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CHARACTERISTICS OF NATAL AND NON-NATAL KIT FOX DENS IN THE NORTHERN CHIHUAHUAN DESERT

Penny J. Rodrick[1] and Nancy E. Mathews[2]

ABSTRACT.—We studied kit fox den characteristics on the northern McGregor Range of Fort Bliss Military Reservation, New Mexico, during 1994 and 1995. Twenty radio-collared kit foxes used 132 different dens, including 16 natal dens. Kit fox dens were located primarily in creosote-dominated habitat found in relatively flat, well-drained terrain. Natal dens were virtually indistinguishable from non-natal dens; however, natal den entrances were taller than non-natal den entrances. Entrances found at all dens were oriented more frequently toward the northwest and southeast. Kit foxes used more new dens during the breeding (January–February) and pup-rearing season (May–July) than during gestation.

Key words: Vulpes macrotis neomexicana, *kit fox, dens, habitat use, Chihuahuan Desert, soils, GIS.*

Ecology of the desert kit fox (*Vulpes macrotis neomexicanus*) in the northern Chihuahuan Desert has not been previously studied. The region includes southeastern New Mexico and southwestern Texas and is recognized by some biologists as a zone of sympatry between the kit fox and swift fox (*V. velox velox*). Some question remains as to which species inhabits this area (Rohwer and Kilgore 1973, Thornton and Creel 1975, Dragoo et al. 1990, Mercure et al. 1993). The U.S. Fish and Wildlife Service (FWS) has concluded that the swift fox is declining throughout its range and determined its listing "warranted but precluded" due to other higher priority species (U.S. Federal Register 1995). It is now listed as a species of concern. Because the kit fox is closely related to the swift fox and appears to have similar behaviors, baseline ecological data for kit fox may contribute to swift fox conservation efforts.

Previous studies on the effects of military activities on San Joaquin kit foxes (*V. m. mutica*) in California demonstrated few direct adverse impacts (Berry et al. 1992, Reese et al. 1992). Controlled public access including hunting and trapping, restricted vehicle traffic, and limited land development on several western military reservations may preserve suitable habitat necessary to sustain fox populations. Although authorized military activities such as missile firings, vehicle traffic, and field exercises may negatively impact some areas suitable for kit fox dens, such disturbance may positively alter vegetation important to prey populations. The primary concern on military lands, however, is destruction of suitable denning habitat by vehicles or construction.

Kit and swift foxes use underground dens for escape cover, protection from environmental conditions, and raising pups (Seton 1925). These foxes are 2 of the only canids to use dens year-round, and they typically use a subset as natal dens in which to raise pups (Morrell 1972). Egoscue (1975) suggested kit fox populations may be limited by available denning habitat. While this has not been definitively confirmed, the kit fox's strong dependence on den sites throughout the year is critical to its survival. We undertook our study to further understand kit fox denning behavior and to describe characteristics of natal dens, non-natal dens, and surrounding denning habitat on the northern McGregor Range of Fort Bliss Military Reservation, New Mexico. Recognition of differences in den traits and denning habitat may assist the military in land-use decisions.

STUDY AREA AND METHODS

Our study area encompasses approximately 53 km^2 in the northern portion of McGregor Range on Fort Bliss Military Reservation in south central New Mexico. Fort Bliss lies in the Tularosa Basin surrounded by the San Andres, Franklin, and Organ Mountains to the

[1]Department of Wildlife Ecology, University of Wisconsin–Madison, 226 Russell Labs, 1630 Linden Dr., Madison, WI 53706.
[2]Department of Wildlife Ecology, University of Wisconsin–Madison, 215 Russell Labs, 1630 Linden Dr., Madison, WI 53706. Corresponding author.

west, Otero Mesa and Hueco Mountains to the east, and Sacramento Mountains to the north. McGregor Range includes 288 km^2 of transition zone from the northern Chihuahuan Desert to the Sacramento Mountains. Elevation ranges from 900 to 1800 m. The area is arid to semiarid with variable precipitation of 8–25 cm per year (Gile and Grossman 1979). Vegetation consists of creosote (*Larrea tridentata*) and tarbush (*Flourensia cernua*) flats, grasslands predominantly characterized by burrow grass (*Scleropogon brevifolius*) interspersed with cactus (*Opuntia* spp.) and yucca (*Yucca* spp.), mesquite (*Prosopis glandulosa*) dunes, and saltbush (*Atriplex canescence*) dunes.

