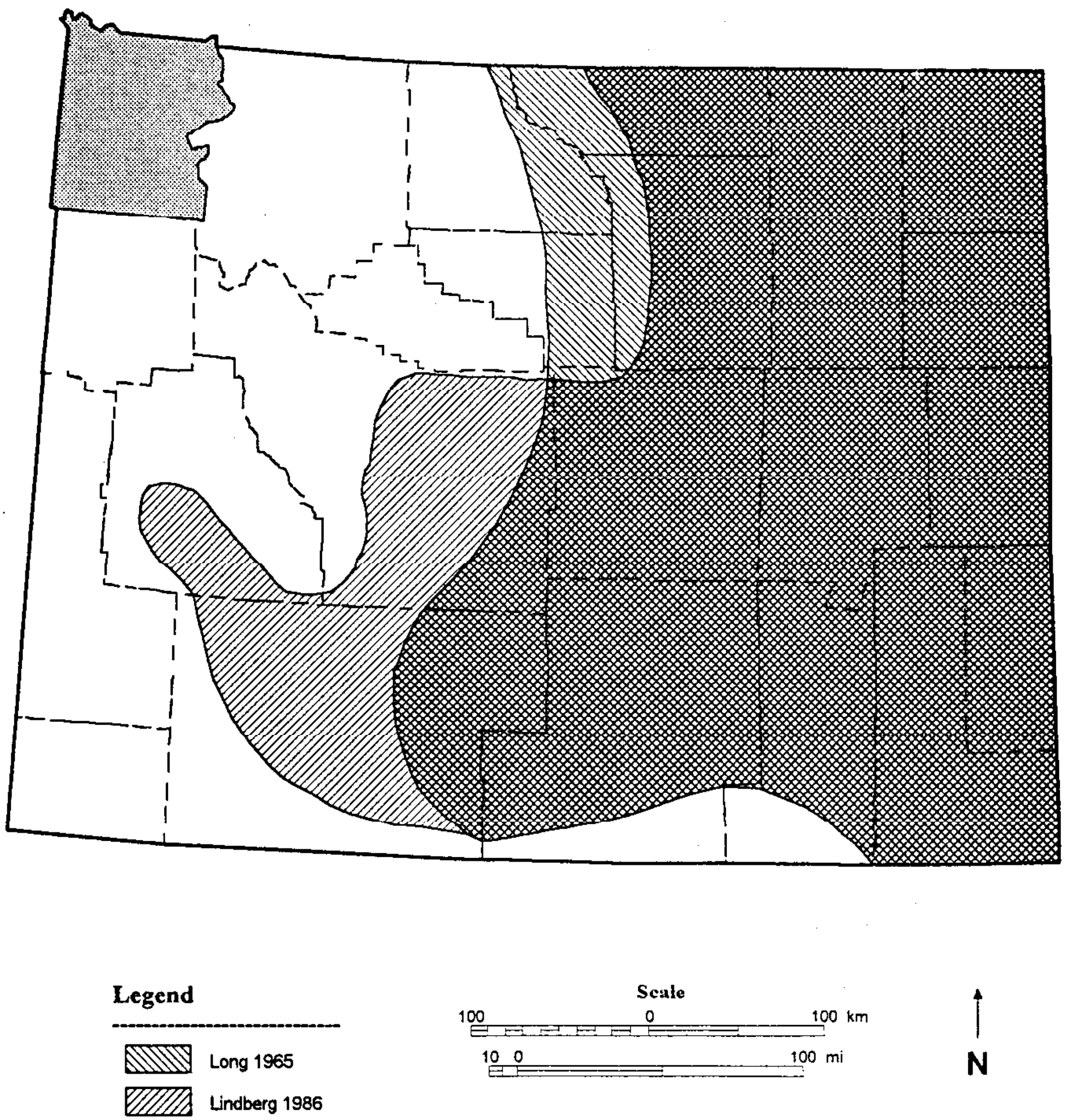
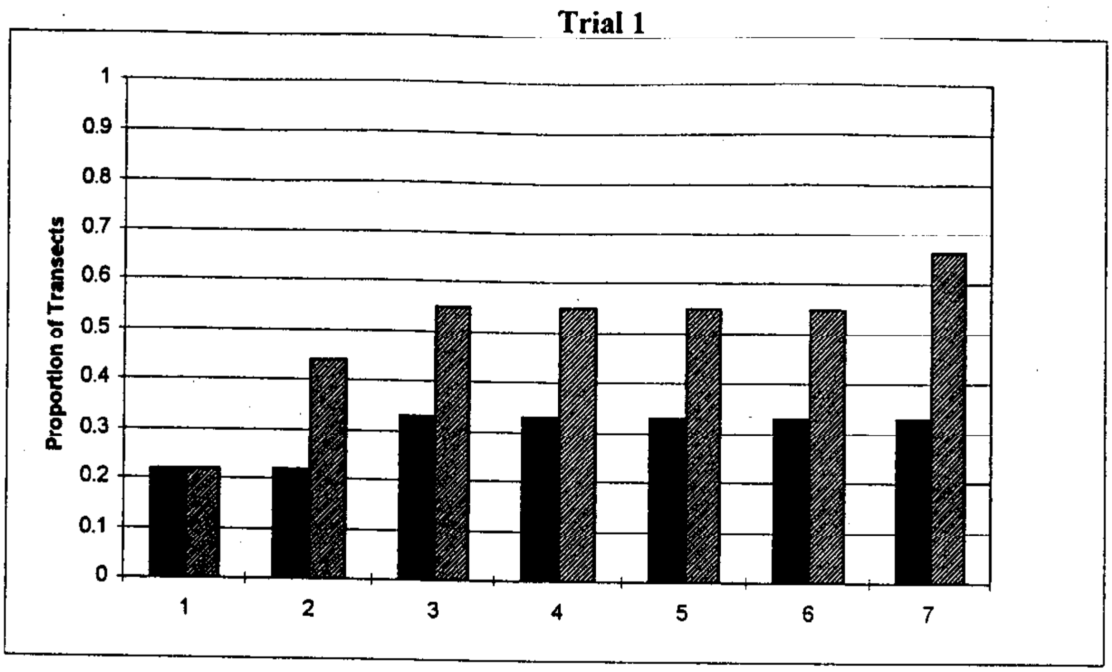


Figure 3. Historical swift fox distribution in Wyoming.



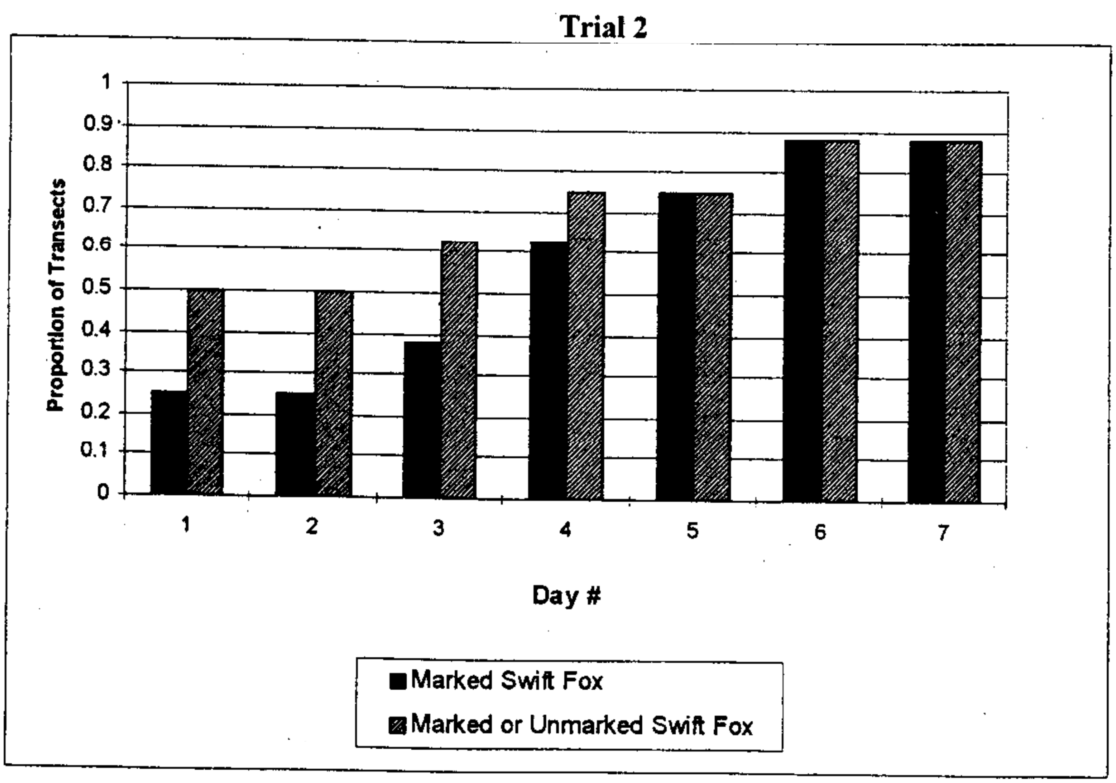
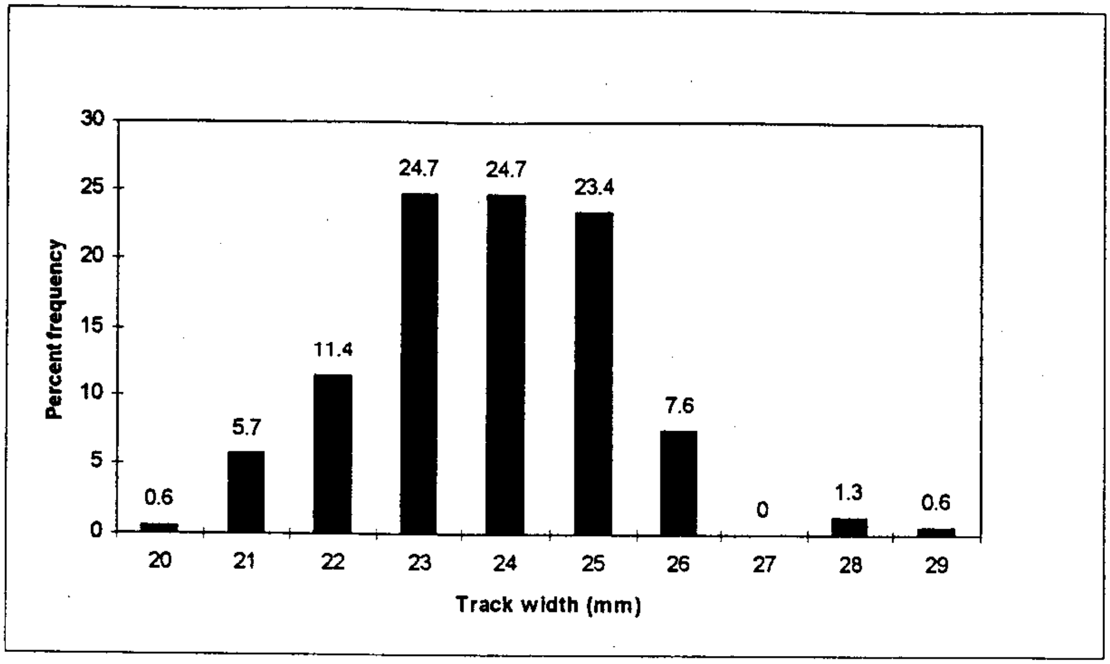


Figure 4. Cumulative proportion of tracking plate transects detecting swift fox over time during late June (trial1; n = 9) and late August (trial 2; n = 8)1997, near Medicine Bow, WY.



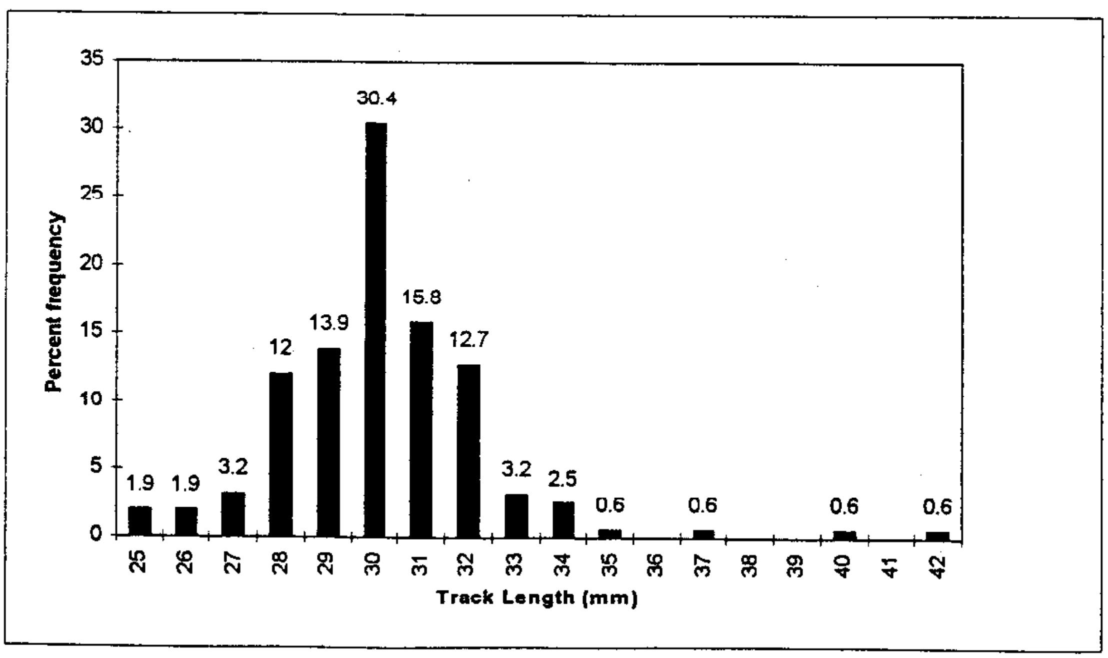


Figure 5. Percent frequency of swift fox track width and length, measured on tracking plates, near Medicine Bow, Wyoming 1997.

