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THE SWIFT FOX

ECOLOGY AND CONSERVATION OF SWIFT FOXES IN A CHANGING WORLD

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Scent-Station Survey Techniques for Swift and Kit Foxes

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Abstract: We compared scent-station survey techniques for monitoring the distribution and relative abundance of swift and kit foxes. We used data collected at Camp Roberts, California, during 1988-97 (kit fox); the U.S. Department of Energy's Naval Petroleum Reserves, California, during 1984-96 (kit fox); and in Sherman and Wallace counties, Kansas, during 1996 (swift fox). Principal results included the following: 1) Scent-station surveys were not cost-effective for determining the distribution of swift foxes. 2) Monthly visitation rates of swift foxes declined from April to August, then increased eight-fold in October, after juveniles began visiting stations. 3) Spring and summer surveys, but not autumn surveys, detected a sustained decline in kit fox abundance. 4) Swift foxes visited scent stations more frequently during the first night of each monthly survey than during subsequent nights. 5) Repeated operation of the same scent stations yielded less information about abundance than could have been obtained by establishing new stations. 6) Swift foxes visited stations with a sand-and-mineral oil substrate 2.4 times as frequently as track plates. These results suggest intuitive perceptions are frequently incorrect and emphasize the need for objective, experimental comparisons of scent-station survey techniques for monitoring swift and kit foxes.

Scent-station surveys have become a popular method for monitoring the distribution and relative abundance of swift foxes (*Vulpes velox*) and kit foxes (*V. macrotis*). However, scent stations frequently fail to detect canids that are present (Griffith et al. 1982, Sargeant et al. 1998) and efforts to link visitation rates to the abundance of swift and kit foxes have been inconclusive (e.g., Harris 1987). Thus, consensus regarding the usefulness of scent-station surveys for either purpose has not been achieved.

Investigators who rely on scent-station surveys of swift or kit foxes choose different techniques of data collection on an ad hoc basis, guided principally by intuition. Some differences among surveys result because the 2 ultimate objectives of scent-station surveys–assessing distributions and monitoring changes in population–dictate different proximate objectives. Methods for assessing distributions should minimize errors of omission (failing to detect resident foxes) and commission (detecting foxes where they are not resident), whereas methods for monitoring relative abundance should result in precise estimates of visitation rates and control for confounding factors. Investigators with similar goals, however, also choose different techniques. This reflects general disagreement regarding the best time to conduct surveys, the most effective means of attracting foxes to stations, the most reliable technique for detecting visits, and the most efficient means of allocating sampling effort. Few techniques have been compared experimentally, survey results are largely unpublished, and available information has not been synthesized.

Our objective was to evaluate scent-station survey techniques for swift and kit foxes, based on an exploratory analysis of 3 data sets and a synthesis of published and unpublished reports. We compared scent-station surveys with other methods for determining the distribution of swift foxes, tested trends in scent-station visitation rates of a rapidly declining kit fox population, examined seasonal variation in visitation rates of a swift fox population, compared replication with repeated operation of stations, and compared 2 types of tracking surfaces (track plates and sand) and 2 types of lures (fatty-acid scent [FAS] and food). In this paper, we discuss the utility of scent stations for surveys of distribution and abundance, relate choices of techniques to proximate objectives of surveys, and compare our results with contemporary perceptions of scent-station survey techniques for swift and kit foxes.

Study Areas

Our data were collected at the Camp Roberts Army National Guard Training Site, California (35° 45' N., 120° 45' W.), during 1988-97 (kit fox); at the U.S. Department of Energy's Naval Petroleum Reserves (NPRC), California (119° 30' N., 35° 15' W.), during 1984-96 (kit fox); and at 2 areas in Sherman and Wallace counties, western Kansas (39° 14' N., 101° 31' W. and 39° 05' N., 101° 33' W.), during 1996 (swift fox). These 4 areas represented a diversity of habitats, wildlife communities, and land management practices encountered within the ranges of swift and kit foxes.