Military activities on McGregor Range include the firing of 7.62-mm coax machine guns, 25-mm Bradley fighting vehicles, Stinger and Avenger missiles, and HAWK and Patriot missiles. These munitions are launched from stationary firing positions into designated impact areas on north McGregor Range. Greatest military use occurs annually during 3 wk in May and June. Primary activities during this period include missile firings and field training. Vehicles, which range from 4-person Jeeps to 28-ton Patriot launchers, utilize only improved, designated roads. Approximately 3500 personnel are involved in off-road field training exercises primarily on Otero Mesa. The range is also used September through December for firing missiles into designated impact areas.

Kit foxes were live-trapped using single-gate, wire-box traps and fitted with radio collars during late January through early June 1994, and late January through February 1995 (Zoellick and Smith 1986, White et al. 1991). Traps were baited and opened for 4 nights. Foxes were handled without using immobilization drugs when possible. When immobilization became necessary, a 5:1 mixture of ketamine hydrochloride (Ketaset, 4.0 mg/kg) and acepromazine maleate (Promace, 0.25 mg/kg) was administered intramuscularly. All foxes were fitted with numbered ear tags. Adults were fitted with a 70-g radio collar equipped with an activity sensor and released at the trap site.

We identified known kit fox dens by tracking radio-collared individuals to dens 3–6 times per week 31 January–14 July 1994 and 1995. The number of dens used by foxes was determined for each of 3 seasons: breeding (31 January–28 February), gestation (1 March–30 April), and pup-rearing (1 May–14 July). Weekly den use was standardized using length of time in each breeding season (breeding 2.9 wk, gestation 8.7 wk, pup-rearing 10.7 wk). Seasonal descriptions of den use were based on observations of resident kit fox behavior.

We used 2 methods to analyze den use. First, we examined the rate of den site change by comparing average number of dens used per fox, including previously inhabited dens revisited by the same fox, between years and among the 3 seasons using 2-way ANOVA. Second, we examined the seasonal rate of new den use by comparing only the number of new dens occupied by each fox, also using 2-way ANOVA. If the season × year interaction was not statistically significant, data were combined and a 1-way ANOVA was used to compare den use among seasons. Analyses were considered statistically significant if $P \leq 0.05$

Habitat condition at each den site was assessed in a 5-m-radius circle (78.5 m^2), centered over the central den entrance, during June and July of each year. In a network of dens with many openings, the entrance that appeared to have most use was classified as the central entrance. Caved-in entrances were not tallied. A den was classified as a natal den based on presence of pup scat or observation of pups at the den site. Mean and standard error were determined for physical characteristics, including height and width of the central entrance and number of entrances at each den.

We categorized surrounding habitat as creosote, grass, mesquite, tarbush, saltbush, or a combination of these types, based on visual assessment of predominant vegetation. Identifying and counting each stem within the circle assessed density of surrounding vegetation. Relative percent cover was estimated at 4 points, randomly placed along a 5-m radius in each cardinal direction. At each point cover was estimated using a 0.8-m^2 circular sampling point frame. Vegetation was classified as shrub, grass, cactus, or yucca. Percent cover of litter, lichen, and bare sand was also estimated. The 4 cover measurements were averaged for analysis. Mean and standard error of stem counts within the sampling radius were determined to compare vegetation density surrounding dens. Mean percent of total vegetative cover was determined in addition to mean percent of cover for shrub, grass, yucca, cactus,

sand, litter, and lichen. We compared all variables between natal and non-natal dens using t tests and considered analyses statistically significant if $P < 0.10$.

A global positioning system was used to determine Universal Transverse Mercator (UTM) coordinates at 94 den sites. UTM coordinates were input into a geographic information system (GIS; ArcInfo) and plotted on a soil survey map. Land slope and aspect at each den site were determined using digital topographic maps in GIS format. The proportion of dens present within each soil type, slope, and aspect class was analyzed relative to availability of those classes in the 53-km^2 study area using chi-square analysis. Den opening orientation was classified as north, northeast, east, southeast, south, southwest, west, or northwest and tested using a chi-square test. Dens with missing data were censored from analyses for that variable but remained in the analysis for remaining variables.