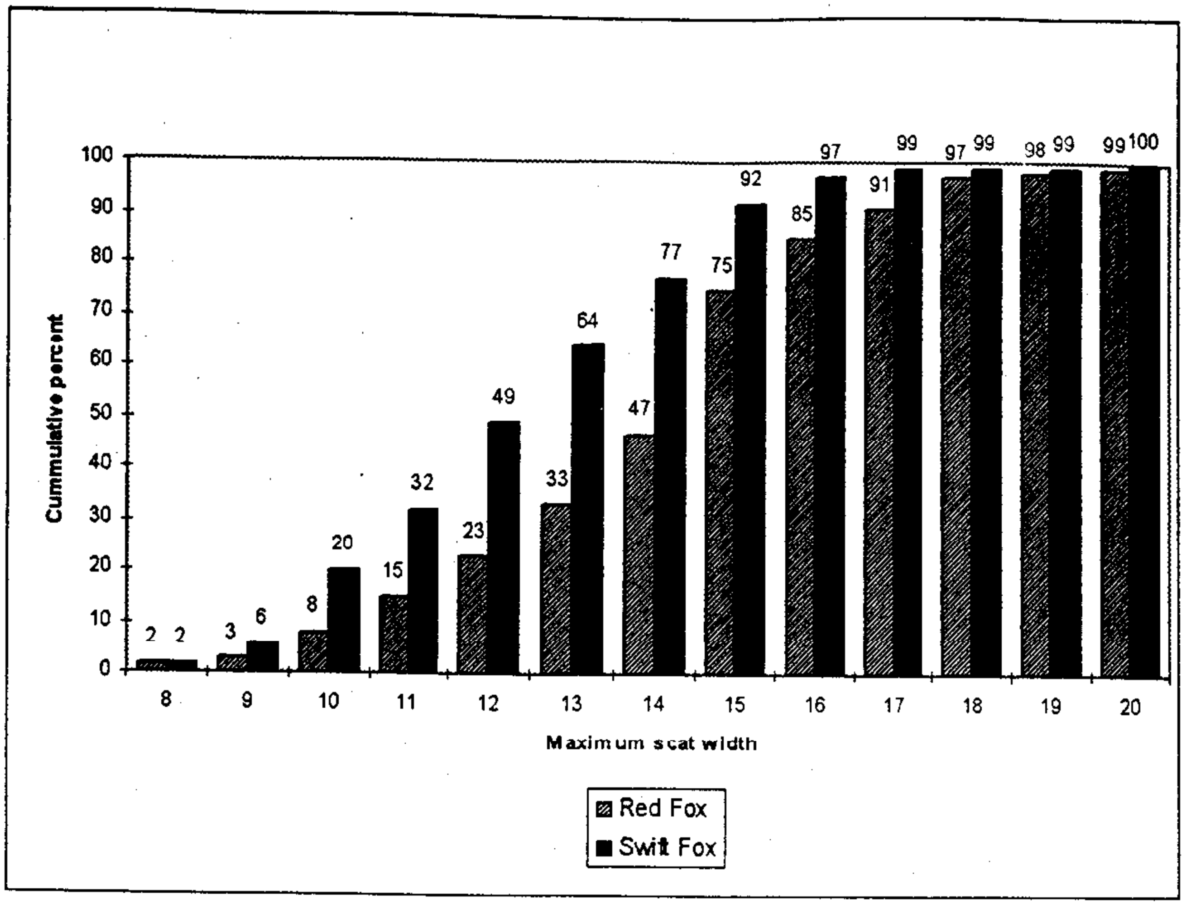


Figure 6. Cumulative percent frequency of maximum scat widths for red fox (Green and Flinders 1981) and swift fox, near Medicine Bow, Wyoming 1997.

SWIFT FOX INVESTIGATIONS IN NEBRASKA, 1997

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ABSTRACT

Swift fox (*Vuples velox*) history, classification and other information on swift fox in Nebraska can be found in previous annual reports (Andelt 1995, Andelt 1996) of the Swift Fox Conservation Team (SFCT).

Swift fox investigations in 1997 involved the routine compilation of swift fox sighting reports and completion of a contractual agreement between the Nebraska Game and Parks Commission (NGPC), US Forest Service (USFS) and USDA/APHIS-Wildlife Services (APHIS-WS) to live-trap swift fox and collect blood samples for genetic analysis. In 1997, blood samples from swift fox trapped in December 1996 were analyzed and additional trapping was conducted in another area of Sioux county.

INTRODUCTION

The swift fox was thought to be relatively common in the central and western parts of Nebraska before the state was settled, but disappeared between about 1900 and the early 1950s (Jones 1964). The species was listed as state endangered in Nebraska in 1972 and has remained protected by that listing since. An ecological study of swift fox was conducted from 1978 through 1980 (Hines 1980). Since then, a number of investigations have been conducted to determine the distribution and status of the species in the state. These have included aerial searches for swift fox dens, spotlight surveys, the distribution of questionnaires to landowners and solicitation of sighting reports. In addition, news releases have been prepared to encourage hunters to be sure of their targets when hunting coyotes, and signs have been installed along one particular stretch of highway, encouraging motorists to avoid collisions with swift fox. An informational brochure pertaining to swift fox in Nebraska was also prepared to increase public awareness of the species.

The SFCT produced a conservation assessment and conservation strategy for swift fox in the United States (Kahn et al. 1996) which identifies a need to investigate swift fox genetic variation among state populations. An application for research funding to conduct genetic investigations was submitted to the US Fish and Wildlife Service in 1995, but funding was denied. A cooperative agreement between the NGPC, USFS and APHIS-WS to live-trap swift fox and collect blood samples for genetic analysis was established in October 1996. Under the agreement, the USFS provided funding and APHIS-WS conducted the trapping. The NGPC coordinated the effort and analyzed the blood samples.

STUDY AREA AND METHODS

Trapping and blood collection was conducted by APHIS-WS personnel in western Sioux county during December 1996 and resumed in northern Sioux county in August 1997. Approximately 25 live traps were used for the capture operation. Traps were baited with mackerel and bacon while grouse or pheasant feathers were used as an attractant at some traps. Blood was drawn from captured animals from an artery in the front leg and was stored for later analysis. During 1997 blood samples from Nebraska, Kansas and Montana were analyzed at the NGPC central office at Lincoln.

Swift fox sighting reports are used to document distribution of the species in Nebraska. Information is acquired from observers and sightings are classified as confirmed, probable or unconfirmed by NGPC prsonnel.

RESULTS

Six different swift fox were caught in approximately 320 trap nights in western Sioux county during December 1996. No swift fox were caught in about 250 trap nights on the Oglala National Grasslands in northern Sioux county in August 1997.

Swift fox from Nebraska were not found to be genetically unique from animals in Montana or Kansas. More detailed results of blood analysis are available from NGPC in an unpublished document, upon request.

Although swift fox sighting reports were not actively solicited in 1997, several reports were received. Three reports of four animals were confirmed in Kimball county in the southern part of the panhandle. Two of the animals were found dead along a highway, but the other two were observed active at a den site.

DISCUSSION

Trapping efforts in western Sioux county were considered quite successful. Previous investigations have shown swift fox numbers in Nebraska to be very low. Although most trapping was conducted in an area not considered the prime area for swift fox in Nebraska, trapping success was very respectable. Lack of trapping success on the Oglala National Grasslands in northern Sioux county was not completely unexpected. Swift fox occurrence in this area has been quite sporadic.

Additional swift fox blood samples should be analyzed from other areas of Nebraska and from other states, especially in the northern portion of swift fox range to better understand genetic variation, if any, among state populations.

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SWIFT FOX INVESTIGATIONS IN COLORADO, 1997

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ABSTRACT

Work in 1997 on the intensive sites in Weld county is summarized. We discuss use of two trap modifications for capture of swift foxes in dens. Infrared-triggered cameras were used to estimate winter swift fox density using mark-resight methods and program NOREMARK. We estimated a mean fox population of 30 animals (18-52, 95% CI) based on the average of four camera sessions. Activity and movement patterns of foxes based on photographic data are discussed.

INTRODUCTION

We present a brief summary of our 1997 swift fox (*Vulpes velox*) studies on the intensive sites in northeastern Colorado including an evaluation of two different traps used at dens. We report on the effectiveness of infrared-triggered camera systems and mark-resight methodology for estimating populations of swift foxes. Estimation of swift fox populations is difficult as they forage at night and retreat to dens during daylight hours. This limits estimation methods to mark-resight techniques in conjunction with spotlight surveys (Dieni et al. 1996) or use of automated camera systems. Infrared-triggered cameras have been used in population estimation for white-tailed deer (*Odocoileus virginianus*) (Jacobsen et al. 1997), grizzly bear (*Ursus arctos*) and black bear (*U. americanus*) (Mace et al. 1994, Beck 1995). Mark-resight methods are reviewed by White (1996) and have been used on small to medium sized carnivores such as the coyote (*Canis latrans*) (Hein and Andelt 1995) and swift fox (Dieni et al. 1996).

STUDY AREA

The Weld county study sites were described in Kahn and Fitzgerald (1995) which includes the 96 km^2 Central Plains Experiment Range (CPER) and the adjacent Pawnee National Grassland (PNG). For camera trials we expanded the Pawnee National Grassland (PNG) site from 52 km^2 to 160 km^2. Almost all of the area was shortgrass prairie. A few sections were cultivated to dryland wheat. The area was moderately grazed by cattle from May to October. Cattle were absent during our camera trials.

METHODS

Methods followed those reported in previous years (Kahn and Fitzgerald 1995, Kahn et al. 1996). However, in 1996 and 1997 we field tested a multiple capture trap at pupping dens (cage trap), and a trap (tube trap) used with irrigation tubing (Advanced Drainage Systems, Inc.) at dens known to harbor foxes. The multiple capture trap consisted of a 149 cm x 76 cm cage constructed from 2.54 cm^2 welded wire mesh. It had a 51 x 51 cm hinged opening at the top for access. The bottom was closed with wire mesh except for a 30 x 30 cm opening in the middle. The 30 x 30 bottom opening received a 46 cm long section of 20.3 cm diameter flexible black plastic tubing that inserted into the primary den opening. Each side of the cage had an opening flush with the floor that led through a wire mesh adaptor to a 20 x 30 x 84 cm live trap.

The tube trap consisted of a live-trap coupled to a 33 x 28 cm adaptor made from 2.54 cm^2 wire mesh. The adaptor in turn coupled to a 1 m, 20.3 cm diameter piece of black tubing. A 20.3 x 15.2 cm plastic reducer allowed coupling of that piece to a 1.5 m tube of 15.2 cm diameter culvert. The 15.2 cm flexible culvert fits tightly into the opening of most swift fox dens.

For the camera trials we captured 18 swift foxes (10 females, 8 males) during November and December 1996 on the expanded PNG site. Individual foxes were radio-collared and marked in distinctive patterns by applying black fur dye (Nyanza A, Jamar Inc.) to their limbs and body. The antennae of radio collars were dipped in quick drying latex in different color combinations to assist in identification. Color bands on antennae showed in many photographs during field testing in 1996 and the latex dip did not seem to effect signal strength.

The recorder-camera system (Trailmaster, Inc.) consisted of a TM 1500 recorder coupled with a TM 35 camera kit. The cameras were Olympus AF-1 mini Quartz Date units. Two hundred ASA print film was used in all cameras. Recorder units were programmed so the infra-red beam had to be broken for 0.25 sec. to be recorded. All beam breaks were recorded by date and time. Cameras were also programmed to record data and time of day on each picture. Camera units were set to allow a series of 1-4 pictures to be taken consecutively. Each series of pictures from a beam break was considered to be a single picture or sighting. A lapse of 10 or more minutes between fox pictures was considered to be a new visit. Because cameras were used in cold weather we changed batteries in the recorders, cameras and transmitters after the second camera session.

The recorder and camera were housed in 28 x 18 x 15 cm metal 50 mm ammunition boxes. Each box had a 6 x 9 cm hole cut out of the bottom for the camera field. Two 3 cm diameter holes were drilled for passage of the infrared beam and the beam alignment light. The recorder box was mounted to the inside of the ammunition case with two machine screws while the camera was secured with a single large-thread tripod screw. The infrared transmitter was housed in a protective box made from 19 cm diameter plastic irrigation pipe.

We used 31 cameras spaced at 1.6 x 3.2 km (1 x 2 mi) intervals across the study site. Camera sessions were conducted Jan 2-7, 18-24, Jan 28-Feb 2, and Feb 9-13. Weather preventing access to cameras, resulted in some sessions being longer than others. The camera units were mounted between two, 1.5 m metal fence posts using cam-loc nylon webbing straps that could be tightened against two saw-edged brackets on the side of the ammunition box. Cameras were placed 70-80 cm above the ground. The infra-red transmitter boxes were placed about 1.5 m from the camera. Care was taken to orient cameras from direct sun to avoid bright light triggering the units. Attractant baits were placed between the camera and transmitter boxes and varied with each camera session. Baits included combinations of chicken and fish paste, mackerel, beef liver, cat food, beaver castor, rabbit urine, and fruit based pastes. At the end of each camera run the units were picked up and film was developed.

Photographs of radio-collared, dyed animals served as resights in a modified Lincoln-Peterson estimator run on program NOREMARK (White 1996). Assumptions were: 1) a closed population; 2) marked animals did not lose their marks; 3) marked animals were properly identified; and 4) marked and unmarked animals had an equal chance of being sighted.

RESULTS

In 1997 we captured 21 foxes on the two study areas. Field effort is winding down and we were primarily interested in maintaining contact with previously radio collared individuals. We captured and recollared 3 males and 2 females on the CPER and radio-collared 2 other males. We replaced collars on 1 male and 1 female on the PNG. Five males and 4 females on the CPER and 1 male and 2 females on the PNG were ear-tagged late in 1997. A minimum of 13 radio-collared animals (7 males and 6 females) were alive on the CPER in 1997 including 3 males and 2 females of our original 1994 cohort of fifteen males and 16 females. On the PNG we had 22 radio-collared animals (9 males, 13 females) alive in 1997 including 4 males and 1 female from our original cohort of 10 males and 9 females marked in March 1995. Six females (19 pups) on the CPER and 4 females (9 pups) on or near the PNG site were documented with pups in 1997.

Our trap modifications proved successful. Using the tube trap we captured 6 adults (5 recaptures and 1 new capture) in 6 trap nights. Three of them had not been recaptured for 487-527 days using conventional traps. The cage trap caught 8 pups and 1 adult in 7 nights use at 4 dens.