Camp Roberts, California, encompassed 172 km^2 of rolling hills between the Salinas River floodplain and the Santa Lucia Mountains. Dominant vegetation included grassland, oak (*Quercus* spp.) woodland, and mixed chaparral: kit foxes, however, occurred primarily in grassland and low- to medium-density oak woodland (Reese et al. 1992). The NPRC was located 42 km southwest of Bakersfield, in Kern County, and comprised 323 km^2 of rolling hills dissected by steep draws and dry stream channels. Vegetation consisted of xerophytic shrubs and patchy herbaceous cover dominated by exotic annual grasses and forbs. Study areas in Kansas encompassed 259 km^2 each. One comprised relatively flat cropland devoted primarily to production of winter wheat, corn, milo, sunflowers and sorghum. The other included rolling hills of moderately to heavily grazed pastures with a few cultivated areas interspersed.

Temperatures averaged 14°C in winter and 23°C in summer at Camp Roberts, with mean annual rainfall of 28.5 cm, and 9°C in winter and 29°C in summer at the NPRC, where mean annual precipitation was only 12.5 cm. In Kansas, temperatures averaged 10°C in winter and 26°C in summer, with mean annual precipitation of 46.2 cm.

At Camp Roberts and the NPRC, potential predators or competitors of kit foxes included coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), gray foxes (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus*), badgers (*Taxidea taxus*), and golden eagles (*Aquila chrysaetos*). Coyotes, badgers, and domestic dogs (*Canis familiaris*) were the only potential predators or competitors observed on study areas in Kansas.

Camp Roberts was used primarily for military training and for grazing by sheep and cattle. The NPRC was devoted primarily to the production of petroleum products. Associated activities included the construction of roads, well pads, and other facilities. Farming and grazing were the dominant uses of study areas in Kansas.

Materials and Methods

Data Collection

At Camp Roberts and the NPRC, we patterned scent-station surveys after Linhart and Knowlton (1975), as modified by Roughton and Sweeny (1982). Each station consisted of a 0.9-m diameter circle of smoothed earth or sand with an FAS disk (Pocatello Supply Depot, USDA) placed in the center. We placed stations on alternate sides of unpaved roads at 480-m intervals, in lines of 10. We placed lines at least 1 km apart and distributed them as regularly as possible, subject to the availability of roads and, at Camp Roberts, to access restrictions in ordinance impact areas. At Camp Roberts, we conducted surveys during autumn (September–November) of 1988; spring (March–May) of 1997; summer (June–August) and autumn of 1989, 1993 and 1995; and spring, summer, and autumn of 1990–92, 1994, and 1996. At the NPRC, we conducted surveys during summer and autumn of 1984; spring, summer and autumn of 1985–91; and spring of 1992–96. At both sites, we operated lines for 1 night per survey.

In Kansas, we constructed stations of 0.37-m^2 (61x61-cm) sheets of 18-ga galvanized steel plate coated with carpenters chalk (track plates). We attached a blank scent disk (Pocatello Supply Depot, USDA) soaked in commercially processed liquefied mackerel in cod-liver oil to the center of each track plate. During the October survey, we supplemented ~60% of track plates with a station composed of sand, which we mixed with mineral oil (approximately 16:1 ratio) to enhance the clarity and durability of tracks. Sand-and-oil stations were placed ~5 m from track plates and had the same dimensions and lure. We placed stations along unpaved roads at 500-m intervals, in lines of 17–19, with a minimum distance of 1.6 km between lines. We conducted surveys monthly during April-August and in October, 1996. During each monthly survey, we checked stations daily until useable data were collected for 3 nights. We considered data to be useable if weather conditions did not interfere with the identification of tracks. While conducting surveys, we also collected telemetry data that showed all stations were placed within home ranges of swift foxes (M.A. Sovada, U.S. Geological Survey, unpublished data).

Statistical Analysis

Stations, lines, and surveys are 3 common choices of experimental units for analyses of scent-station data (Sargeant et al. 1998). We opted for a conservative approach. We treated surveys as experimental units when we considered several simultaneously (i.e., when testing for association and for seasonal differences in visitation) and treated lines as experimental units when we considered surveys individually (i.e., when comparing tracking media). In all cases, we used daily visitation rates (number of visits/number of station-nights) as our population index. SAS (SAS Institute, Inc. 1988) and S-PLUS (MathSoft, Inc. 1997) were used to perform analyses.

To test for an association between abundance and daily visitation rates, we assumed a monotonic decline in kit fox numbers at Camp Roberts and used Spearman's rank-order correlation coefficient (ρ; Daniel 1990). We applied the same method to data from Kansas to test for a seasonal trend in daily visitation rates during April-August. We used analysis of variance with year as a blocking factor (Sokal and Rohlf 1981) to test for seasonal differences in visitation at Camp Roberts and the NPRC.

