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SWIFT FOX RESPONSE TO PRESCRIBED FIRE IN SHORTGRASS STEPPE

Craig M. Thompson[1,2], David J. Augustine[3], and Darren M. Mayers[4]

ABSTRACT.—Swift foxes (*Vulpes velox*) are shortgrass specialists and as a result are heavily dependent upon grassland disturbance regimes to maintain high-quality habitat. To better understand this relationship, we monitored the movement and spatial ecology of resident swift foxes before and after a 2005 prescribed burn in southeastern Colorado. We hypothesized that foxes would shift home ranges into and increase foraging activity within the prescribed burn area. Foxes did appear to alter their space-use patterns in response to the burn, although the response was constrained by territoriality. Foxes whose core-use areas overlapped the burn increased their use of the burn area for foraging and denning, but we did not observe shifts of individual home ranges to encompass more of the burned area. Foxes whose core-use areas did not overlap the burn did not alter their space use or change home range boundaries in response to the burn. Because we observed only positive or neutral responses to prescribed burning, we recommend this tool as an appropriate method to maintain high-quality swift fox habitat.

Key words: swift fox, Vulpes velox, *prescribed fire, disturbance, shortgrass prairie, Colorado, Comanche National Grassland.*

Historically, North American grasslands and shrubsteppe systems were maintained through the interactions of frequent, low-intensity disturbances (Valone et al. 2002). Drought, fire, and grazing by ungulates and prairie dogs (*Cynonyms* spp.) were key disturbances that contributed to a shifting mosaic in grassland structure and composition (Wright 1980, Lauenroth and Milchunas 1991, Knapp et al. 1999, Valone and Kelt 1999). Swift foxes (*Vulpes velox*) were well adapted to this mosaic and ranged throughout the Great Plains, from central Canada into New Mexico and Texas and from the Rocky Mountains east into Iowa (Stephens and Anderson 2005). However, during the 1900s, natural grassland systems were altered by the conversion of prairie into ranchland and cropland, fire suppression, predator-control programs, and shrubland expansion (Barbour et al. 1999). As a result of severe habitat loss, swift fox numbers declined, and in 1995 the species was classified as a candidate for listing under the Endangered Species Act and placed on the U.S. Forest Service regional sensitive species list. While populations appear to have stabilized, swift foxes currently inhabit only 25% of their historic range and existing populations are highly fragmented (Stephens and Anderson 2005).

Predation is a significant factor influencing swift fox populations, particularly predation by coyotes (Sovada et al. 1998, Olson and Lindzey 2002, Schauster et al. 2002, Kamler et al. 2003a). Because predation rates may be mediated by vegetation cover and structure, previous research has examined whether disturbances such as livestock grazing and other land-use practices can indirectly affect swift foxes (Thompson 2006). However, to our knowledge, no studies have examined the influence of prescribed burning or wildfires on swift fox space-use patterns. We evaluated the effects of a prescribed burn on swift foxes by monitoring the space use of resident swift foxes on the Comanche National Grassland in southeastern Colorado for 2 years (2003 and 2004) before a prescribed burn and 1 year (2005) after the burn.

The study area is within the Comanche National Grassland in Otero County and overlaps a 10-km swift fox trapping transect (Fig. 1). The area consists of shortgrass steppe dominated by blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*), with a sparse shrub layer dominated by tree cholla (*Cylindropuntia imbricata*). Mean annual precipitation during 1971–2000 for La Junta, Colorado (ca. 30 km north of the study area), was

[1]Department of Forest, Range, and Wildlife Sciences, Utah State University, Logan, UT 84322-5210.
[2]Present address: USFS Pacific Southwest Research Station, Sierra Nevada Research Center, 2081 E. Sierra Ave., Fresno, CA 93710. E-mail: cthompson@fs.fed.us
[3]USDA Forest Service, Comanche National Grassland, Box 127, Springfield, CO 81073.
[4]USDA Forest Service, Comanche National Grassland, 1420 E. 3rd St., La Junta, CO 81050.