Three of the 18 marked, radio-collared foxes, 2 males and 1 female, were killed before the first camera session. Another male died during the trials. We obtained 790 photographs during the trials with 469 of them swift foxes (Table 1). Thirteen marked foxes were photographed 147 times during 93 visits. Males stayed longer at the bait stations resulting in more photographs of them but station visits by males and females were about equal. Nineteen (61%) of the camera units were visited by marked foxes (Table 2). Three of the marked foxes visited only a single camera station during the trials, 3 visited two camera stations, 3 visited three stations, 3 visited five stations, and 1 visited six stations. Fourty-one percent of station visits by marked and unmarked foxes were between 1800 and 2000 hours. Six marked foxes (3 males, 3 females) visited 2 or more camera stations a total of 12 times within a 24 hour period. One male and 1 female each visited 3 stations in one night in movements covering a minimum of 4-6 mi.

Twenty-eight of 31 cameras (90%) were visited 169 times by unmarked animals resulting in 322 pictures. The unmarked fox photographs included 49 pictures of foxes that had ear tags or radio-collars but no dye marks indicating capture earlier in the study. We had few pictures of animals other than swift fox. Raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*) and some heteromyid and sciurid rodents are typically inactive over much of this time period. In trials on the CPER in 1996 we obtained a number of photographs of those species. We also did not obtain photographs of cottontails (*Sylvilagus audubonii*) or jackrabbits (*Lepus spp.*) on the PNG while summer trials on the CPER resulted in several photographs of these species.

Estimates of the density of foxes on the PNG using NOREMARK were made for each camera sessions and averaged over the 4 sessions (Table 3). The mean estimated number of swift foxes was 30 with a 95% CI of 18-52. This is a winter population density of about 1 animal per 5.2 km^2.

Costs for completion of the field portion of the eastern plains inventory and intensive site work in Weld county in 1997 was about $38,000. This does not reflect costs of the infra-red camera units originally purchased by the Colorado Division of Wildlife for black bear research.

DISCUSSION

We continued to collect data on mortality, survival, reproduction, and habitat characteristics on the Weld county sites through 1997. Four University of Northern Colorado graduate students are writing theses on various aspects of swift fox biology: 1) Finley - eastern plains inventory; 2) Roell - population biology; 3) Gilin - habitat and den relationships; and 4) Eussen - food habits of kit (*V. macrotis*) and swift foxes. Roell and Finley made presentations at The Wildlife Society annual meeting in Snowmass, Colorado in September of 1997.

We believe the tube trap modification will prove useful to other researchers trying to recapture individual animals. Covell (1992) discussed problems of recapture of foxes and/or capture of pups at natal dens. We found the tube trap to be totally effective in recapturing animals for collar changes and for capture of individuals known to be in the den. There was no indication foxes were reluctant to enter the tubing. The manufacturer makes T adaptors that would allow placement of two traps using the tube system. We have not tried the T, but believe it would work. The tube trap is easier to assemble than the double-trap enclosure described by Covell (1992). We hope others will test it and report on its success.

We have not utilized the cage trap enough to evaluate its full potential. Covell (1992) modified the trap/enclosure described by Zoellick and Smith (1986). Our pup trap is similar to those approaches but the cage is easier to put up and stake and does not require a field technician to be present at all times. The main problem we have encountered is premature springing of traps. We think this is caused by foxes entering the cage and hitting the wire causing vibrations to trigger door drop on the live-traps. We are modifying the adaptor so the live-traps will not be in contact with the walls of the cage.

Our mean density estimate (30 individuals, 18-52, 95% CI) for a winter fox population is close to the spring estimate (28 individuals; 17-65, 95% CI) made by Dieni et al. (1996) on their Medicine Bow study site in Wyoming where they used 16 radio-collared foxes, spotlight surveys and NOREMARK. Covell (1992) estimated 1 animal per 2.5 mi^2 at the Pinyon Canyon site in southern Colorado but did not discuss how he arrived at that number.

Based on our work and that of Dieni et al. (1996) it appears camera or spotlight techniques using the mark-resight method are both suitable for swift fox population estimation. The camera units are costly and require considerable placement time. Colorado has used the camera systems on different inventory projects (black bear, wolverine (*Gulo gulo*), lynx (*Lynx canadensis*), swift fox) so cost has been low. Cameras provide voucher photographs of species visiting sites and expand knowledge on activity and movement patterns of marked animals. We had two problems using the systems on our study sites. In 1996 visitations by domestic cattle during the spring and summer months prevented effective use of the units. The winter survey eliminated that problem. We also had a relatively high number of "site" pictures when cameras triggered for unknown reasons. Spotlight surveys using resights of radio-collared animals are also man power intensive and costly with spotters having to endure long nights and perhaps loss of daytime productivity. Inventory biologists need to weight these factors in deciding on appropriate techniques for their particular needs.

Our photos of marked foxes suggest other workers may need to consider distances covered by individual foxes in their foraging when considering spacing for scent stations and/or scent station transect lines. The 1996 annual report of the swift fox conservation team (Luce and Lindzey 1996) shows considerable variation in distances between scent stations (Table 4). Camera data suggests that scent stations close together may be visited by the same fox a number of times in a short time span.

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Table 1. Numbers of photographs taken in 4 camera sessions, PNG, Jan.-Feb. 1997.

Photographs:	Number	% Total
Site pictures*	310	39
Dye-marked foxes (13 animals)	147	19
Radio-collared foxes (Old captures)**	49	6
Unmarked or undetermined foxes	273	35
Mice (Sp.)	5	<1
Domestic dogs	4	<1
Raccoon	1	<1
Striped Skunk	1	<1
Total photographs	790	100

* A site picture means the camera fired for an unknown reason.
** These are undyed animals captured earlier in the study. They count as unmarked in estimating population.

Table 2. Camera station visits by marked swift foxes, PNG, 1997.

Fox	Camera Units	#Visits	Maximum Distance Between Cameras (Mi)
M150.863	23	1	-
F151.602	22	1	-
F150.068	18	2	-
F150.961	5,6	2	2.0
F150.208	2,6	5	1.5
F151.004	8,11,15	5	3.0
F150.724	2,3,7	8	3.0
F151.365	15,18,21	8	3.0
F151.402	10,14	8	1.5
M151.049	16,17,19,20,23	9	3.0
M150.426	11,13,14,15,17,20	11	4.0
F150.564	16,17,19,20,23	16	3.0
M150.782	12,14,15,18,21	17	3.0

Table 3. Estimated fox population on the PNG using photographs of marked animals and program NOREMARK, 4 camera sessions, Jan.-Feb., 1997.

Session	Number Marked Photographed	Estimated Population	95% CI
1	3	29	14-58
2	9	42	27-64
3	7	25	15-42
4	11	25	16-42
Ave	7	30	18-52

Table 4. Scent station placement distance and distances between transects, various studies.

Minimum Distance Between Stations in Miles	Minimum Distance Between Transects	Authors
0.1	1.0	Dieni et al. 1996
3.0	NA	Lomolino Shaughnessy 1996
1.0	NR	Mote 1996
0.3	NR	Sovada and Roy 1996
0.25	NR	Dateo et al. 1996

SWIFT FOX (*VULPES VELOX*) MANAGEMENT AND RESEARCH IN KANSAS: 1997 ANNUAL REPORT

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ABSTRACT

We tested a new method for determining the distribution of swift foxes (*Vulpes velox*) in Kansas. From a sampling frame of 24 counties in western Kansas, we selected a systematic sample of alternate townships in a checkerboard pattern. During September and October 1997, experienced observers delineated suitable swift fox habitat within each sample township and searched it for evidence of occupancy (tracks, dens, and the animals themselves) by swift fox and other furbearers. Each township was searched for a minimum of 30 minutes, with searches continuing until swift foxes were either detected or for 120 minutes. Of 288 townships we selected for surveys, 271 (94.1%) were searched effectively. Adverse weather conditions prevented surveys in two northwestern counties of our sample frame. Swift foxes were detected in 40.5% of townships surveyed, including 16 counties. Swift fox tracks were not detected in Morton, Seward, Stevens, and Meade counties, where the species is thought to be uncommon or absent, nor in Haskell County, although an incidental observation by one of our trackers confirmed the presence of swift fox there. Factors that interfered with track identification were the principal impediments to our survey. Tracks were difficult to discern in areas with hard or sandy soils and were sometimes obliterated by adverse weather, vehicle traffic, and agricultural activities. Conducting surveys during periods of favorable weather, in the morning, and prior to the harvest of agricultural crops might have increased detection rates. To determine how frequently we failed to detect swift foxes that were present, we plan to repeat searches in 1998 in townships where swift foxes were not detected in 1997. Nevertheless, preliminary results suggest our method to be a practical means for conducting landscape-scale presence/absence surveys of swift fox. Restricting searches to habitat judged best for swift foxes and most favorable for track detection helped control costs and achieve high detection rates.

INTRODUCTION

In 1996, a preliminary study on the usefulness and precision of five survey methods to estimate the distribution and abundance of swift foxes was conducted (Sovada and Roy 1996). Survey methods evaluated included: 1) spotlight survey; 2) track search on both line transects and within quarter-sections (Sargeant *et al.* 1993); 3) scent-station survey (Linhart and Knowlton 1975); and 4) scat-deposition rate survey. Each survey tested successfully detected swift fox. However, rate of detection, time to run the survey, and cost expenditure varied greatly. Preliminary results suggested that furbearer track search of roads provided the most reliable and practical mean of detecting swift fox (Sovada and Roy 1996). Our objectives are to evaluate the effectiveness of a systematic track search on a large scale area and determine the distribution of swift fox throughout western Kansas.

METHODS

From a sampling frame of 24 counties in western Kansas, we selected a systematic sample of alternate townships in a checkerboard pattern. The use of townships as survey blocks, as opposed to predetermined transects, allowed us to restrict and adapt our search areas to habitat judged best for swift foxes and most favorable for track detection. Surveys were conducted during September and October 1997. This period coincides with the time when swift fox detection rates are the highest (Sovada and Roy 1996). Trackers were initially required to bid on the blocks they wished to cover and the overall costs of performing the surveys. We selected four individuals based on their experience at reading tracks and familiarity with the areas to survey. Three of the trackers were allocated 80 townships to survey. The southern most block, comprising 48 townships, was covered by one tracker. All trackers were required to attend a one day training session to familiarize themselves with the data recording requirements and to ensure proper identification skills of furbearer tracks.

Trackers were provided detailed county maps and a listing of the most appropriate roads to survey based on surrounding habitat. Emphasis was placed on searching secondary roads, low maintenance roads, section lines, and areas where tracks could be observed without requiring private land access. Public land in Kansas is scarce and having to request permission to access private properties would be unfeasible. Allen (1996) found no differences in furbearer track detection rates between searches on roads and within quarter sections, making searches along roads less time consuming and more efficient.

Townships were searched for a minimum of 30 minutes. For all furbearer tracks encountered, we identified the species, recorded the soil tracking conditions, habitat surveyed, and the time needed to find a track. If no evidence of swift fox occupancy was detected during the first 30 minutes, the search continued either until swift foxes were detected or for a maximum of 120 minutes. When a swift fox track or a den was identified, a photographic record was taken of one or several tracks with an indication of the track's length. If a dead fox was encountered (usually due to a vehicle accident), a photographic record was taken and a lower canine was extracted for future identification and aging. Trackers were also required to maintain a log of live or vehicle-killed swift fox locations observed outside the survey areas.

RESULTS

The use of a bidding system to enlist trackers was reasonably successful. Finding qualified individuals familiar with the area to survey and available during the survey period was, however, challenging. Twelve individuals responded to the bid process from which four were selected.

Bids ranged from $25.00 to $100.00 per township with an average final remuneration of $70 per township. Trackers drove an average of 23 miles per township and 250 miles per day and averaged 14 days to complete the surveys.

Only one individual performed poorly, and could not detect the presence of swift fox in several townships where previous surveys had indicated swift fox were present (Fox and Roy 1995, Sovada and Roy 1996, Sovada et al., in press). Half of this individual's townships were resurveyed by the two most experience trackers. Their results were used in the analysis. The tracker with the northern most townships could not complete all his surveys due to adverse weather conditions in late October.

Of 288 townships selected for surveys, 271 (94.1%) were searched effectively. Swift foxes were detected in 40.5% of townships surveyed, including 17 of the 23 counties selected (Fig. 1). No swift fox tracks could be detected in Haskell county, however, two vehicle killed swift foxes were observed as the tracker was moving from one survey area to the other. A Kansas Department of Wildlife and Parks (KDWP) employee also reported sighting a vehicle-killed swift fox in Stevens county where no tracks were detected by the tracker.

For each township where we successfully detected swift foxes, tracks were detected up to four times during the initial 30 min. search period. Detection rates ranged from 1 min. to a maximum of 102 min. Trackers invested less then 60 min. to detect swift fox tracks 91% of the time.

Swift fox tracks were detected next to rangeland habitats in 11.9% of the time compared with 45% in winter wheat, 26.6% in fallow wheat, and 12.8% in other crops. Swift fox tracks were observed along the edge of land enrolled in the Conservation Reserve Program (CRP) only 3.7% of the time. The type of habitat where other furbearer tracks were encountered had similar proportions. Furbearers detected included coyotes (*Canis latrans*), cottontails (*Sylvilagus floridanus*) or jackrabbits (*Lepus* sp.), skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*), raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), mink (*Mustela vison*), bobcats (*Lynx rufus*), and domestic dogs (*C. familiaris*) and cats (*Felis catus*).

DISCUSSION

Preliminary results suggest our method is a practical means for conducting landscape-scale presence/absence surveys of swift fox. We surveyed 26, 853 km^2 at a total cost of $9,700. When compared with previous surveys conducted by the KDWP, swift foxes were detected in seven additional counties (Sheridan, Lane, Stanton, Grant, Haskell, Rawlins, and Gray) (Roy 1996). With surveys conducted during the fall crop harvest period, we substantially affected our ability to detect furbearer tracks due to the increased road activity associated with harvest. Wind speed typically increased in the afternoon and affected our ability to find tracks. We would recommend conducting surveys in August or before the crop harvest season, and preferably during the morning. Longer daylight hours in August would also provide more time to search for tracks. To determine how frequently we failed to detect swift foxes that were present, we plan to repeat searches in 1998 in townships where swift foxes were not detected in 1997 and in additional peripheral areas. Restricting searches to habitat judged best for swift foxes and most favorable for track detection helped control costs and achieve high detection rates in most areas.