To compare tracking media, we used a one-tailed *t*-test with October data from Kansas, which we paired by station and date within line (Sokal and Rohlf 1981). We used a one-tailed test because we anticipated higher daily visitation rates to sand stations than to track plates. To determine whether observed visits were equally likely to occur on the first, second, and third nights of surveys, we used chi-square tests of homogeneity (Daniel 1990) with data from Kansas. Our null hypothesis was $P_1 = P_2 = P_3$ where P_1, P_2, and P_3 were the respective proportions of visits expected on the first, second, and third nights of surveys. We conducted separate tests for April-August, when most visits were attributable to adult foxes, and October, when juveniles were probably responsible for most visits.

To determine whether stations should be operated for more than 1 night in succession and to assess the value of repeating surveys, we resampled empirical distribution functions (ED's; Efron and Tibshirani 1993:31-35) comprising subsets of data from Kansas and the NPRC. In Kansas, where we operated stations for 3 nights in succession during each monthly survey, results of each survey could be organized as an $n \times 3$ matrix. The first column of each matrix constituted an ED for stations operated 1 night each (i.e., replicate stations). The set of n rows, however, constituted an ED for the joint trivariate distribution sampled when data were collected by operating each station for 3 nights in succession (i.e., repeated stations). Similarly, results of spring, summer, and autumn surveys at the NPRC could be envisioned as a set of three $n \times 1$ vectors, each of which was a seasonal ED, or as a set of n 1×3 vectors, an ED for repetition across seasons. From these distributions, we calculated estimates of mean daily visitation rates and their standard errors by resampling. We used means and standard errors to estimate coefficients of variation resulting from replication (establishment of new stations) and repetition (repeated operation of the same stations). We recommend methods of allocating survey effort that resulted in smaller coefficients of variation.

Results

Capture records (J. Eliason, U.S. Army National Guard, Camp Roberts, unpublished data) suggested a rapid, sustained decline in the Camp Roberts fox population. From 1988 to 1996, the number of individuals captured annually declined from 103 to 9, despite identical trapping techniques and similar trapping effort. This decline in population was evident from spring ($\rho = 0.89$, $P = 0.009$) and summer scent-station surveys ($\rho = 0.71$, $P = 0.02$), but not from autumn surveys ($\rho = 0.43$, $P = 0.13$; Fig. 1). Declines in spring and summer visitation rates were of much smaller magnitude than changes in the number of foxes captured. The disparity suggests individual foxes were more likely to visit stations when fox density was low than when it was high.

In Kansas, monthly visitation rates for track plates declined steadily from April to August, then increased nearly eight-fold in October (Fig. 2), after juveniles began traveling away from natal dens (M.A. Sovada, U.S. Geological Survey, unpublished data). During April-August, foxes habituated to track plates operated for more than 1 night. Habituation resulted in higher visitation rates ($\chi^2_2 = 11.97$, $P = 0.003$) on the first night (2.6%) stations were operated successfully than on the second (0.9%) or third (0.9%). In October, visitation rates were higher ($\chi^2_2 = 6.77$, $P = 0.034$) for track plates, but not for sand-and-oil stations ($\chi^2_2 = 0.095$, $P = 0.95$), on the first night of successful operation (plates = 15.1%; sand = 27.0%) than on the second (plates = 11.9%, sand = 25.2%) and third (plates = 6.9%, sand = 26.4%). We found no evidence of consistent seasonal variation in visitation rates at Camp Roberts ($F_{2,12} = 0.01$, $P = 0.99$; Fig. 1) or the NPRC ($F_{2,13} = 2.64$, $P = 0.11$; Fig. 3).

Swift foxes were not readily detected with track plates during spring or summer in Kansas. Although all stations were placed within fox home ranges, we observed a daily visitation rate of only 1.5% and monthly track plate surveys frequently failed to detect foxes that were known to be present. During October, foxes in Kansas visited sand-