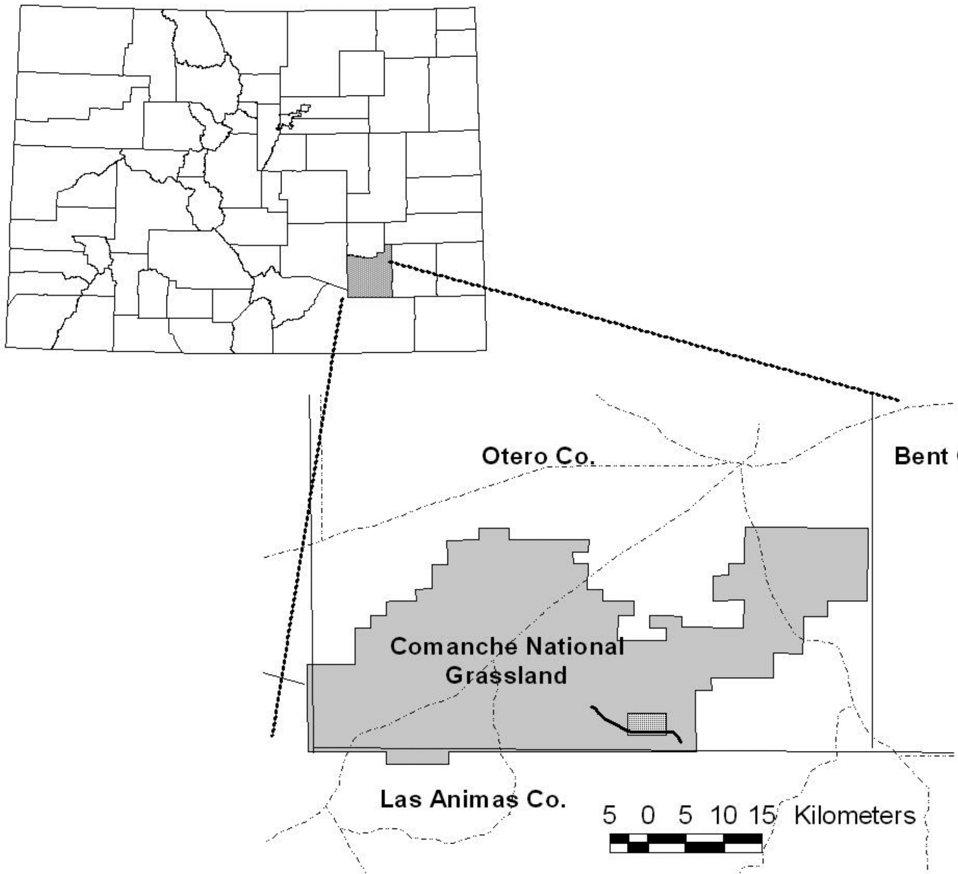

Fig. 1. Location of the Comanche National Grassland (CNG) and the approximate study area in southeastern Colorado. Shaded area indicates first Otero Co., and then the CNG boundary; crosshatched area indicates the approximate location and size of the 2005 Picketwire prescribed burn. The line intersecting the Picketwire burn indicates the 10-km transect along which swift foxes were captured.

30.0 cm. The study area is typically grazed by cattle from 1 May through 30 October each year, with a stocking rate of approximately 2.5 ha per animal unit month. For details on vegetative structure within the study area, see Thompson and Gese (2007). A prescribed burn was conducted on 260 ha within the study area during March 2005. Due to the timing of the burn (early spring) and the fuel loading (shortgrass steppe with a discontinuous litter layer), the burn was discontinuous, primarily consumed the grass layer, and did not affect the shrub layer.

We compared the size of pre- and post-burn home ranges, and the percentage of telemetry locations for individual animals located within the burn boundaries before and after the burn. We also determined whether resident foxes altered their space use in response to the burn by comparing pre- and post-burn den locations and comparing the overlap of 2003 and 2004 ranges versus the overlap of 2004/2005 ranges for the 2 animals whose territories overlapped the burn and who were initially captured in 2003. We used SASv8 (SAS Institute, Inc., Cary, NC) for statistical analyses and ArcView 3.2 (ESRI, Redlands, CA) for spatial analyses.