Swift fox tracks were encountered closer to cropland habitats then rangeland, however, large expenses of rangelands are not readily accessible to the trackers without private landowner authorization. The restriction of searches to roads may limit our ability to detect swift foxes in rangeland habitats. Past research has demonstrated that swift fox successfully utilize rangeland and cropland habitats and are not restricted to utilizing only shortgrass prairie habitats to survive (Kilgore 1969, Hines 1980, Fox and Roy 1995, Sovada and Roy 1996, Sovada et al., in press.).

Optimal time to invest in a township search may vary depending on swift fox population densities. We suggest a 60 min. search, at an 80-90% detection rate, as appropriate. By limiting our time to survey a township we can provide a greater coverage of swift fox range in relatively less time. Further survey efforts in areas with limited swift fox populations may provide different optimal search time and provide better insight on the variety of habitats utilized by swift foxes.

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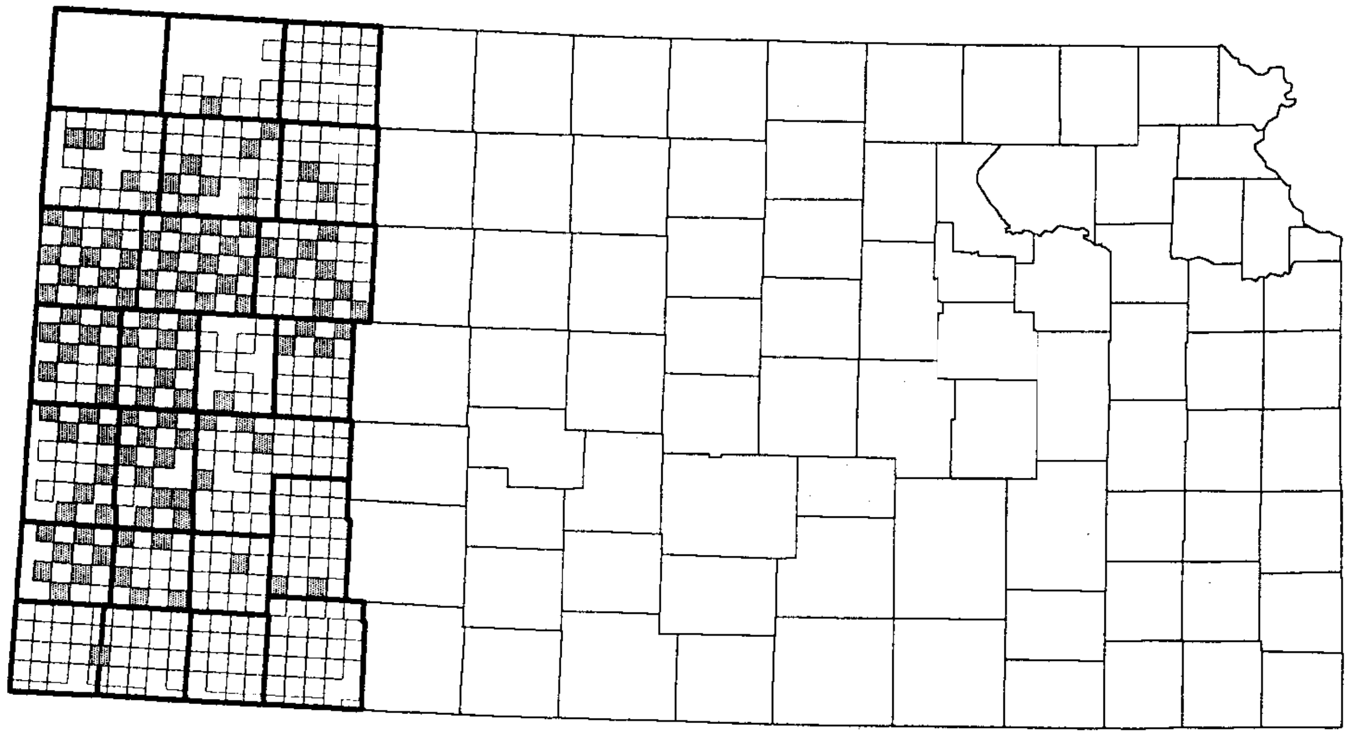

Figure 1. Location of swift fox tracks observed during the 1997 swiftf fox survey in western Kansas.

SWIFT FOX INVESTIGATIONS IN OKLAHOMA, 1997

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ABSTRACT

Swift fox (*Vulpes velox*) investigations in Oklahoma were limited to the third and final year of the Section 6 project investigating swift fox distribution in the Panhandle region of Oklahoma. The Oklahoma Department of Wildlife Conservation contracted this study to the Oklahoma Natural Heritage Inventory and provided $13,500 in Section 6 funds for activities during 1997. Only two sampling periods were conducted since the 1996 annual report (October 1996 and February 1997). In October 1996, new tracking stations were conducted in three additional counties in northwestern Oklahoma. One swift fox detection occurred in Harper County, outside of the Oklahoma Panhandle region. In February 1997, the original Panhandle tracking stations were surveyed with 10 swift fox detections occurring. The summer sampling period scheduled for 1997 was canceled because of a lack of funds.

INTRODUCTION

The swift fox is classified as a furbearer species in Oklahoma with a year-round closed taking season. The swift fox is also a species of special concern in Oklahoma. The swift fox has been documented to occur in the Panhandle region as well as in four counties in the northwestern corner of the body of the state. Historical range and distribution information for the swift fox in Oklahoma is provided in Hoagland (1995) and Hoagland (1996).

The Section 6 swift fox survey project, E-35, was initiated in September 1994 and completed in December 1997. The project was contracted by the Oklahoma Department of Wildlife Conservation (ODWC) to the Oklahoma Natural Heritage Inventory (ONHI) at the University of Oklahoma. The project investigators were Dr. Mark V. Lomolino and Michael J. Shaughnessy of the ONHI. During 1997 the Section 6 project E-35 continued to document the current distribution of swift fox within selected portions of Oklahoma.

Also during 1997, a proposal was submitted for additional Section 6 funds to conduct a population distribution of swift fox in northwestern Oklahoma using a track search survey. Implementation of a track survey in northwestern Oklahoma would allow swift fox populations, as well as other furbearer populations, to be adequately monitored in the same region. Being able to monitor the population trends of all furbearer species in the region is essential to understanding the various predatory mammal community components that may affect the population trend of the swift fox and other potentially vulnerable species. The objectives of the proposed Section 6 survey, to begin September 1998, are to: 1) establish a track search survey to monitor population trends of swift foxes throughout the shortgrass prairie ecosystem in Oklahoma; and 2) develop a baseline database of swift fox distribution and abundance in northwestern Oklahoma.

METHODS

In the final year of Section 6 Project E-35, baited, stainless steel, chalked tracking plates were used to detect swift fox presence at 42 new tracking stations in Harper, Ellis and Woodward counties in northwestern Oklahoma during October 1996; and at the permanent 90 tracking stations in Cimarron, Texas and Beaver counties in the Oklahoma Panhandle during February 1997.

For the proposed Section 6 project, two qualified contracted wildlife technicians, along with ODWC wildlife biologists, experienced in reading furbearer tracks, will be employed to conduct the track search surveys. Half of all townships in the seven counties to be surveyed will be sampled in a systematic sampling scheme. This will provide data that may allow the development of a probability model for non-surveyed townships. Thus, allowing a prediction of the presence of swift fox in a county with a degree of likelihood. Because this project will provide the base for a long term swift fox population monitoring survey, surveys sites will be carefully selected. The same sites will be used every year unless major changes occur at survey sites that may bias the survey, in which case new survey sites will be selected. The location of track survey sites within townships will be determined, based on areas with the highest probability of finding tracks if swift foxes are present.

Survey sites, therefore will be selected based on the best available substrate for tracks, lack of human disturbance (farmhouses, towns, etc), and intensity of traffic. Surveys will be conducted with a search time per township of 2 hours maximum. Once a swift fox track is found, the time of search will be recorded and the searcher will move on to the next township. All track surveys will be conducted during the month of September. A total of seven counties (Cimarron, Texas, Beaver, Harper, Woodward, Ellis, and Roger Mills) will be surveyed for a total of 152 survey sites. By surveying Cimarron, Texas and Beaver counties, where the presence of swift fox has been documented, it will be possible to determine the probability of detecting swift foxes when they are present. Survey sites will be block sampled, (i.e. conducted from the northwest corner of the Panhandle in Cimarron and Harper counties outward in all directions). The time and days when the surveys will be run will be affected by current weather. At least two dry days will be required before surveys can be performed following a rainstorm. Information on den site locations encountered during the surveys or received from area residents having swift fox on their lands will also be recorded.

RESULTS

Under Section 6 project E-35, one swift fox detection occurred in Harper County out of 126 functional plate nights surveyed in Harper, Ellis and Woodward counties. Ten swift fox detections (nine in Cimarron County and one in Beaver County) were detected over 258 functional plate nights conducted in the Panhandle during February 1997. Although, $13,500 was granted to ONHI from ODWC for this project during 1997, the summer sampling period for 1997 was canceled because of a lack of funds.

Initial track search surveys will supplement information on the distribution of swift fox in

Oklahoma. By conducting field survey and monitoring of all furbearer species within the swift fox's range, new information will be gained on the types of habitats commonly used by these furbearers and the factors that may affect population growth of swift fox. Results will be used make sound management decisions, promote and protect crucial habitats or reduce the threats limiting swift fox population expansion into suitable habitats.

Section 6 project E-35 contributed toward reaching the objective of documenting the current distribution of swift fox in Oklahoma by recording swift fox presence/absence and relative abundance, within the Panhandle and three northwestern counties of the state. Funding for the project E-35 was provided for by Section 6 funds. The ODWC provided $12,000 for the first year of the Section 6 project; $13,000 for the second year; and $13,500 for the third year.

DISCUSSION

The current knowledge of swift fox presence/absence and relative abundance has increased from information collected through Section 6 project E-35. Tracking plate stations added in counties adjacent to the panhandle further aided in determining presence/absence outside of the panhandle region of Oklahoma. Section 6 project E-35 ended in December 1997. Section 6 funds have been requested for additional swift fox investigations to begin in September of 1998.

The prioritized research needs for Oklahoma beyond 1998 include: 1) to continue a periodic monitoring program for existing swift fox populations; 2) to identify and delineate existing suitable swift fox habitat within Oklahoma based on developed criteria, and using this information to evaluate the potential for swift fox population expansion and stability within Oklahoma; and 3) to identify and delineate private land ownership patterns in occupied and suitable swift fox habitat, so that habitat conservation and habitat management can be promoted on private land in areas of occupied and suitable swift fox habitat.

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SWIFT FOX INVESTIGATIONS IN NEW MEXICO, 1997

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ABSTRACT

Swift fox (*Vulpes velox*) historically occurred in eastern New Mexico, but the current population status of swift fox in New Mexico is not known. We surveyed the presence of swift fox within their historic range in New Mexico with scent-stations and spotlighting from October 1996 through May 1997. We also collected specimens and examined New Mexico Department of Game and Fish and USDA Wildlife Services records. Swift fox presently occur throughout their historic range. However, we did not find swift fox in the cropland areas of Curry or eastern Roosevelt Counties and southeastern Quay County where grass was taller and shrubs were more abundant than in the rest of the study area. Swift fox in New Mexico prefer *Bouteloua* rangeland with low shrub density and grass length less than 30 cm. Rodent densities are depressed in areas with swift foxes. Roadway type and number of fences and powerlines are not important factors to swift fox distribution. Trends in agricultural development, state furbearer harvest, and incidental capture by USDA Wildlife Services are discussed.

INTRODUCTION

The swift fox (*Vulpes velox*) historically occurred in the shortgrass prairie of eastern New Mexico (Egoscue 1979) and is presently a Category 1 candidate for endangered species listing by the US Fish and Wildlife Service (Federal Register 1995). Candidate listing of the swift fox has highlighted the general lack of current knowledge of swift fox biology. The population status, distribution, and general ecology of swift fox in New Mexico have never been systematically studied. Previously collected swift fox specimens (Table 1, Fig. 1; Schmitt 1996) have indicated the presence of swift fox throughout eastern New Mexico, although no specimens were collected from large areas of potential habitat (Findley et al. 1975, Hubbard 1994). Prior to this study, the last collection of a museum specimen was in 1982 (Hubbard 1994). Unpublished New Mexico Department of Game and Fish (NMDGF) furbearer harvest records from 1976 to 1991 indicate the presence of swift fox in all counties within the species historic range.

As a first step toward determining the current status of swift fox within areas of historic occurrence in New Mexico, we examined the current distribution and habitat selection of swift fox using scent-station and spotlight surveys. We also collected specimens and examined NMDGF furbearer harvest records and the US Department of Agriculture

Animal and Plant Health Inspection Service, Wildlife Services (APHIS-WS) animal control records.

STUDY AREA

Shortgrass prairie (described as plains-mesa grassland by Dick-Peddie 1993) and cropland habitats east of the Pecos River constitute the historic range of the swift fox in New Mexico (Egoscue 1979)(Fig.1). Topography is typically flat with rolling hills. Land use is primarily rangeland, with cropland and Conservation Reserve Program (CRP) land dominating areas adjacent to the Texas border. Cultivated crops within the study area consist primarily of winter wheat (*Triticum*) and sorghum (*Sorghum*).

MATERIALS AND METHODS

Scent-station and spotlight surveys were conducted from October 1996 through May 1997. We created scent-stations (Linhart and Knowlton 1975, Conner et al. 1983) by clearing vegetation from 0.7 x 0.7 m areas, placing a plaster of paris tablet (Pocatello Supply Depot, USDA, Pocatello, Idaho) soaked in a mixture of mackerel and cod liver oil (Trailing Scent, On Target ADC, Dekalb, Illinois) in the center of each of the cleared areas, and sifting a 1:32 mixture of mineral oil and dried plaster sand over the areas and tablets. We secured tablets to the ground with nails inserted through previously drilled holes to prevent removal by rodents. We covered tablets with a thin layer of sand to prevent removal by common ravens (*Corvus corax*). Scent stations were placed in transects of 10 stations, with stations separated by 1.6 km. Transects were located along public roadways and were separated by at least 8 km, which represents the diameter of the maximum reported home range size of swift fox (Hines and Case 1991)..

Stations were examined on the day following placement of scent sets. We classified species visiting scent-stations by track identification (Muric 1974, Halfpenny 1986). Swift fox tracks may be easily distinguished from those of gray foxes (*Urocyon cinereoargenteus*), other canids, and domestic cats (*Felis catus*) (Orloff et al. 1993), but not from those of kit foxes (*V. macrotis*). If no swift fox tracks were found on a transect after the first night, all the stations within the transect were reset with a new tablet and additional sand and then observed after a second night. Visits by swift foxes to more than one station within a single transect were considered as one observation.