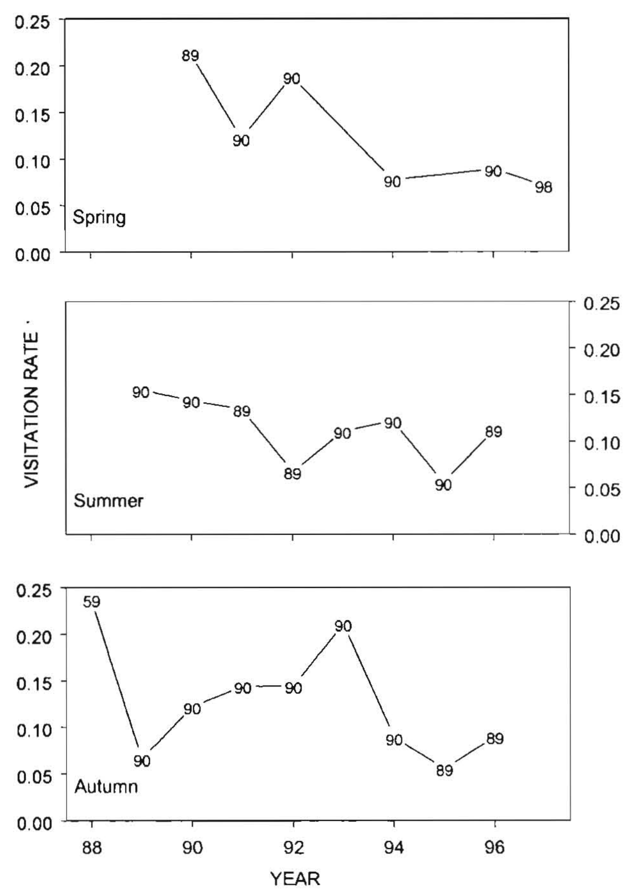

Figure 1. Scent-station visitation rates for kit fox at Camp Roberts, California, 1988-96. Plotting symbols are numbers of stations operated.

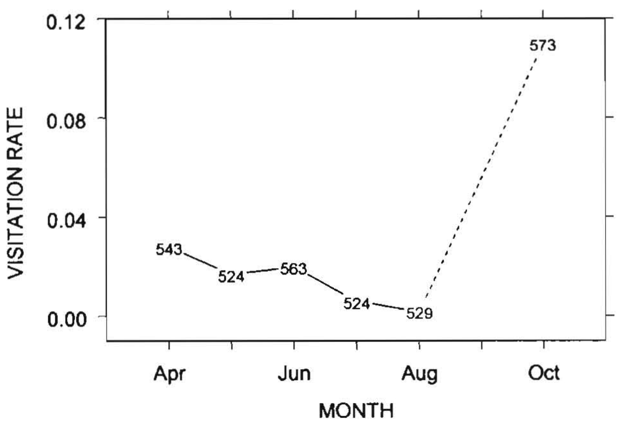

Figure 2. Scent-station visitation rates for swift fox in Sherman and Wallace counties, Kansas, during April-October, 1996. Plotting symbols are numbers of stations operated.

and-oil stations (26.2%) more readily (t_6 = 2.34, P = 0.029) than track plates (11.2%).

Because track plates were visited at higher rates on the first night stations were operated successfully than on the second or third, operating stations for more than 1 night unexpectedly increased coefficients of variation for 5 of 6 monthly surveys conducted in Kansas. At the NPRC, where the same stations were monitored 3 times annually, establishing new stations each season would have produced a smaller coefficient of variation for all 7 years where a comparison was possible.

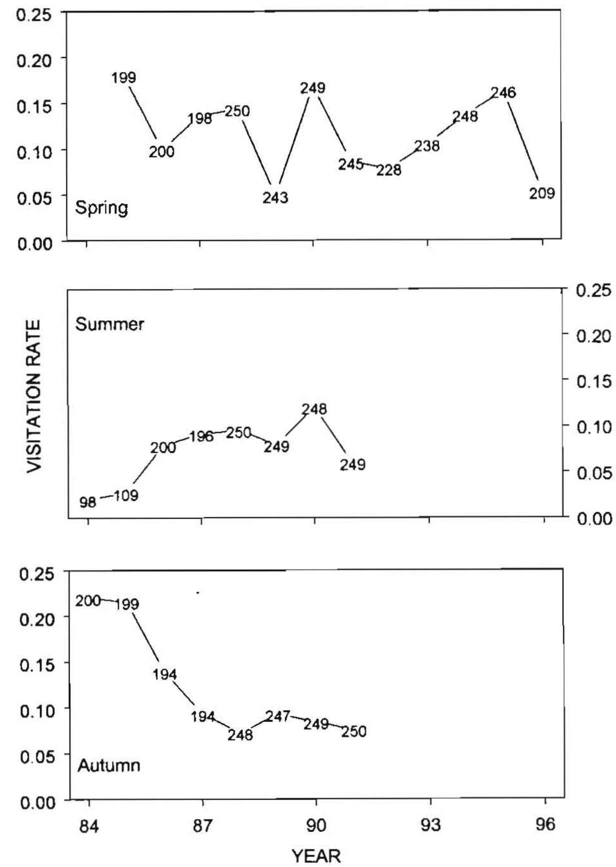

Figure 3. Scent-station visitation rates for kit fox at the Naval Petroleum Reserves in Kern County, California, 1984–96. Plotting symbols are numbers of stations operated.