RESULTS

We captured 20 kit foxes (14 females, 6 males) during 1680 trap-nights in 1994 and 1995. During the study period we observed 7 different mated pairs. Based on 480 radiolocations, 116 non-natal and 16 natal dens were located. Mean number of den site changes did not differ within seasons between years ($P = 0.84$). When each year was combined, the rate of den site changes did not vary seasonally ($P = 0.28$; Fig. 1). The number of new dens used within each season did not differ between years ($P = 0.99$). Therefore, years were combined and we found that kit fox used more new dens during breeding and pup-rearing seasons ($P = 0.05$; Fig. 2).

Natal dens did not differ from non-natal dens with few exceptions (Table 1). Natal den entrances were taller than non-natal den entrances ($P = 0.01$). Overall, den entrance heights were significantly larger than widths ($P < 0.01$). Vegetative characteristics did not differ between natal and non-natal dens, although mean percent vegetative cover tended to be greater around natal dens ($P = 0.10$). Cactus species were more abundant around non-natal dens ($P = 0.02$).

Kit foxes on McGregor Range denned more frequently than expected in creosote habitat associations, relative to availability ($P < 0.01$; Fig. 3). Small sample sizes precluded statistical analysis of habitat differences between natal and non-natal dens. Kit foxes denned more frequently than expected within the Mimbres-Tome soil series association in relation to its availability ($P < 0.01$). Ninety-four percent ($N = 88$) of kit fox dens were located within this series, which is well drained and occurs throughout lowlands. Slope is less than 5% and flooding may occur periodically. Predominant vegetation associated within this series is creosote bush. Most soil within this association is

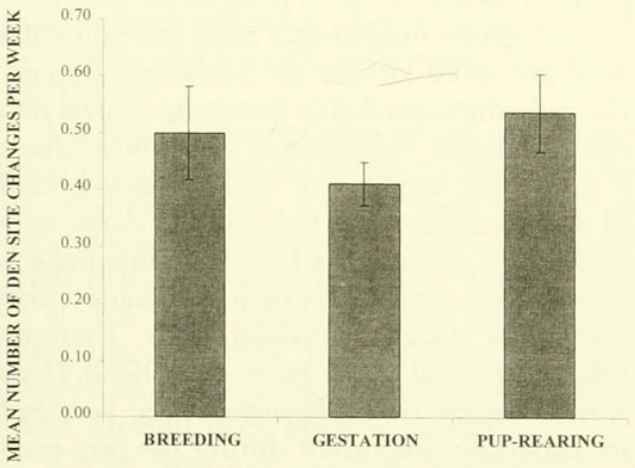

Fig. 1. Mean and standard error number of den site changes per week by kit foxes during breeding, gestation, and pup-rearing seasons in the northern Chihuahuan Desert, Fort Bliss Military Reservation, New Mexico, 1994 and 1995.

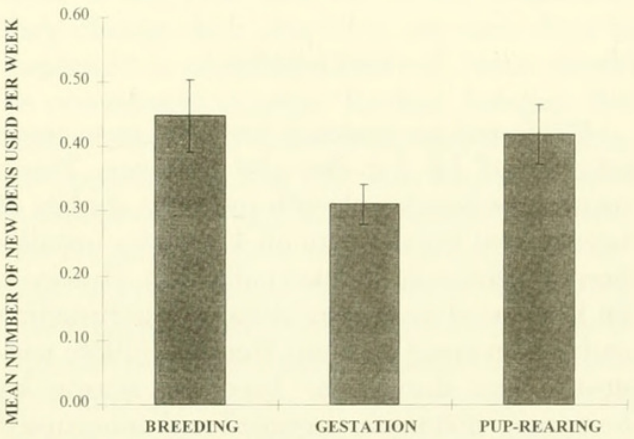

Fig. 2. Mean and standard error number of new dens used per week by kit foxes during breeding, gestation, and pup-rearing seasons in the northern Chihuahuan Desert, Fort Bliss Military Reservation, New Mexico, 1994 and 1995.

TABLE 1. Physical and vegetative characteristics of natal and non-natal kit fox dens on Fort Bliss, Otero County, New Mexico, 1994–1995.