We visually searched for swift foxes while driving along public roadways at night using one million candlepower spotlights. We conducted spotlight surveys for 3-4 hours per night, beginning at dusk. If a swift fox was seen within 8 km of a scent-station where swift fox tracks had been recorded, we treated the two sampling occurrences as a single observation.

At each scent-station we recorded the land use (rangeland, cropland, or CRP), genera of grasses and shrubs, road type (paved or unpaved), and number of fences and powerlines. We also estimated the average grass length within four categories (<15 cm, 15-30 cm, 30-45 cm, and >45 cm) and average nearest neighbor distance between shrubs. If no shrubs were present, we assigned a value of 500 m to the average nearest neighbor distance.

We collected swift fox specimens from APHIS-WS, private trappers, and road-killed animals during the study period. Specimens will be deposited at the Museum of Southwestern Biology, University of New Mexico.

We examined the effect of grass length, grass and shrub genera, roadway type, and number of fences and powerlines on swift fox visitation with log-likelihood ratio goodness of fit (*G*) tests (Zar 1984), using data from all stations to calculate expected visitation rates. We compared means of the number of stations per transect visited by rodents and means of average nearest neighbor distance between shrubs per transect between transects visited by swift foxes and transects that were not visited by swift foxes with *t* tests (Zar 1984).

RESULTS

We recorded visits by swift foxes at 39 stations on 22 of 80 transects and observed nine swift fox by spotlighting, achieving a total of 27 independent observations within 10 of the 12 counties surveyed (Table 1, Fig. 1). We found no swift foxes in Chaves or Curry counties. Area of swift fox habitat within counties estimated from Dick-Peddie (1993) correlated well with the number of transects (Pearson $r = 0.770$, $P = 0.009$) and kilometers of spotlighting (Pearson $r = 0.708$, $P = 0.022$).

Collected specimens and NMDGF and APHIS-WS harvest records indicate the recent presence of swift fox in all counties within their historic range except San Miguel. These records list the locations of animals killed by county only and indicate swift or kit fox were taken in Chaves, De Baca, and Guadalupe Counties, although it is not known whether the foxes were taken east or west of the Pecos River. Swift fox taken by APHIS-WS in Quay county were trapped in the northeastern section of the county.

Habitat data were available from 670 scent-stations. Swift fox were located only in rangeland, and not in cropland or CRP land (Table 2). Swift fox visited stations in areas of <15 cm and 15-30 cm grass length more than expected and visited stations in areas of grass length 30-45 cm or >45 cm less than expected (Table 2). Swift fox visited stations in areas of *Bouteloua* more than stations in areas of *Andropogon* or *Aristida* and visited stations in areas without shrubs more than stations in areas with shrubs (Table 2). Roadway surface and number of fences and powerlines did not produce significant differences in visitation rates by swift fox (Table 2).

The average number of scent-stations visited by rodents was less on transects that were visited by foxes ($\bar{x}$ = 2.7 stations, *SE* = 0.16) than on transects not visited by foxes (x = 6.4 stations, *SE* = 0.05, t = 5.130, df = 65, $P < 0.001$). The average nearest neighbor distance between shrubs was marginally greater on transects visited by foxes ($\bar{x}$ = 261.9 m, *SE* = 9.90) than on transects not visited by foxes ($\bar{x}$ = 165.0 m, *SE* = 3.85, t = -1.924, df = 65, P = 0.059).

No evidence of swift fox were found in southeastern Quay county. In this portion of the county, taller grass and shrubs, *Andropogon* and *Aristida*, were more abundant than in the rest of the study area. Rodents were also more abundant in southeastern Quay county ($\bar{x}$ = 7.6 stations/transect visited by rodents, *SE* = 0.17, n = 9 transects) than in the rest of the study area ($\bar{x}$ = 5.0, *SE* = 0.05, n = 58, t = -2.40, df = 65, P = 0.019). The average nearest neighbor distance between shrubs was less in southeastern Quay county ($\bar{x}$ = 39.6 m, *SE* = 10.90) than in the rest of the study area ($\bar{x}$ = 216.2 m, *SE* = 3.27, t = 2.723, df = 65, P = 0.008).

DISCUSSION

On a statewide scale, swift foxes presently occur throughout their historic range in New Mexico, although significant gaps in Curry, Quay, and Roosevelt counties may exist (Fig. 1). Swift fox in New Mexico prefer *Bouteloua* rangeland free of shrubs with grass length less than 30 cm. Rodent densities are depressed in areas with swift foxes. Roadway type and number of fences and powerlines are not important factors to swift fox distribution.

We did not find evidence of swift fox in the cropland areas of eastern Curry or Roosevelt counties, despite extra sampling efforts (Fig. 1). Museum specimens from these areas were collected in 1957 and 1968 (Hubbard 1994). Recent NMDGF and APHIS-WS records indicate swift fox in Curry and Roosevelt counties, but do not specify locations. Whether swift fox populations in these areas have been reduced by agricultural development is not known. Swift fox did occur historically in cropland in Texas and Oklahoma (Cutter 1958, Kilgore 1969) and are currently present in cropland in Kansas (C. Roy, pers. comm.).

We found no evidence of swift foxes in Chaves county. However, only a small portion of Chaves county enters historic swift fox range, and we set only one transect there. No evidence indicating the presence of swift fox has been reported for central Quay county which contains extensive cropland or southeastern Quay county which is primarily rangeland consisting of taller grasses and more shrubs than the rest of the study area. Availability of suitable den sites may limit swift fox distribution (Egoscue 1979), but soils in southeastern Quay county do not appear to be obviously different from soils in other areas where swift foxes were found (Maker et al. 1974).

The security of the swift fox population in New Mexico remains unknown. Swift fox are presently widespread in New Mexico, but no population or demographic estimates are available. The stability and viability of the swift fox population in New Mexico remains to be examined. Factors potentially threatening the swift fox include habitat loss, fur harvesting, and incidental mortality by APHIS-WS. Total cropland and CRP lands increased by an annual average of 0.26% in counties not overlapping kit fox range from 1970 to 1995 (Anon. 1970-1995). As of 1995, approximately 15% of potential swift fox habitat had been lost to cropland and CRP land in counties not overlapping kit fox range. Significant habitat loss is unlikely in the near future, as funds for enrolling new land in to the CRP program has decreased and existing CRP lands would be placed into production before new areas are developed (R. Lansford, New Mexico State University, pers. comm.).

Total sport and commercial fur harvest of swift fox in counties not overlapping kit fox range peaked at 271 in 1985, decreasing to an annual average of four from 1990 to 1995 (NMDGF unpubl. records). Although fur prices are currently low, advertising of fur garments has increased in recent years (pers. observ.), indicating that fur harvests may increase in the future. The annual total number of swift fox removed by APHIS-WS averaged 20 from 1991 to 1997, in counties not overlapping kit fox range (APHIS-WS, unpubl. records). APHIS-WS trapping efforts are largely determined by the number of coyotes (*Canis latrans*), which is unlikely to change significantly in the near future, given the relative stability of habitat and land use in eastern New Mexico.

Other factors which are more difficult to assess may also affect the future of the swift fox population in New Mexico, such as predation by coyotes, competition with red fox (*V. vulpes*) or an increase of shrubs in response to global warming or poor land management. Much further research is needed to predict the outlook for swift foxes in New Mexico.

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Table 1. Evidence of swift fox within their historic range in New Mexico. Scent-station and spotlight surveys were conducted from October, 1996, to May, 1997. Total survey observations = no. scent-station visits and spotlight observations separated by at least eight km. Specimens were collected from 1996 - 1997. New Mexico Department of Game and Fish (NMDGF) fur harvest records and USDA Wildlife Services (ADC) records indicate no. animals reported killed from 1991-1996 and 1991-1997, respectively.

County	Number of transects	Swift fox visits to transects	Kilometers spotlighting	Swift foxes spotlighted	Total Survey Observations	Specimens Collected	NMDGF fur harvest records	ADC records
Chaves	1		73		0			
Colfax	7	3	605	1	4		1	
Curry	9		504		0		3	
De Baca	2	1	87		1			
Guadalupe	4	1	304	1	1			
Harding	6	1	429		1	6		15
Lea	3	2	232	3	4	11		98
Mora	5	1	353	1	1		1	
Quay	15	1	869		1	5		3
Roosevelt	11	1	533	1	2	1	15	2
San Miguel	2	2	205		2			
Union	15	9	747	2	10	4		1
TOTAL	80	22	4941	9	27	27	20	119

Table 2. Habitat characteristics of scent stations placed within the historic range of swift foxes in New Mexico from January to May, 1997. Categories with less than five stations were combined for analysis. G = log-likelihood ratio. * $P < 0.05$.

	Percent of all stations ($n = 670$)	Percent of stations visited by foxes ($n = 35$)	G	df	P
Land management:					
rangeland	87.2 %	100.0 %			
cropland	8.4	0.0			
C.R.P.	4.4	0.0			
Average grass length:					
< 15 cm	29.0	34.3	10.689	2	0.005*
15 - 30 cm	29.1	42.9			
30 - 45 cm	31.2	22.8			
> 45 cm	10.7	0.0			
Grass genera present:					
Bouteloua	72.5	94.3	15.763	2	<0.001*
Andropogon	24.6	11.4			
Aristida	11.9	11.4			
Sporobolus	5.1	0.0			
Eragrostis	5.1	0.0			
Triticum	4.5	0.0			
Shrub genera present:					
Yucca	48.5	25.7	11.070	2	0.004*
No shrubs	36.4	60.0			
Opuntia	15.5	14.3			
Prosopis	15.7	2.9			
Roadway type:					
gravel	60.4	65.7	0.222	1	0.665
paved	39.6	34.3			
Number of fences:					
2	62.5	60.0	1.352	2	0.511
1	18.5	25.7			
0	19.0	14.3			
Number of powerlines:					
2	3.4	5.7	0.662	2	0.723
1	46.0	48.6			
0	50.6	45.7			

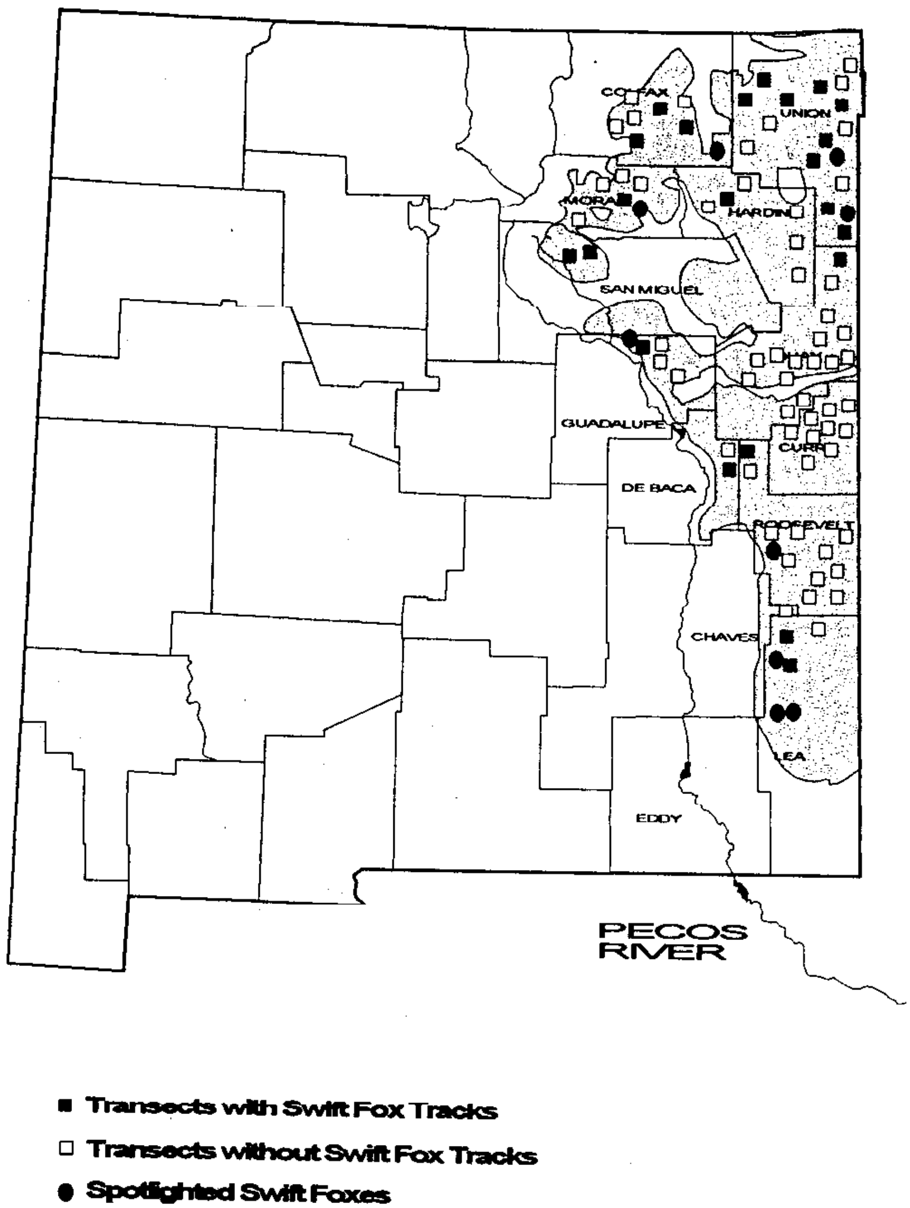

Figure 1. Locations of scent-stations and spotlighted swift foxes from October 1996 through May 1997 in New Mexico. Shaded areas represent short grass prairie east of the Pecos River and approximate range of the swift fox in New Mexico.

SWIFT FOX INVESTIGATIONS IN TEXAS, 1997

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ABSTRACT

During 1997 our efforts were focused upon monitoring populations of swift fox (*Vulpes velox*) at the two known areas in Sherman and Dallam counties and to begin investigating reported sightings on private property. Monitoring efforts in Dallam county included a total of 58 miles of spotlight route and 24 trap nights for a two night period resulting in 6 swift observations and no captures. Sherman county produced 8 swift sightings and 5 captures as a result of 28 miles of spotlight route and 20 trap nights for a two night period. Reports of recent swift sightings were investigated on five large ranches in five different counties. However, limited manpower permitted only two ranches to be surveyed, resulting in no conclusive information supporting the presence of swift fox.