Discussion

Surveys of Distribution

Low detection rates, such as we observed in Kansas, are apparently the rule for swift foxes and other canids. In Wyoming, swift foxes were photographed visiting track plates without leaving identifiable tracks in 50% of cases in 1 trial and in 12% of cases in another (T.L. Olson, Wyoming Cooperative Wildlife Research Unit, unpublished data). In Utah, Griffith et al. (1981) were able to detect tracks at only 28.8% of stations where coyotes left identifiable tracks within 10 m. In Minnesota, Sargeant et al. (1993) found evidence of red foxes in 96.4% of quarter sections they searched. Foxes were nevertheless detected at only 63.3% of 4800 m lines of 10 scent stations operated concurrently in the same counties (W.E. Berg, Minnesota Department of Natural Resources, unpublished data). At typical levels of sampling effort, scent stations may not be effective for detecting the presence of swift or kit foxes. They clearly cannot be used to determine where swift foxes are absent.

Although detection rates may be increased by sampling intensively and conducting fall surveys, other methods of detection are likely to be more cost effective. Because we conducted 6 monthly surveys, each survey line in Kansas eventually detected foxes. However, the time and expense of searching legal quarter-sections (0.65 km^2; Sargeant et al. 1993) for evidence of swift fox was less than required to conduct repeated scent-station surveys. Moreover, probabilities of detecting foxes were higher (M.A. Sovada, U.S. Geological Survey, unpublished data). Similarly, C.C. Roy (Kansas Department of Wildlife and Parks, unpublished data) detected evidence of swift foxes in approximately 40% of townships she surveyed in western Kansas, simply by spending 2 hours identifying and searching likely swift fox habitat in each township.

Surveys of Relative Abundance

Estimates of carnivore abundance are usually imprecise because most carnivores are cryptic, secretive, neophobic, and occur at low densities. Hence, short-term variation in abundance is seldom of sufficient magnitude for conclusive validation of population indices. Because manipulation of populations on a scale sufficient for index validation is neither feasible nor acceptable, scent-station population indices for swift and kit foxes have not been experimentally validated or calibrated. Results from Camp Roberts, where spring and summer surveys detected a decline in the kit fox population, are important in this context. However, it is noteworthy that visitation rates at Camp Roberts declined proportionately less than population size. Thus, individuals visited stations at comparatively high rates when population density was low. Negative relations between individual visitation and abundance, if present, reduce the sensitivity of scent-station indices (Smith et al. 1994).

Despite limited information for swift and kit foxes, circumstantial evidence suggests a correspondence between scent-station visitation rates and canid abundance (Sargeant et al. 1998). Prevailing evidence thus suggests long-term trends in spring and summer visitation rates reflect gross changes in swift and kit fox populations when samples are of sufficient number and surveys are properly designed. Scent-station surveys have low spatial resolution, however, because reliable inferences require large sample sizes (Zielinski and Stauffer 1996, Sargeant et al. 2003), kit and swift foxes have home ranges of 4-20 km^2 (Zoellick et al. 1987, White and Ralls 1993, M.A. Sovada, unpublished data), and observational units (stations or groups of stations) should be spaced sufficiently to ensure sampling of different individuals (Zielinski and Stauffer 1996).

Survey Timing

Most scent-station surveys of canids are conducted wholly or partly in autumn (e.g., Wood 1959, Linhart and Knowlton 1975, Morrison et al. 1981, Linscombe et al. 1983). Our results suggest presumed benefits of autumn surveys, which include favorable weather (Linhart and Knowlton 1975) and high visitation rates (Beltrán et al. 1991) that maximize statistical power for detecting changes in visitation (Roughton and Sweeny 1982), are outweighed by other considerations. Although spring and summer surveys tracked changes in the abundance of kit foxes at Camp Roberts, autumn surveys did not. At the NPRC, spring, summer, and autumn surveys were suggestive of different population trends (Fig. 3).