We captured foxes along a 10-km transect following the southern and eastern boundaries of the burn and extending to the west and north (Fig. 1). Double-door box traps (Tomahawk Live Trap Company, Tomahawk, WI) were placed 500 m apart and baited with raw chicken (Covell 1992, Karki 2003). Each trap was oriented and covered with brush to provide

TABLE 1. Adaptive kernel home ranges (km²) and associated samples sizes (n) for swift foxes monitored on the Comanche National Grassland in southeastern Colorado between March 2003 and July 2005.

Fox ID	Sex	Age	Date of capture	2003			2004			2005			Fate as of 31 Jul 2005
				95%	50%	n	95%	50%	n	95%	50%	n	
F201	F	adult	29 Jan 2002	5.61	0.94	34	3.29	0.68	64	3.09	0.73	27	mortality 8 Jul 2005
F202	M	adult	29 Jan 2002	10.38	3.39	48	7.07	1.48	75	9.14	1.32	25	alive
F243	M	juvenile	22 Oct 2002	8.30	0.81	45							mortality 18 Feb 2004
F269	F	juvenile	19 Aug 2003				4.88	1.13	75	2.74	0.63	22	mortality 22 Jun 2005
F283	M	adult	23 Feb 2004				6.16	0.81	80	5.53	0.98	30	alive
F301	M	juvenile	23 Nov 2004							4.92	0.95	26	alive

protection from sun exposure. Traps were set in the late afternoon, checked early the following morning, and left closed throughout the day. Captured foxes were handled without anesthesia, weighed, sexed, and aged (adult, juvenile) through tooth wear. Foxes were considered juvenile until the pup-rearing season following their birth (15 April). Foxes were eartagged and collared with 30–50-g radio-transmitters (Advanced Telemetry Systems, Isanti, MN).

We located foxes a minimum of 3 times per week, twice during nighttime hours when animals were actively hunting and once during daylight hours to locate den sites. Locations were considered independent when separated by at least 4 hours (Swihart and Slade 1985), which was more than sufficient time for a swift fox to cross its home range. Nocturnal locations were estimated using triangulation of 2–3 bearings collected within 5 minutes and separated by at least 40°. Locations were calculated using Program Locate II (Pacer, Truro, Nova Scotia). Diurnal locations were collected by tracking transmitter signals until either a den could be identified or the animal was observed. Using the home range extension for ArcView 3.2, we calculated seasonal adaptive kernel home ranges for animals that were located a minimum of 25 times.

Between January 2003 and December 2004, we captured 10 animals and equipped them with radio-collars (Table 1). Of these, we successfully monitored 6 to the point at which home range estimates could be generated. The remaining 4 were lost, due either to movement into inaccessible private land or to presumed collar failure. Four of the remaining animals were monitored long enough to provide pre- and post-burn home range estimates (Table 1).

Home Range Size

Prior to the burn, the 95% kernel home ranges of resident foxes averaged 6.53 ± 2.33 km² ($\bar{x} \pm s$), and the 50% core-use areas averaged 1.32 ± 0.95 km² (Table 1). After the burn, 95% home ranges averaged 5.08 ± 2.56 km² and 50% core use areas averaged 0.92 ± 0.27 km², a statistically insignificant change (95%: $t_8 = 1.00$, $P = 0.35$: 50%: $t_7 = 1.05$, $P = 0.33$).

Fox Use of Burn Area

The 2 foxes with home ranges and 50% core-use areas that overlapped the burn area (F201 and F283) denned inside the burn area

TABLE 2. Relative use of a prescribed burn area, before and after burn, by 4 resident swift foxes on the Comanche National Grassland in southeastern Colorado. Monitoring was conducted between 1 March and 31 July each year, and the burn was conducted in March 2005.