INTRODUCTION

The historic range of swift fox in Texas is provided in the 1995 swift fox conservation team (SFCT) annual report (Horner 1995). Current known distribution data are unchanged from the 1996 SFCT annual report (Mote 1996). In 1996 a systematic search was conducted of 25 counties within the historic species range to determine the current distribution of swift fox in Texas. During this study no population density information was collected, only presence/absence data. Therefore, in 1997, a program was established to monitor population trends at the two locations where swift fox were located in 1995.

In addition to annually monitoring of known populations, the Texas Parks and Wildlife Department (TPWD) continues to investigate areas on private property where the best swift fox habitat exists, where recent sightings have been reported, and where landowner permission can be gained. TPWD biologists will continue to focus efforts on private land in the future.

METHODS

Monitoring efforts were conducted at two locations where swift fox were located in 1996. During March of 1996, 20 scent stations were established at the Dallam county site using sand and oil. This method was abandoned due to the destruction of 70% of the stations by wind and tumbleweeds. Similar results have been obtained using track plates and chalk in Texas. During the month of October, surveys were conducted in Dallam county on the Rita Blanca National Grassland, a 29 mile spotlight route was established as well as 12 trap locations. A spotlight route of 14 miles and 10 trap locations were established at the monitoring site in Sherman county during September. The Sherman county site is located on a 9,000 acre private ranch. Surveys were conducted for two consecutive nights and will be replicated annually.

Reported swift fox sightings were investigated on five ranches in as many counties during 1997. Initial contact was made by telephone to obtain more information, then preliminary site visits were made to three of the five ranches. Actual field surveys were conducted on two private ranches in Randall and Gray counties. These surveys entailed live-trapping, spotlighting, and track searches around water holes, cow trails, and ranch roads.

RESULTS

An attempt was made to conduct surveys in Dallam county during March. This attempt was abandoned after the first night due to high winds. During this first attempt, 70% of the scent stations were destroyed by wind blown tumbleweeds and sand. Visibility was limited to the road ditch on greater than 50% of the spotlight route due to the accumulation of tumbleweeds on roadside fences. Monitoring efforts were conducted again during October in Dallam county using only spotlight and live-trap methods. Spotlight surveys produced 6 swift observations during two nights. No swifts were captured during the 24 trap nights of effort. Track searches were not productive due to poor tracking surfaces at the site. Monitoring at the Sherman county site resulted in 8 swift observations during the two nights of spotlight surveys. Three males and two female swifts were captured. Each animal was marked with a numbered metal ear tag, morphological data was collected, blood samples were taken, and the animals were released. The total for 1996 and 1997 trapping periods are: three swifts have been captured, marked, and released at the Dallam county site (out of 59 trap nights) and 6 swifts were captured, 4 of which were tagged and released, one released untagged, and one mortality at the Sherman county site (out of 26 trap nights).

The two field surveys of private land in Gray and Randall counties produced no conclusive evidence of swift fox. During the survey in Randall county a fox was observed during the spotlight survey, however a positive identification could not be made to determine if it was a gray fox or a swift. We will attempt to survey this area again in 1998.

DISCUSSION

The process of conducting surveys on private land requires a major investment of time to develop a working relationship with the landowner, conduct preliminary reconnaissance, then actually following up with a field survey if warranted. However, this approach is much more effective at conducting the surveys in the most suitable swift habitat.

While scent stations and track searches may work well in other portions of the swift fox range, it requires a greater flexibility in personnel schedules and a greater amount of manpower to efficiently conduct these surveys than are currently available in Texas. The success of scent station and track surveys are too often affected by the weather conditions. Track searches are most effectively conducted shortly following rain or snow to provide adequate tracking surfaces and scent stations are commonly destroyed by blowing sand or vegetation. For this reason we have found that a combination of spotlighting and live-trapping to be the most reliable and cost efficient methods for determining swift presence and monitoring their population trends. When time and tracking conditions are favorable, track searches can be used as an additional source of information. TPWD continues to receive more reports of swift fox locations than can be investigated on an annual basis. Therefore, our primary research need continues to be the determination of current distribution.

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SUMMARY OF SWIFT FOX INVESTIGATIONS ON NATIONAL GRASSLANDS (USDA FOREST SERVICE, REGION 2)

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ABSTRACT

A summary of swift fox (*Vulpes velox*) investigations from seven US Forest Service National Grasslands (NG) are reported for 1997. No surveys were conducted on five of the NGs. The results of survey efforts for local swift fox populations is reported for the Pawnee NG and Buffalo Gap NG. Two of the NGs (Comanche and Buffalo Gap) provided additional sighting reports.

INTRODUCTION

Surveys to monitor local swift fox populations are periodically conducted on seven NGs in Forest Service Region 2, depending on available funding and personnel. Surveys to determine locations of swift fox were conducted on the Pawnee NG during 1997 and have been conducted on the Buffalo Gap NG from 1989 through 1996. Additional new areas were surveyed in 1997, as well as one of the annual routes established in 1994 on the Buffalo Gap NG.

STUDY AREAS

Study areas comprise the seven NGs in Region 2, which include the Thunder Basin NG in Wyoming, Oglala NG in Nebraska, Comanche NG and Pawnee NG in Colorado, Fort Pierre NG and Buffalo Gap NG in South Dakota, and Cimarron NG in Kansas.

Approximately 5,600 acres of formerly unsurveyed areas of Buffalo Gap NG were surveyed for presence of swift fox in 1997. The established annual route which was also completed surveyed 2,720 acres.

METHODS

Sighting information is collected annually as it becomes available on the NGs. Sighting reports on Buffalo Gap NG from the Wall Creek District were collected during black-footed ferret (*Mustela nigripes*) surveys. Surveys on the Pawnee NG were conducted by spotlight for three consecutive nights during September 15-17, 1997. One spotlight on each side of the vehicle would sweep the landscape searching for eye shine. The vehicle traveled along graveled county and two-track trails at about 20 mph. Spotlight surveys occurred for six hours each night.

On the Fall River District of the Buffalo Gap NG, approximately 150 man-hours (including travel time) were spent establishing and utilizing bait stations. A bait station consists of a circular area 18 to 20 inches in diameter cleared of vegetation. A mixture of fine sand and vegetable oil is then spread over the circle and smoothed. The mixture consists of one cup of oil to one gallon of sand. A masonry sand was purchased this year in an attempt to see if there is an advantage to using an extremely fine sand. Approximately one-half ounce of jack mackerel was placed in the center of the station to serve as bait. Because of the swift fox's primarily nocturnal habits, the stations were baited during the early evening hours. Bait stations are placed approximately one-quarter mile apart on ridge tops to give better scent dispersal on the evening downdrafts.

RESULTS AND DISCUSSION

No surveys or sightings were reported from the Thunder Basin NG, Oglala NG or Fort Pierre NG. The Comanche NG reported observing swift fox on a regular basis indicating a stable population, but did not conduct formal survey activities. The Cimarron NG did not conduct surveys in 1997 or report swift fox sightings, although foxes are suspected in very low numbers.

Five swift fox sightings were reported for the east half of Buffalo Gap NG in the Wall Creek District during black-footed ferret surveys. Four of these sightings (4 adults, 3 young) were made in Sage Creek and one sighting (1 adult) came from Agate Basin.

The three night spotlight survey on the Pawnee NG resulted in 56 confirmed swift fox sightings, which produced an average of three sightings per spotlight hour. Thirteen, 20 and 23 sightings occured during consecutive nights, respectively. This data compares well to previous year's results.

In the Fall River District, or west half of the Buffalo Gap NG, two of the three areas previously established as routes to be done annually were not completed this year, because the surveys conducted in 1994, 1995 and 1996 yielded swift fox tracks at one station, one night only, for the entire three year period. It appears that these two populations may have died out or moved. The presence of the tracks at one station suggests that the population formerly in the Smithwick area may have moved to nearby private land, with an occasional foray into their old territory on federal land.

Red fox (*Vulpes vulpes*) and striped skunk (*Mephitis mephitis*) tracks were found in all new areas surveyed, with coyote (*Canis latrans*) tracks alsofound on the Roller and Pfister areas. Swift fox, striped skunk and coyote tracks were found in the Ardmore annual survey route. Of the 31 stations, swift fox tracks were found on only five the first night, none the second night and seven the third night. This totals only 12 track station-nights, compared to 45 track station-nights on the same route last year. This year, all tracks were found only on the second half of the route, whereas last year they were found on the last two-thirds of the route.

The fine masonry sand used this year did prove to be an improvement over sand used in previous years. It accepts a much more detailed track, leading to easier and more accurate track identification. However, two changes were suspected which may have been responsible for the decrease in swift fox track numbers this year. The usual brand of jack mackerel was not readily available locally this year, and a finer textured and lighter-colored brand of masonry sand was used for the first time. An experiment was set up to determine if these changes could have caused a decrease in bait station visitation rates. Eight pairs of stations were set up in the part of the route that had shown swift fox to be present. One station of each pair was made with the new masonry sand and the other with sand used in previous years. In addition, one station was baited with the new brand of mackerel and the other with the previous brand. The second night, the placement of the mackerel was reversed in the stations. Each recognizable swift fox track was recorded for each station. The new sand received 102 tracks and the previously used sand also received 102 tracks. The new mackerel brand drew 111 tracks, while the previously used brand produced 103 tracks. These results indicated that the two variables in substrate and bait were not responsible for the decrease in track detections this year.

The reduced number of swift fox tracks in 1997 may signify a reduction of the population, but there are other factors that could explain it. No extensive surveys have been done on adjacent private land. The population we are dealing with may be on the edge of a larger population of which we have no knowledge; the population could be holding steady with a reduction in use of the surveyed area. Also, the amount and timing of the precipitation in 1996 and 1997 resulted in above normal vegetative growth. Presumably this would allow for an increase in population of swift fox prey species, which could result in decreased time spent, as well as distances traveled, in foraging.

Only one active swift fox den was found this year in the Fall River District on the Buffalo Gap NG, and it appeared to be inhabitated by a single individual which was seen on two consecutive days, after which the den was abandoned.

A REVIEW OF LITERATURE RELATED TO SWIFT FOX HABITAT USE

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The purpose of this chapter was to compile a current review of literature regarding swift fox (*Vulpes velox*) habitat use. The literature review was focused primarily on peer-reviewed literature, theses and dissertations. State wildlife agency reports were used as well in this review. Habitat information for swift fox has been published either in the form of study area descriptions or, more often as swift fox denning habitat, in Texas (Cutter 1958), Oklahoma (Kilgore 1969), Kansas (Zumbaugh and Choate 1985, Zumbaugh et al. 1985, Jackson 1997), Nebraska (Hines 1980), South Dakota (Van Ballenberghe 1975, Hillman and Sharps 1978, Uresk and Sharps 1986), Wyoming (Floyd and Stromberg 1981, Lindberg 1986, Wooley et al. 1995), and Colorado (Loy 1981, Cameron 1984, Covell 1992). Swift fox habitat information is presented as general descriptions, study area descriptions and den habitat characteristics, as reported in published literature sources.

Swift fox apparently evolved in a prairie environment where grasses were the dominant plants (Snow 1973). Historically swift fox occupied the shortgrass and mixed grass prairies of the Great Plains east of the Rocky Mountains, but it is not known if their populations were continuous or patchy throughout this range (Kahn et al. 1996). Although the habitat types used by swift fox vary geo-physiographically, swift fox primarily occupy habitats with level to gently rolling topography within the shortgrass and midgrass prairie ecosystem (Kilgore 1969, Hillman and Sharps 1978, Egoscue 1979, Samuel and Nelson 1982). The extent to which swift fox can adapt to various native and non-native habitats within the grassland prairie ecosystem has not been well documented.

Conversion of prairies to cropland has been implicated as an important factor in the decline of swift fox populations or their failure to recover (Cutter 1958, Kilgore 1969, Hillman and Sharps 1978, Hines 1980, Loy 1981, Cameron 1984). It has been suggested that the swift fox occupy marginal habitat over a large portion of its present range as a result of settlement and cultivation of the native prairie (Snow 1973). Samuel and Nelson (1982) argued, however, that swift fox numbers declined when the prairies were settled as a result of trapping, hunting, predator control, and rodent control programs. Kahn et al. (1996) suggested that it wasn't the conversion of native prairies to cropland that hindered swift fox conservation efforts, but rather the juxtaposition of the remaining prairie, the grassland and cropland management, and the changes in the canid community that may have resulted from prairie to cropland conversion.

Swift fox accounts since 1950, however, suggest that populations have been increasing and re-occupying some portions of their historic range in the United States (FaunaWest 1991, Samuel and Nelson 1982). Floyd and Stromberg (1981) speculated that one cause for increasing swift fox populations may be the declining number of homesteads and small farms and ranches in the Great Plains region. Lindberg (1986) speculated that the suspension of the use of compound 1080 in coyote (*Canis latrans*) control programs also contributed to the expansion of swift fox populations in the early 1970's. Today, swift fox distribution in the United States could be considered relatively widespread, although it remains limited to only a portion of its original range (Kahn et al. 1996).

GENERAL HABITAT DESCRIPTION

Swift fox prefer flat plains with low ground cover, depending upon the visibility in open areas to detect predators and their speed to escape from them (Cameron 1984, Covell 1992). Swift fox select for long sight-lines when choosing a habitat, generally avoiding any vegetative or topographic situation, such as canyons, treed areas, and areas with dense shrubs, which would provide cover for larger canids (Cameron 1984, Covell 1992). The texture and friability of the soil may also be an important factor in selecting a habitat, since swift fox dens are usually located in soil that is easy to dig (Snow 1973).

Vegetation in swift fox habitat is usually sparse and short (25 cm or less in height), dominated by shortgrass and midgrass species. Native short and midgrasses commonly associated with swift fox habitat have included buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), needle-and-thread grass (*Stipa comata*), and needleleaf sedge (*Carex eleocharis*) (Kilgore 1969, Hines 1980, Loy 1981, Cameron 1984, Uresk and Sharps 1986, Covell 1991). Shrubs commonly present have included saltbush (*Atriplex canescens*) and sagebrush (*Artemisia spp.*) (Loy 1981, Cameron 1984, Uresk and Sharps 1986, Covell 1992). In many areas with extensive cultivation, the native grasses have been replaced by crested wheatgrass (*Agropyron cristatum*), Russian thistle (*Salsola pestifer*), common sunflower (*Helianthus annuus*), lamb's quarter (*Chenopedium album*), bindweed *(Convolvulus spp.*), grassbur (*Cenchrus spp.*), western ragweed (*Ambrosia psilostachya*), and prickly pear cactus (*Opuntia polyacantha*) (Kilgore 1969, Loy 1981, Cameron 1984, Covell 1992).