The persistence of canid populations depends on the distribution and abundance of adults in spring, when reproduction occurs. We believe juveniles are responsible for increases in visitation rates that are often observed in autumn. Thus, autumn surveys are appropriate only if the distribution and abundance of juveniles in autumn correspond closely with the distribution and abundance of adults in spring. Available evidence suggests they may not.

Details of dispersal are not well-known for swift and kit fox, but juvenile canids frequently disperse great distances in autumn (Storm et al. 1976, Gese and Mech 1991, Harrison 1992). Thus, surveys conducted after dispersal occurs in autumn may very well detect swift or kit foxes in areas where they are not resident. Density-independent factors strongly influence reproduction of swift and kit foxes. Reproductive rates of kit foxes are associated with prey density (White and Garrott 1998), which fluctuates markedly with precipitation (White and Ralls 1993). Neonatal survival rates of kit foxes are variable and are also controlled by rainfall through effects on prey availability (Spiegel and Tom 1996). Most juvenile swift and kit foxes do not survive from autumn to spring (Fitzgerald and Roell 1995, Ralls and White 1995, M.A. Sovada, unpublished data). Further, swift and kit foxes are similar, in many demographic respects, to coyotes and red foxes. Litter sizes of coyotes may decline when prey is scarce (Todd and Keith 1983), and reproductive output of coyotes and red foxes shows evidence of density-dependent limitation (Windberg 1995). For these reasons, we expect weak relations between autumn visitation rates and spring population densities.

Replication and Repetition

For efficiency, surveys should balance information gained by establishing new stations (replication) with effort saved by operating stations repeatedly (repetition). Replication is advisable when the act of data collection biases the outcome of future survey efforts (i.e., when foxes habituate to stations) and when repetition produces redundant data (i.e., when successive operation of the same stations produces essentially the same results).

It seems counterintuitive that repetition reduced the sensitivity of monthly surveys conducted in Kansas, but this surprising result has a simple explanation. Swift foxes in Kansas habituated to stations and daily visitation rates decreased after the first night. This caused proportionately greater reductions in means than in their standard errors and increased coefficients of variation. Thus, our attempt to increase the sensitivity of indices by obtaining three nights data for each station was counterproductive.

Conversely, we expected to find that repetition of surveys was less efficient than establishment of new stations at the NPRC. We suspected redundancy of results from different surveys due to variation in individual behavior. Our suspicion is supported by Kahn and Beck (1996), who photographed marked swift foxes at scent stations and noted that some individuals consistently traveled roads and visited a number of stations in succession.

Repeated operation of permanent stations is an element of most scent-station surveys. If surveys are repeated, steps that reduce habituation of foxes will improve the precision and reduce the bias of survey results. When costs of replication and repetition are similar, we recommend replication.

Lures

Swift foxes in Kansas quickly habituated to stations baited with mackerel in cod-liver oil. We believe visitation rates declined after the first night of operation and with successive monthly surveys, until autumn when juveniles began visiting stations, because foxes had visited stations without obtaining food they anticipated. Had we rewarded foxes with food, we might have faced the opposite problem: visitation rates that increased with habituation. Seasonal variation in the attractiveness of food may further complicate matters. Foxes in Wyoming always consumed mackerel baits when visiting stations in early spring, but not in summer when food was more abundant (Woolley et al. 1995). Effects of seasonal differences in food availability can be controlled via survey design, but effects of annual differences cannot. Annual differences in attractiveness of food baits may therefore reduce the effectiveness of food-based lures for surveys of relative abundance because such lures may provoke different responses on different survey occasions.

FAS is an obvious alternative to food-based lures. Swift and kit foxes, however, may avoid FAS because they associate it with coyotes or other canids (Orloff 1992, Hoagland 1995). Most evidence of differences in the performance of lures is anecdotal, however, and reasons given for hypothesized differences are speculative. Although coyotes were the principal source of kit fox mortality on both our California study areas (Cypher and Scrivner 1992, Standley et al. 1992), foxes visited stations baited with FAS at relatively high rates.