	Active telemetry locations collected			Proportion of active locations within burn boundary			Proportion of home range located within burn boundary		
Fox ID	2003	2004	2005	2003	2004	2005	2003	2004	2005
F201	27	58	20[a]	0.70	0.83	0.95	0.43	0.49	0.64
F202	37	65	22	0.11	0.02	0.05	0.15	0.08	0.07
F269		67	10[a]		0.01	0.10		0.11	0.02
F283		68	27		0.26	0.70		0.38	0.43

[a]Animal died during monitoring

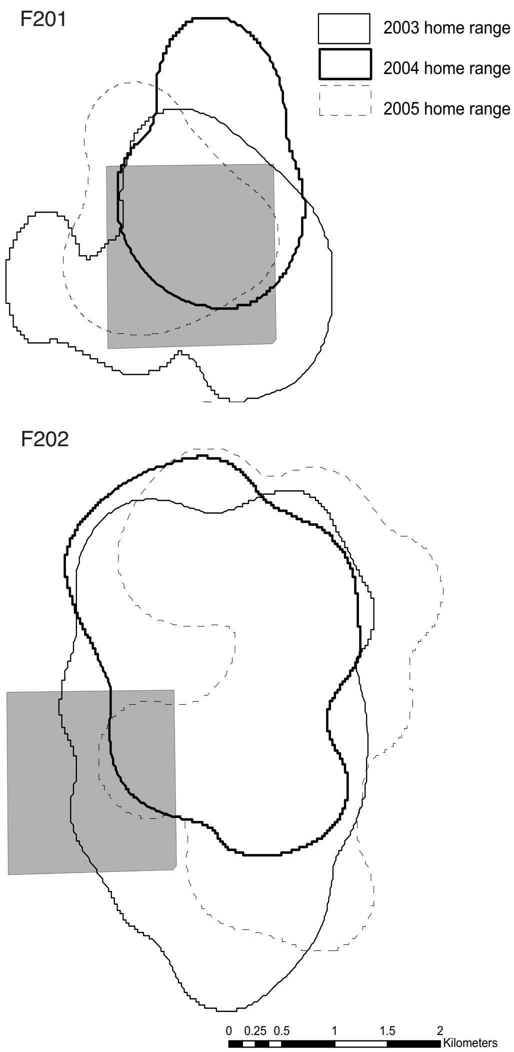

Fig. 2. Seasonal (March–July) home ranges for 2 swift foxes, F201 and F202, on the Comanche National Grassland in southeastern Colorado. The shaded area indicates a prescribed burn conducted in March 2005.

75% and 60% of the time prior to the burn, respectively. Both animals denned exclusively within the burn boundaries following the burn. For the 2 foxes with home ranges overlapping the burn but with 50% core-use areas outside the burn (F202 and F269), both denned exclusively outside the burn area both before and after the burn. This suggests that the foxes whose core-use areas overlapped with prescribed burns increased their use of the burned area for denning.

Swift fox use of the burn area for hunting, based on the percentage of nocturnal locations within the burn boundaries, also increased following the burn. Two of the animals, F201 and F202, were captured early in 2003, providing both 2003/2005 and 2004/2005 comparisons. The remaining 2 foxes, F269 and F283, were captured in 2004 and provided only 2004/2005 comparisons. Prior to the burn, these animals were located within the burn area 32.2% of the time (Table 2). After the burn, these same animals were located within the burn area 45.0% of the time, with average use increasing 14.5% (Table 2). While this is a statistically insignificant difference based on a paired, 2-tailed *t* test ($t_5 = 2.005$, $P = 0.10$), this is likely a result of the small sample size.

Annual Change in Home Range Placement

Similar to the comparison of hunting locations, we were able to make 6 comparisons between the percentage of home range overlap with the prescribed burn area for control (pre-burn) seasons and treatment (post-burn) seasons. Prior to the burn, resident fox home ranges averaged a 27% ± 18% overlap with the prescribed burn area (Table 2). Following the burn, the ranges averaged a 31% ± 29% overlap, a statistically insignificant difference based on a 2-tailed paired t test ($t_5 = 0.779$, $P = 0.47$).

Only 2 animals were tracked long enough to compare the change in home range placement following a control period (2003–2004) to that following a treatment period (2004–2005). The 95% kernel home range in 2004 for F201, an adult female, overlapped her 2003 range by 68% (Fig. 2A). Her 2005 range overlapped her 2004 range by 58%. Similarly, the 95% kernel home range in 2004 for F202, an adult male, overlapped his 2003 range by 92% (Fig. 2B). His 2005 range overlapped his 2004 range by 62%. The lower percentage of overlap between 2004 and 2005 for both animals indicates that both resident foxes did change the placement of their home ranges more following the prescribed burn than between years without a burn. However, the direction of that shift did not appear to be influenced by the burn for either animal.