Swift fox have been found in habitats within the shortgrass/midgrass prairie ecosystem considered non-typical such as the badland-like areas in Wyoming (Wooley et al. 1995), the Sandhills of Nebraska (Blus et al. 1967), pinon-juniper habitat in Colorado (Covell 1992) and Oklahoma (Lomolino and Shaughnessy 1997), shortgrass prairie interspersed with winter wheat, alfalfa, and fallow fields (Cutter 1958, Kilgore 1969, Floyd and Stromberg 1981, Loy 1981, Cameron 1984, Jackson 1997) and directly in cultivated fields in Kansas (Jackson 1997), Oklahoma (Kilgore 1969) and Texas (Cutter 1958). Observations in highly modified or other non-native habitats suggest a need to further investigate the swift fox's adaptative capabilities and survival rates within areas that are considered to be outside of the classic native grassland prairie.

STUDY AREA DESCRIPTIONS

Cutter (1958) observed swift fox dens in overgrazed pastures, plowed fields and fence rows in Hansford County, in the Texas Panhandle. Kilgore's (1969) swift fox den investigations were conducted in southwestern Beaver county, in the Oklahoma Panhandle, where 35 dens were found in grazed pastureland and cultivated fields. Sherman and Wallace counties, Kansas served as Jackson's (1977) study area for swift fox den investigations. Hines (1980) studied swift fox denning ecology in the shortgrass grazed prairie of west central Sioux county, Nebraska. Swift fox dens were examined on 77 km^2 of grasslands and river bottom in southwestern Shannon county, South Dakota within the Pine Ridge Indian Reservation (Hillman and Sharps 1978, Uresk and Sharps 1986). Uresk and Sharps (1986) also investigated swift fox den habitat in Haakon county, South Dakota, 40 km north of Philip. This area was characterized by gently undulating hills of short to midgrass prairie with numerous livestock watering ponds (Uresk and Sharps 1986). Loy (1981) and Cameron (1984) studied swift fox on the U.S. Forest Service Pawnee National Grassland (PNG) in northeastern Colorado. Swift fox have also been studied in southeastern Colorado on the Piñon Canyon Maneuver Site (PCMS) in Las Animas County (Covell 1992). Swift foxes primarily used open grassland habitat of which there was about 258 km^2 on the 1040 km^2 PCMS (Covell 1992).

Lindberg (1986) partitioned the state of Wyoming into three areas on the basis of past swift fox sightings, predicted habitat suitability and geographic location in relation to swift fox populations outside Wyoming. The eastern third of the state, which occurs within the Great Plains region, was considered to comprise the primary habitat for the swift fox in Wyoming, and has traditionally been the westernmost extent of swift fox range on the Great Plains (Lindberg 1986). This area consisted mainly of rangeland and cropland habitat types (Lanka et al. 1984). Nearly all past sightings of swift fox in Wyoming have occurred within this area (Floyd and Stromberg 1981, Lindberg 1986).

Cattle grazing has been the predominant use of the shortgrass prairie region where many swift fox investigations have occurred (Hillman and Sharps 1978, Hines 1980, Loy 1981, Cameron 1984, Uresk and Sharps 1986, Covell 1992, Jackson 1997). To a lesser extent, these areas have been used for raising hay for cattle forage, sheep grazing, and center-pivot farming (Hines 1980, Loy 1981, Cameron 1984, Uresk and Sharps 1986, Jackson 1997). Wheat, corn and sorghum and sunflowers were the primary crops grown in Jackson's (1997) western Kansas study area. Size of famed plots in Kansas ranged from quarter mile sections to mile sections, while rangeland plots usually consisted of several one mile sections (Jackson 1997). Jackson (1997) also reported some of the land area was also used in the Conservation Reserve Program (CRP). The PNG has also been used for mineral development (uranium and natural gas), and limited recreational pronghorn antelope hunting and bird watching (Loy 1981). Since federal acquisition in 1982 of the PCMS, cattle grazing has been discontinued on the area (Covell 1992).

Topography and Slope

Hine's (1980) Nebraska study area was in the White and Niobrara river drainages. The altitude varied from 1375 m and 1525 m, except in the river valleys. Gently rolling hills predominated in this area. The topography in both South Dakota study areas investigated by Hillman and Sharps (1978) and Uresk and Sharps (1986) consisted of gently sloping to undulating uplands, as well as a the White River's broad floodplain. Badland outcroppings were found throughout the Pine Ridge study area (Uresk and Sharps 1986).

The topography of the PNG consisted of rolling hills dissected with numerous drainages and playa lakes which contained water only during periods of precipitation (Loy 1981, Cameron 1984). Elevation on the PNG varied from 1,311 m to 1,936 m with extensive flat areas occurring (Cameron 1984). Several areas of rough terrain and escarpements occurred to the north and east of Loy's (1981) PNG study area. The elevation on Covell's (1992) PCMS study area in southeastern Colorado, ranged from 1,310m to 1,740 m.

Soils

Kilgore's study area in the Oklahoma Panhandle contained clay loam soil types. Swift fox dens in Nebraska, were found where soils ranged from loamy sand to loam (Hines 1980). Soils on the White River flood plain in Hillman and Sharps' (1978) study were of the alluvial land-Haverson association. Badlands, characterized by bare soil, intermingled with clayey and loamy soils on the uplands and mesas in this area of South Dakota (Hillman and Sharps 1978). The soil type at the Philip study area was primarily clay to clay-loam (Uresk and Sharps 1986). The soils on the PNG were low in humic content and generally classed as sandy loams to clay loams (Loy 1981, Cameron 1984). Most of the soils on the PNG contained a mineralized hardpan close to the surface, restricting water percolation (Loy 1981).

Climate

The climate in Beaver county, Oklahoma was characterized by limited and irregular precipitation, a high rate of evaporation, low relative humidity, a high average wind velocity, hot summer days followed by cool nights, and moderate winters with occasional severe cold spells of short duration (Kilgore 1969). The mean annual precipitation was 47.2 cm much of which fell as sudden torrential rains during late spring and summer, resulting in heavy run-off (Kilgore 1969). The average annual temperature was 14.5 °C, and ranged from -16.1 °C in February to 37.9 °C in July (Kilgore 1969). Average annual precipitation in Hine's (1980) Nebraska study was 46.4 cm, falling primarily in April through July. Annual snowfall averaged 142 cm. Average temperatures ranged from -6° C in January to 21° C in July (Hines 1980). To the north in South Dakota, precipitation on the Pine Ridge study area averaged 41.4 cm of rain, 78% of which occurred between April and September; and 78.7 cm of snowfall (Hillman and Sharps 1978). The Philip study area had an annual average precipitation of 43 cm of rain and 30 cm of snow (Uresk and Sharps 1986). The climate on the PNG in northeastern Colorado was considered semi-arid with an average annual precipitation of 31 cm (maximum 38 cm) (Loy 1981, Cameron 1984). In the spring, the wind averaged 10 km/hour and commonly exceeded 48 km/hour (Cameron 1984). The winters on the PNG were cold and the summers hot, with the daytime temperature often above 37.7° C (Cameron 1984). The climate on southeastern Colorado's PCMS was also semi-arid with annual precipitation ranging from 26 to 38 cm (Covell 1992).

Vegetation

The vegetation in the Oklahoma Panhandle was originally dominated by buffalograss and blue grama, but in some areas little bluestem (*Andropogon scoparius*), wire grass (*Aristida*), and side-oats grama (*Bouteloua curtipendula*) occurred (Kilgore 1969). The area was extensively cultivated, resulting in the original vegetation being largely replaced with Russian thistle, common sunflower, cocklebur (*Xanthium commune*), lamb's quarter, bindweed, western ragweed, and grassbur (Kilgore 1969). Prickly pear cactus grew on closely grazed pastureland (Kilgore 1969). Rangeland vegetation in Jackson's (1997) Kansas study area consisted of short and midgrasses, especially buffalograss, big bluestem (*Andropogon gerardii*), smooth brome (*Bromus inermis*), Japanese brome (*B. japonicus*), hairy grama (*Bouteloua hirsuta*), and blue grama. Predominant forbs were scurfy pea (*Psoralea tenuiflora*), nine-anther prairie clover (*Dalea enneandra*), horse-weed (*Conyza canadensis*), and red false mallow (*Sphaeralcea coccinea*) (Jackson 1997). Vegetation in Kansas croplands consisted of planted crops plus invading forbs, incuding buffalo bur (*Solanum rostratum*), devil's claw (*Proboscidea louisianica*), western wallflower (*Erysimum asperum*), Russian-thistle, and fireweed (*Kochia scoparia*) (Jackson 1997). Dominant plants typical in Hine's (1980) Nebraska study area were needleleaf sedge, needle-and-thread grass, and blue grama. The dominant vegetation on the Pine Ridge study area in South Dakota consisted of buffalograss, needleleaf sedge, blue grama, and western wheatgrass; while on the Philip study area western wheatgrass, buffalograss, and blue grama dominated (Uresk and Sharps 1986).

Grass species dominated the vegetation on the PNG. Of the more than 200 plant species identified on the PNG the shortgrasses blue grama and buffalograss were the most abundant (Cameron 1984), and occurred in many locations as pure stands (Loy 1981). This grassland community covered 74% of the PNG (Loy 1981). In localized areas, the midgrasses western wheatgrass, crested wheatgrass, three-awn grass *(Aristida longiseta*), salt grass (*Distichlis spicata*), and needle-and-thread grass; as well as the shrubs and forbs prickly pear cactus, Russian thistle, winterfat (*Ceratoides lanata*), saltbush, sagebrush, locoweed (*Astragalus spp.*), daisy (*Erigeron spp.*), rabbitbrush (*Chrysothamnus nauseosus*), yucca (*Yucca glauca*), buckwheat (*Polygonum spp.*), and rose (*Rosa spp.*) were found (Loy 1981, Cameron 1984). According to Loy (1981) crested wheatgrass had been introduced in many locations on the PNG by livestock management programs.

The PCMS in southeastern Colorado, was dominated by two vegetation types: shortgrass prairie and pinon-juniper communities in which Covell (1992) classified three distinct habitat types present. Grasslands made up about 55% of the 1,040 km^2 Piñon Canyon area, but open grassland only mades up 45% of this total (Covell 1992). The central areas of the PCMS were primarily shortgrass prairie, characterized by blue grama, galleta (*Hilaria jamesii*), alkali scaton (*Sporobolus airoides*), western wheatgrass, matt muhly (*Muhlenbergia richardsonii*), three-awn grass, needle-and-thread grass, cholla (*Opuntia imbricata*), and yucca (Covell 1992). The Purgatoire River canyon system formed the eastern border of PCMS. Piñon pine (*Pinus edulis*), one seed juniper (*Juniperus monosperm*), skunkbush sumac (*Rhus trilobata*), mountain mahogany (*Cercocarpus montanus*) and fourwing saltbush *(Atriplex canescens)* dominated the canyon vegetation (Covell 1992). Tamarisk (*Tamarix pentandra*) and cottonwood (*Populus sargentii*) occurred commonly in canyons and arroyos. The piñon-juniper woodland on the Bear Springs Hills, Black Hills and Big Arroyo Hills characterized the northern and western boundaries of the PCMS (Covell 1992).

Seventy-three percent of all reported swift fox observations in Lindberg's (1986) Wyoming study occurred within either the shortgrass or prairie/sagebrush habitat types (46.6% and 26.8%, respectively). Roadside observations accounted for 6.8% of the total swift fox observations. Of the remaining 8 swift fox observations, 4 were near old buildings, 2 in yards, and 1 each in a meadow and on a lake (Lindberg 1986). A Chi-square test showed a significant relationship existed between habitat type and the number of swift fox observations, with the shortgrass habitat type being the most used by swift fox (Lindberg 1986). Lindberg (1986) considered the wide distribution of shortgrass habitat in the eastern third of Wyoming to be a major factor in the swift fox's recolonization of much of this part of the state. Swift fox observations in Wyoming occurred second in frequency in the prairie/sagebrush habitat type (Lindberg 1986).

DEN HABITAT

Swift foxes spend more time underground than any other North American fox, using dens throughout the year for protection, rearing of young, and to avoid predation (Kilgore 1969). A pair of swift foxes usually has numerous burrows within their home range and may use up to 13 different dens throughout the year (Hillman and Sharps 1978). Swift fox spend most of the day in dens or very near a den (Covell 1992). Thus, a suitable den is considered a critical habitat requirement for swift fox (Snow 1973). The ability to detect danger at a safe distance seems to be the overriding factor in den site selection by swift fox (Cameron 1984). Swift fox burrows have usually been located in well-drained soil on a small hilltop with a good view of the surrounding prairie (Cutter 1958). Swift fox dens, however, have been found in a variety of habitat types (Snow 1973).

Kilgore (1969) found 35 swift fox dens in the Oklahoma Panhandle; 22 of which were occupied at the time of discovery. Two of 13 dens that were unoccupied when encountered were later occupied, but all others remained vacant over the course of his study (Kilgore 1969). Sixty dens were located by Jackson (1997) in western Kansas, and den site characteristics were recorded for 15 dens in rangeland and 15 in cropland. Sherman county, Kansas was 78.3% cropland and the majority of swift fox dens found were in cropland versus rangland (Jackson 1997). In Wallace county, Kansas, however, cropland only composed 58.5% of the land area and the majority of swift fox dens found in this county occurred in rangeland (Jackson 1997).

Hines (1980) located 40 dens (12 of which were natal) in westcentral Nebraska, but only investigated 28 dens. Hines (1980) found that non-natal dens were not distributed randomly in the home ranges. He believed that nonrandom distribution of these dens was possibly the result of patchy resources creating a clumped arrangement of dens. Natal dens were located closer together, particulary in late summer. Hines (1980) surmised that this was probably due to difficulties in moving pups which were nearing their adult size by July and August. Hillman and Sharps (1978) found six active natal den sites, which consisted of several individual dens scattered within a 200 ha area. The distance between any two dens was rarely more than 100 m, and the number of dens used by the four family groups observed ranged from 4 to 13 per family (Hillman and Sharps 1978). Uresk and Sharps (1986) believed that swift fox were able to select den sites within various habitat types ranging from plowed fields, fence rows, to moderately cattle-grazed midgrass prairie. All of the swift fox dens Covell (1992) found on the PCMS in southeastern Colorado were in grassland habitat with the average height of the vegetation around the den ranging between 20 and 30 cm.