Tracking Media

Previous efforts to maximize visitation rates of swift foxes have focused on the use of various baits and lures (Allen et al. 1995, Luce and Lindzey 1996). Our results, however, suggest the choice of tracking medium may be much more important. Visitation rates to stations composed of natural materials were much higher than for track plates. Although natural materials may require greater care in track identification, this disadvantage is outweighed by benefits of higher detection rates. Moreover, mixing sand with mineral oil greatly facilitated identification of swift fox tracks in Kansas.

Conclusions

Responses of carnivores to scent stations may vary locally. Our results nonetheless suggest contemporary perceptions of scent-station techniques are frequently inaccurate and sometimes lead to inefficient survey designs. We question the use of scent stations for surveys of distribution; acknowledge potential of the method for assessments of relative abundance; discourage autumn surveys; show that repeated operation of stations can lead to habituation and reduce, rather than increase, precision of results; demonstrate a marked reduction in visitation rate resulting from wariness of swift foxes toward track plates; and prescribe cautious extension of our results to different populations.

For the most part, our insights were gained through study of data collected for other purposes. We hope they inspire controlled experimental comparisons of scent-station survey techniques for swift and kit foxes. Given current interest in the precarious population status of these smallest North American canids and widespread use of scent-station surveys, such comparisons seem overdue.

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In 1998, biologists and endangered species experts from fifteen states, three provinces, and seven countries met at an International Symposium on Swift Foxes, held in Saskatoon, Saskatchewan, to exchange information and identify the "state-of-the-science" of swift fox ecology and status in North America. Papers presented at the symposium, together with others written afterwards, are brought together in this peer-reviewed volume, which is divided into five major sections. Papers in Part I (Setting the Stage) consider swift fox conservation issues in general. Part II (Distribution and Population Shifts) explores what is known about the current distribution of the species on the North American continent. Part III (Censusing and Techniques) is devoted to evaluations of scent stations for surveying fox presence and abundance, along with a review on mitigating capture-related injuries. The papers in Part IV (Population Ecology) attempt to better understand the dynamics of changes in distribution and abundance of swift foxes on the continent, particularly as related to loss of suitable habitats, ecosystem modification brought on by human activities, and climate change. Part V discusses the current knowledge of swift fox taxonomy, physiology, and disease-related issues. Broad-ranging and comprehensive, *The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World* will provide invaluable information for scientists, resource managers, and students.

Part I – Setting the Stage

- A Review of the Ecology, Distribution, and Status of Swift Foxes in the United States
- The Socio-Economic Context for Swift Fox Conservation in the Prairies of North America
- A Design for Species Restoration—Development and Implementation of a Conservation Assessment and Conservation Strategy for Swift Fox in the United States
- Canada's Experimental Reintroduction of Swift Foxes into an Altered Ecosystem

Part II – Distribution and Population Shifts

- The Historic and Recent Status of the Swift Fox in Montana
- The Status and Ecology of Swift Foxes in North-central Montana
- Swift Fox Detection Methods and Distribution in the Oklahoma Panhandle
- Current Swift Fox Distribution and Habitat Selection Within Areas of Historical Occurrence in New Mexico
- A Literature Review of Swift Fox Habitat and Den-Site Selection

Part III – Censusing and Techniques

- Swift Fox Detection Probability Using Tracking Plate Transects in Southeast Wyoming
- Scent-Station Survey Techniques for Swift and Kit Foxes
- Reducing Capture-Related Injuries and Radio-Collaring Effects on Swift Foxes

Part IV – Population Ecology

- A Review of Small Canid Reproduction
- Factors Influencing Populations of Endangered San Joaquin Kit Foxes: Implications for Conservation and Recovery
- Aspects of Swift Fox Ecology in Southeastern Colorado
- Home Range, Habitat Use, Litter Size, and Pup Dispersal of Swift Foxes in Two Distinct Landscapes of Western Kansas
- Using Tooth Sectioning to Age Swift Fox
- Den Ecology of Swift, Kit and Arctic Foxes: A Review
- Coyote and Kit Fox Diets in Prairie Dog Towns and Adjacent Grasslands in Mexico
- Assessing Restoration of Swift Fox in the Northern Great Plains
- Captive Breeding of the Swift Fox at the Cochrane Ecological Institute, Alberta

Part V – Taxonomy/Physiology/Disease

- Systematics and Population Genetics of Swift and Kit Foxes
- Behavioral and Physiological Adaptations of Foxes to Hot Arid Environments: Comparing Saharo-Arabian and North American Species
- A Review of Parasites and Diseases of Wild Swift Fox

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