Mortality Rates

The average mortality rate of foxes increased in the year following the prescribed burn; however, this appeared to be a result of abnormally high pre-burn survival rather than reduced post-burn survival. During the 2003 and 2004 seasons, only 1 of 8 animals being monitored was killed. Three more were lost from our study due to their moving into inaccessible private land bordering the national grassland. During the 2005 season, 2 of 5 animals being monitored died. The 1st mortality was attributed to a vehicle collision based on the location and condition of the carcass, and the 2nd mortality was attributed to predation (carcass decomposed and scattered with no tracks observed).

Between 2002 and 2005, annual survival of swift foxes on the nearby Pinon Canyon Maneuver Site and private ranchlands averaged 0.52 ± 0.14 (Thompson 2006). Olson and Lindzey (2002) reported annual survival rates of swift foxes in Wyoming ranging from 0.40 to 0.69. Therefore, the 0.88 survival rate of swift foxes on the Comanche National Grassland during spring and summer months in 2003 and 2004 appears abnormal. The 0.60 survival rate we observed during the 2005 season is more consistent with other studies.

Swift foxes coevolved with grassland systems and as a result are affected by grassland disturbance processes that influence vegetation structure. When these natural disturbance regimes are disrupted, swift fox habitat quality may be degraded, leading to population decline. Kamler et al. (2003b) documented a nearly complete avoidance of Conservation Reserve Grasslands by swift foxes in Texas. They speculated that the tall herbaceous vegetation there, created by a lack of disturbance, formed an environment where swift fox visibility and mobility were reduced while coyote stalking cover was enhanced. Thompson (2006) reported a similar scenario, in which swift foxes avoided areas of reduced disturbance and high vegetation density on military lands in southeastern Colorado. In both cases even inexperienced juveniles showed an avoidance of the areas, indicating an innate behavioral response to habitat quality.

Although this study is based on a single prescribed burn and a limited number of foxes, experimental analysis of changes in vertebrate habitat is logistically difficult. We believe our study was the first to directly examine the relationship between fire and swift foxes in shortgrass steppe. Based on previous studies that have documented high coyote predation rates on swift foxes (Sovada et al. 1998, Olson and Lindzey 2002, Schauster et al. 2002), the fact that taller herbaceous vegetation reduces visibility for swift foxes (reviewed by Stephens and Anderson 2005), and the finding that many small mammal populations increase post-fire (Dubis et al. 1988, Valone et al. 2002), we hypothesized that foxes would shift home ranges into and increase foraging activity within the prescribed burn. While we did find evidence that foxes whose home ranges overlapped the burn area prior to burning spent more time within the prescribed burn boundaries after the burn, we found no evidence that swift foxes changed the placement of their home ranges to incorporate more of the burned area.

One additional factor to be considered is the intensity of the burn. Due to the discontinuous grass and litter layer, the burn primarily consumed large patches of standing dead grass but did not cause mortality in the scattered shrub layer. Prescribed burns or wildfires in shortgrass steppes that lack such a shrub layer may provide greater benefits to foraging swift foxes through greater reduction in overall vegetation height and improved visibility. Conversely, in shortgrass steppe areas with a shrub layer, increased fire intensity may be necessary to achieve similar results.

Swift fox habitat quality represents a balance between prey availability and exposure to predation (Thompson and Gese 2007). Low-intensity grassland fire, a natural component of historic swift fox habitat, has the capacity to shift that balance in favor of the foxes. In our observations territoriality may have precluded foxes from immigrating into burned areas, and the burn itself did not significantly alter the spatial structure of the population. However, resident animals whose ranges overlapped the burned area spent more time hunting within the burn, presumably reflecting an increase in habitat quality. By reducing the risk of intraguild predation and increasing prey availability, prescribed burning may be an effective means to enhance swift fox population persistence.

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