Topography and Slope

The flatness of terrain and lack of vegetation appear to be the most important factors in swift fox den site selection (Cutter 1958, Loy 1981). In Kansas, slope averaged 2.9% around rangeland den sites and 3.5% around those in cropland (Jackson 1997). Hines and Case (1991) found dens in west central Nebraska to be in flatland to gently rolling hills with a 3 m to 6 m change in altitude per 100 m. Half of the 40 dens Hines and Case (1992) observed were on flat terrain. Most dens from hilly areas were in valleys near the base of hills. Hines (1980) speculated that it may be impossible for swift fox to construct dens on steep slopes because of shallow soils. Hillman and Sharps (1978) found swift fox in South Dakota denning in uplands within 1.6 km of the White River. Dens were often located near the crest or top of a hill, but several were on flat plateaus above the flood plain (Hillman and Sharps 1978). One of the four families denned in a steep cutbank; the other dens were in areas where the slope did not exceed 15° (Hillman and Sharps 1978). Dens on the PNG in Colorado, were usually located along sloping plains, or other well drained sites where vegetation was sparse (Loy 1981). The slope of the terrain for 77% (53) of the dens on the PNG was found to be less than 3° (Loy 1981). Cameron (1984), also working on the PNG, observed 28 den sites (seven active and 21 inactive) associated with flat terrain at least 30 m from the nearest altitude change. Of the dens associated with rises of 3 m or more in height, three were located at midslope, two were located on the top of hills, and three were located at the base of hills (Cameron 1984).

Dens faced all four cardinal directions in Kansas (Jackson 1997). In Nebraska, swift fox dens were more than non-randomly facing east and west (Hines 1980). On the PNG entrances to swift fox dens were found facing all four principal exposures, however, 69% (74) of the entrances faced either south or east (Loy 1981). Hillman and Sharps (1978) observed that swift fox dens in South Dakota tended to have eastern exposures.

Soils

Swift fox are probably limited to loose friable soils which do not contain high percentages of clay or sand, that allow for easy digging and maintenance of den structure (Hines 1980, Loy 1981). Swift fox dens in Oklahoma's cultivated fields were placed in two types of soil, Richfield clay loam and Ulysses-Richfield complex (Kilgore 1969). The Richfield clay loam was friable, with a surface layer about 18 cm thick and a subsoil of dark-brown silty clay loam; Below about 90 cm the soil was moderately fine-textured, loamy, pale, and contained occasional concretions of lime (Kilgore 1969). The Ulysses-Richfield complex generally occurred in broad areas of low, rounded knolls and ridges and was paler than the Richfield series (Kilgore 1969). A silty surface layer over a granular friable subsoil contained lime concretions below a depth of 118 cm (Kilgore 1969). In Kansas, swift fox dens were constructed in a variety of soil types, all in areas that were well drained and had moderate permeability (Jackson 1997). In rangeland, eight of 14 den sites were in the Ulysses soil, while the remainder were in Keith, Colby, and Colby-Ulysses soils (Jackson 1997). Most den sites in cropland were in Colby or Ulysses soils (Jackson 1997). Texture of the soils used for den construction uniformly were either silt-loam or loam (Jackson 1997).

In Nebraska, Hines (1980) observed swift fox dens in areas where soil classes ranged from loamy sand to loam, the majority being sandy loam. Large rocks (> 10 cm) were found at only one den which had not been renovated, and Hines (1980) speculated that swift fox may be excluded from rocky areas. Soils were highly variable among the seven den sites investigated by Uresk and Sharps (1986) in South Dakota. Den sites in the Pine Ridge contained soils which were loam, clay-loam, and sandy-clay-loam; while soils at dens found in the Philip study area were mostly clay (Uresk and Sharps 1986). Uresk and Sharps (1986) , however, did not believe that swift fox were selecting for a particular soil type for the construction of dens.

Vegetation

Percent vegetation cover of areas surrounding swift fox dens in croplands averaged 26% within 9 m of the den (zone one) and 30% between 10 m and 99 m (zone two) from the den; while in rangeland cover averaged 46% in zone one and 51% in zone two (Jackson 1997). Randomly selected sites in cropland had 33% and 34% vegetation cover within zone one and zone two, respectively; while randomly selected sites in rangeland had 51% cover in zone one and 46% cover in zone two (Jackson 1997). Although Jackson (1997) found a significant difference in percent vegetation cover between rangeland and cropland, she suggested that these differences resulted from the intrinsic nature of these habitats. Rangeland habitats consisted of grasses growing close together interspersed with forbs and a few woody plants. Cropland areas were planted with a particular crop in evenly spaced rows, and herbicides and tilling were used to control the spread of weeds in cropland habitats. Jackson (1997) concluded that since there was no difference between percent vegetation cover at randomly selected sites and at sites surrounding dens suggests that swift fox do not select areas of low percent cover from a variety of choices within rangeland and cropland, but rather exploit what is available to them. The average height of vegetation surrounding den sites in cropland was 1.56 cm in zone one and 3.66 cm in zone two, while in rangeland vegetation height averaged 3.88 cm in zone one and 4.95 cm in zone two (Jackson 1997). The significant differences in vegetation height between cropland and rangeland den sites resulted primarily from the larger expanse of bare ground in cropland and the number of tall plants growing in rangeland (Jackson 1997).

In Nebraska, the percent occurrence of bare soil, litter and live plants around 13 swift fox dens averaged 14%, 68.8%, and 17.2%, respectively (Hines and Case 1991). The species composition consisted principally of blue grama (40.7%), needle-and-thread grass (29.3%) and needleleaf sedge (22.2%), however, a detailed analysis of surrounding areas would have been necessary to determine selection of preferred vegetative characteristics by swift fox (Hines and Case 1991).

The vegetation associated with swift fox dens at the Philip site, in South Dakota, was less diverse than at Pine Ridge, with 43 and 57 species reported, respectively (Uresk and Sharps 1986). Grasses and grasslike plants comprised 76% and 55% of the vegetation composition, while forbs constituted 23% and 43% at Pine Ridge and Philip, respectively (Uresk and Sharps 1986). Shrubs were low at both sites, constituting only 1% and 2% of the composition. At Pine Ridge, 17 grass and grasslike species were found, including (in order of decreasing relative abundance), buffalograss, needleleaf sedge, blue grama, and western wheatgrass (Uresk and Sharps 1986). Thirty-nine forb species were recorded with the most common forbs being scarlet globemallow (*Sphaeralcea coccinea*) and rush skeletonplant (*Lygodesmia juncea*) (Uresk and Sharps 1986). The only shrub reported by Uresk and Sharps (1986) was silky wormwood (*Artemisia dracunculoides*). Only 10 grass species were observed at the Philip area, including western wheatgrass, buffalograss, blue grama, and needleleaf sedge (Uresk and Sharps 1986). Forbs at the Philip area included 29 species, dominated by prairie pepperweed (*Lepidium virginicum*), curlycup gumweed (*Grindelia squarrosa*), stickseed (*Lappula redowskii*), and yellow sweetclover (*Melilotus officinalis*) (Uresk and Sharps 1986). The four shrub species present in the Philip area were silky wormwood, silver sagebrush (*Artemisia cana*), sand sagebrush (*A. filifolia*), and fringed sagebrush (*A. frigida*) (Uresk and Shaprs 1986). Uresk and Sharps (1986), believed that the relative plant cover measured during the first year of their study indicated that swift fox did not select for a particular vegetation type such as grasses, forbs, or shrubs when choosing a den site. During the following year, however, grasses were pre-dominant in the selection of a den site.

The vegetation type at 77% (53) of the dens on the PNG in northeastern Colorado was identified as blue grama/buffalograss community (Loy 1981). The remaining 16 dens were located in short or midgrass communities with little or no tall vegetation near the den sites (Loy 1981). All dens observed by Cameron (1984) on the PNG were associated with areas of short vegetation where a swift fox would be able to use long sight-lines to view its surroundings. Cameron (1984), however, did observe that the den entrance itself may be located in an isolated patch of taller grass. The grasses at two den entrances were 20 cm to 40 cm in height and 2-4 m across (Cameron 1984).

Land Use (Cultivated Fields, Shortgrass Pastures and Other Uses)

Of the 25 occupied dens found by Cutter (1958) in Texas, only two were in plowed fields, whereas half of the 35 dens Kilgore (1969) found were in cultivated fields. Cutter (1958) did, however, observe many unoccupied swift fox dens in cultivated fields. Kilgore (1969) believed that these ratios reflected the difference in the percentage of land under cultivation in the areas studied and not a preference for native pasture versus cultivated fields. Lindberg (1986) also felt that the relatively low numbers of swift fox observations in agricultural habitat types in Wyoming was due to the relatively small portion of Wyoming's land was under cultivation. Likewise, no dens were observed in hay or cultivated fields in Nebraska, but these habitat types comprised a small percentage of the landscape (Hines 1980).

In Oklahoma, dens were generally located at or near a summit of low knolls, but several dens were in level fields (Kilgore 1969). One such flatland den was occupied through two periods of flood. As a result, Kilgore (1969) believed that drainage was not the critical factor in den site selection as Cutter (1958) supposed. One of the two dens observed by Cutter (1958) in a cultivated field was a confirmed natal den with a family of two adults and six whelps. Because dens observed in the spring had disappeared by the fall of the same year, Kilgore (1969) concluded that dens in cultivated fields were temporary and rarely reopened. Jackson (1997), however, more recently in Kansas determined that construction and maintenance of dens by swift foxes was the same in both cultivated fields and native rangeland. Jackson (1997) found 27 of 60 total dens in cropland, six of which were natal dens. Two of the 15 dens found in cultivated areas in Kansas were located within 1 km of rangeland, while none were located near CRP land (Jackson 1997).

Nineteen of the 25 dens discovered by Cutter (1958) in Texas were found in overgrazed pastures.

Cutter (1958) believed that swift foxes chose the most barren areas, devoid of any bushes or tall plants, to construct dens. Dens were concentrated, three to six in 160-acre pastures. Six of the 15 dens observed by Kilgore (1969) in shortgrass pastures were placed in what he termed "blow-ridges" (the result of extensive wind erosion and deposition that occurred during in the 1930's) and generally bordered playa lakes and depressions in pastures. "Blow-ridges" occasionally extended for considerable distances with the soil in these ridges accumulating to a depth of 46 cm to 61 cm. In one ridge, there were four dens with a maze of tunnels and many entrances (Kilgore 1969). All 40 dens located by Hines (1980) were within shortgrass grazed prairie in Nebraska. Kilgore (1969) assumed that the number of suitable swift fox den sites in shortgrass pasture habitat was limited, therefore such sites were frequently reused. Kilgore (1969) found that dens in shortgrass pastures tended to have more entrances than those in cultivated fields, perhaps indicating more prolonged occupancy. The mean number of entrances for dens in shortgrass pastures was four and ranged from one to nine (Kilgore 1969). Jackson (1997) found that the 15 den sites in Kansas cropland had 30 entrances, while the 15 dens in rangeland had 33 entrances.

Other dens examined by Kilgore (1969) in shorgrass pastures were mounds 3 m to 4.5 m in diameter and 15 cm to 26 cm high, resulting from continued excavation and renovation of the den over a long period. One swift fox den was an enlarged prairie dog (*Cynomys spp.*) burrow in a "dog" town (Kilgore 1969). Although it has been suggested that swift foxes may use burrows excavated by other animals, such as badgers, instead of digging their own (Warren 1942), Kilgore (1969) believed that the entrances to swift fox dens were too narrow to accommodate either adult coyotes or badgers. Therefore, Kilgore (1969) believed that swift foxes excavate their own dens with few exceptions. Cutter (1958) also believed that, at least in Texas, swift foxes dug their own dens. Hillman and Sharps (1978), found that some swift foxes used black-tailed prairie dog (*C. ludovicianus*) burrows as escape cover in South Dakota. They also observed that three families of swift fox used dens previously occupied by different swift fox in earlier years.

Kilgore (1969) found three dens in unusual places; one in a culvert, and two in a cemetery. Kilgore (1969) suggested that culverts were used in drought years and when debris accumulated over the ends, providing a darkened enclosure. In the cemetery, den entrances were excavated at the edges of concrete caps covering two of the graves. One of the cemetery dens was used for whelping (Kilgore 1969). Cutter (1958) found four occupied swift fox dens along fence rows, none of which were believed to be natal dens. One den observed by Hines (1980) in Nebraska was in a natural opening of a rock outcrop. Loy (1981) observed on the PNG in Colorado that swift foxes frequently excavated their dens along ground squirrel (*Ammospermohpilus spp.*) or pocket gopher (*Thomomys spp.*) tunnels in soft sandy soil.

Water

Because none of the 40 swift fox dens observed by Hines (1980) were within 4 km of permanent available water sources, he believed that water was not a limiting factor for den site selection for swift fox. All of the dens observed by Loy (1981) on the PNG in Colorado were located within 1 km of available water sources such as ponds, seeps and cattle tanks. Uresk and Sharps (1986) observed several cattle watering tanks in their Philip study area and concluded that swift fox prefer to den in short to midgrass prairie ecosystems within close proximity to an available water supply.

Proximity to Human Disturbance

Hines (1980) believed that swift fox in Nebraska were relatively tolerant of human activity. Sixty-eight percent of the dens he observed in Nebraska were within 200 m of roads. Thirty-nine (56%) dens studied by Loy (1981) on the PNG in Colorado were located within 100 m of roads or cattle paths, with one den located 5 m from a heavily traveled highway. The remaining 30 dens were located in areas further from roads or paths, but none were found more than 1 km from a road (Loy 1981). All the swift fox dens observed by Hillman and Sharps (1978) were within 1.6 km of traveled roads. Cutter (1958) found three dens within 100 m of human residences, and six within 100 m of windmills that were probably visited by people weekly. Hillman and Sharps (1978) found several dens near human occupied residences, and two swift foxes even burrowed beneath abandoned farm buildings.

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