Characteristic	Non-natal dens (mean ± $s_{\bar{x}}$)	N	Natal dens (mean ± $s_{\bar{x}}$)	N	P-values
Mean den entrance height (cm)	19.9 (0.4)	116	22.9 (1.5)	16	0.01
Mean den entrance width (cm)	18.7 (0.4)	116	19.6 (0.1)	16	0.18
Mean number of den entrances	1.9 (0.2)	116	2.0 (0.3)	16	0.39
Mean percent shrub cover	13.4 (1.5)	80	14.0 (0.3)	15	0.44
Mean percent yucca cover	0	80	1.3 (0.3)	15	0.17
Mean percent cactus cover	0.1 (0.1)	80	0	15	0.02
Mean percent grass cover	19.6 (1.7)	80	23.7 (4.0)	15	0.19
Mean percent sand cover	52.9 (1.8)	80	45.5 (4.0)	15	0.05
Mean percent litter cover	11.5 (1.3)	80	10.5 (2.1)	15	0.37
Mean percent lichen cover	5.0 (1.0)	80	6.1 (1.9)	15	0.34
Mean percent total vegetative cover	31.4 (1.4)	80	38.6 (5.1)	15	0.10
Shrub density (stems per 78.5m^2)	46.2 (4.7)	106	32.6 (6.8)	15	0.28
Grass density (stems per 78.5m^2)	49.9 (4.7)	106	32.9 (10.3)	15	0.20
Yucca density (stems per 78.5m^2)	0.3 (0.2)	106	0.3 (0.3)	15	0.85
Cactus density (stems per 78.5m^2)	1.7 (0.4)	106	0.9 (0.4)	15	0.42

silty loam or silty clay loam in higher elevations and sandy loam in lower elevations (Derr 1981). There were several soil associations within the study area in which no dens of radio-collared kit foxes were located. These associations have steeper slopes, ranging from 5% to 20%, are more rocky, and may have been unsuitable for den excavation.

Eighty-five percent of the study area had minimal slope (0 to 1 degree). Kit fox dens were located in expected proportions within these slope classes ($P = 0.93$). Kit fox dens occurred more frequently than expected ($P = 0.03$) on slopes oriented to the northwest. Both natal and non-natal dens opened more frequently to the southeast and northwest ($P < 0.01$).

DISCUSSION

We found no seasonal variation in average number of kit fox den site changes. These results are consistent with previous studies of seasonal kit fox den use on a military installation in California (Reese et al. 1992). However, kit foxes used more new dens during breeding and pup-rearing seasons. Egoscue (1956) suggested that during the breeding season kit foxes may visit many occupied and unoccupied dens sites, possibly surveying for potential dens or a prospective mate. Egoscue (1956) also noted that on several occasions natal dens have been abandoned suddenly and the pups moved to a new den. Movement between natal dens has been attributed to predator avoidance, local depletion of food, or intolerable flea levels (Egoscue 1956). Such behaviors may have contributed to the greater number of new dens used per fox during these seasons.

Kit foxes often den with a mate or in a social group; therefore, there may be a lack of independence in den use among individual foxes. Within this study no groups of 3 or more radio-collared foxes were located, and paired radio-collared kit foxes were found in the same den in only 20% of total locations. Although we did not account for autocorrelation in our analysis, we recognize that we may have underestimated the average number of new dens due to the presence of mated pairs in our sample.

Our results suggest that natal and non-natal dens are quite similar on McGregor Range. The only distinguishable feature is central den entrance height. Furthermore, a "keyhole" shape (e.g., greater height than width) characterized all den entrances. We believe this shape may allow quick entrance by kit foxes while impeding entrance of predators such as coyotes (*Canis latrans*) or badgers (*Taxidea taxus*; Egoscue 1962, Berry et al. 1987, Reese et al. 1992). Dens provide escape cover throughout the year but are especially important during the pup-rearing season when pups are most vulnerable.

Kit foxes selected sites most frequently in creosote habitat associations. Denning habitat in general was characterized by relatively short, patchy vegetation. These results concur with

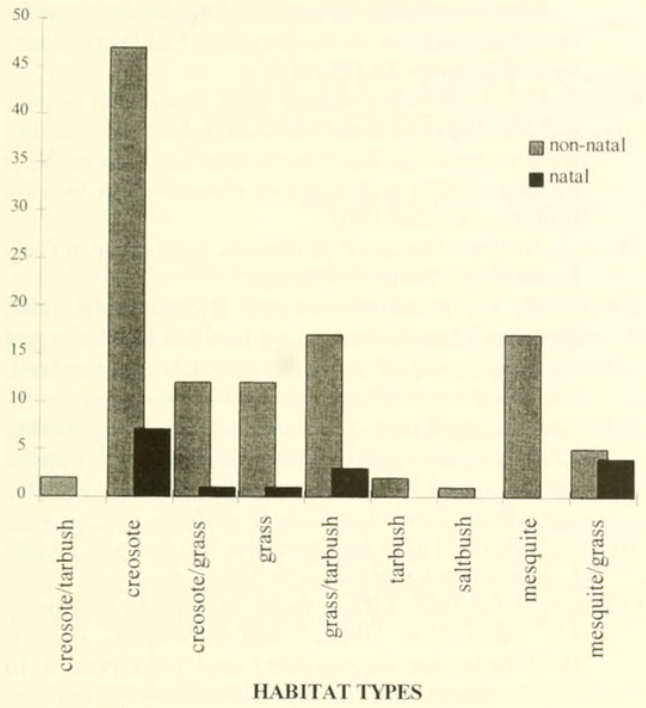

Fig. 3. Number of kit fox dens by habitat type in the northern Chihuahuan Desert, Fort Bliss Military Reservation, New Mexico, 1994 and 1995.

previous studies examining kit fox habitat utilization throughout their range (Egoscue 1956, 1962, O'Farrell 1987, Zoellick et al. 1989). Egoscue (1962) stressed the importance of creosote habitat for den sites in the Great Basin and suggested that kit foxes utilize adjacent sandy dune habitat in Utah for foraging. Both kit and swift foxes have demonstrated an ability to adapt to open habitats including creosote flats and grasslands with low and sparse vegetation. These adaptations may allow small foxes to more efficiently detect predators such as coyotes and bobcats (*Felis rufus*; Zoellick et al. 1989).

We found characteristics of soil and terrain used as denning habitat similar to those reported in previous studies. Kit and swift foxes typically den in loose, sandy, and well-drained soils (Hall 1946, Cutter 1958, Egoscue 1962, O'Neal et al. 1987, Zoellick et al. 1989, Reese et al. 1992). Past studies indicate dens are often located on gentle to moderate slopes (Egoscue 1956, Morrell 1972, Berry et al. 1987).

Kit fox dens were located on slopes with a northwest aspect more than expected, and den openings were more frequently oriented toward the northwest and southeast. Previous studies suggest that direction of den opening may reflect the prevailing orientation of slopes in the area (Berry et al. 1987). While aspect may confer special advantages for dens, direction of den opening may be related to site-specific conditions such as vegetation, drainage, or climate. Den orientation for red fox (*V. vulpes*) on Assateague Island, Maryland, is often associated with local prevailing wind directions (Krim et al. 1990). Cheesemore (1969) found that most arctic fox (*Alopex lagopus innuitus*) den entrances had a southerly, easterly, or westerly orientation, possibly indicating a preference for a warmer exposure. If orientation is related to wind and microclimate, it is possible that kit foxes orient their dens toward a cooler northern exposure. We did not, however, assess any microclimatic variables.

Recognition of kit fox dens and denning habitat may be useful to the military in making land-use decisions and assessing potential impacts of activities on the environment. Previous studies of the effects of military activities discovered that vehicles had damaged several dens, but kit foxes were not trapped inside the dens (Berry et al. 1992). On our study site we did not observe direct impacts resulting from military activity on any surveyed dens. Additionally, there was no evidence of damage to dens from live-fire exercises. However, we had limited access to designated impact zones to fully document effects of such use in this area.

Berry et al. (1992) suggest that numerous dens sites provide adequate shelter and protection for kit foxes while allowing for the destruction of several dens without adversely impacting fox populations. Because kit foxes change dens at a constant rate throughout most of the year, and we do not know why they change their den sites, we view dens as important to population survival. None should be considered surplus. Further, because few traits distinguish natal from non-natal dens, we recommend that all dens be considered potential natal dens. Although military activities do not adversely impact den sites on our study area, off-road activities hold the greatest potential for inadvertent impacts to dens or suitable denning habitat. Careful consideration should be given to intensity of off-road activities in potential kit or swift fox habitat.

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