Movements and Habitat Use by Coyotes and Bobcats on a Ranch in Southern Texas[1]

Lisa C. Bradley,[2] *Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843*

Daniel B. Fagre,[3] *Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843*

Abstract: Movements of coyotes (*Canis latrans*) ($N = 6$) and bobcats (*Felis rufus*) ($N = 4$) on the La Copita Research Area in southern Texas were determined by radio-telemetry from April 1985 through September 1986. Mean home range sizes of resident individuals were 3.04 km^2 for coyotes and 2.88 km^2 for bobcats. These predators frequently traveled outside their home ranges and exhibited extensive interspecific home range overlap. Frequent travel outside the home range seemed related to subsequent dispersal. Several individuals captured on La Copita proved to be non-residents or temporary residents of the ranch. Thickets and drainages were important habitat types in bobcat home ranges. Coyotes were less selective in their habitat use patterns. Drainages were used as travel corridors by both coyotes and bobcats.

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The Rio Grande Plains Region of southern Texas (Gould 1975) supports high densities of coyotes (*Canis latrans*) and bobcats (*Felis rufus*). Knowlton et al. (1986) reported densities of 1.4–2.7 coyotes/km^2 in Webb County. Andelt (1985) estimated a density of 0.9 coyotes/km^2 on the Welder Wildlife Refuge in San Patricio County. Beasom and Moore (1977) collected 51 bobcats in 1971 and 74 bobcats in 1972 on a 23.3-km^2 area in Kleberg County, resulting in yearly density estimates of 2–3 bobcats/km^2.

The home ranges and social structure of coyote populations have been studied in various geographic regions, including southern Texas (Andelt 1985), but little

[1] Manuscript No. TA-22950 of the Texas Agricultural Experiment Station.

[2] Present address: Department of Range and Wildlife Management, Texas Tech University, Lubbock, TX 79409.

[3] Present address: Indiana Dunes National Lakeshore, 1100 N. Mineral Springs Rd., Porter, IN 46304.

information is available on bobcat ecology in this region. Also, the spatial and temporal interrelationships between these species with regard to home range overlap and habitat use in this region have not been considered.

Understanding the interrelationships between these carnivores and their relationships to the brush country ecosystem of southern Texas will become increasingly important as the area is fragmented by agricultural development. Information on habitat use and movement patterns will aid wildlife biologists and ranch managers in predicting changes in local coyote and bobcat populations resulting from changing land use practices.

The purpose of this study was to determine home ranges, movements, habitat use, and interspecific relationships of coyotes and bobcats in southern Texas. More specifically, we wanted to determine the use by coyotes and bobcats, as potential predators of livestock and marketable wildlife, of a typical southern Texas ranch managed for both cattle and wildlife production.

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Methods

Study Area

The study was conducted at the La Copita Research Area, a 10.9-km^2 ranch located in western Jim Wells County, Texas, in the ecotone between the Rio Grande Plains and Gulf Coast Prairies (Gould 1975). The climate of this region is warm and humid. Average annual rainfall is 67.7 cm. Average daily temperature is 30.5° C in summer and 12.2° C in winter (Soil Conservation Service 1979).

La Copita is predominantly flat, with slopes from 0%–5%. The mean elevation is 83.8 m. Approximately 69% of the ranch is composed of upland range sites associated primarily with sandy loam and gray sandy loam soils. La Copita's drainage areas are claypan prairie and clay loam range sites (Soil Conservation Service 1979).

Common shrub species at La Copita included honey mesquite (*Prosopis glandulosa*), huisache (*Acacia farnesiana*), blackbrush (*Acacia rigidula*), whitebrush (*Aloysia gratissima*), lime prickly ash (*Zanthooxylum fagara*), brasil (*Condalia obovata*), spiny hackberry (*Celtis pallida*), Texas persimmon (*Diospyros texana*), and prickly pear cactus (*Opuntia* spp.) (Walsh 1985). Common forb and grass species included common broomweed (*Xanthocephalum dracunculoides*), sensitivebriar (*Shrankia latidens*), dayflower (*Commelina erecta*), doveweed (*Croton* spp.), Indian mallow (*Abutilon incarnum*), bermudagrass (*Cynodon dactylon*), purple threeawn (*Aristida purpurea*), curly mesquitegrass (*Hilaria belangeri*), buffelgrass (*Cenchrus ciliaris*), bristlegrasses (*Setaria* spp.), and *Chloris* spp. (Walsh 1985).

Overall, the vegetation type was a thornscrub woodland with a variety of habitat sub-types. Vegetative types and habitat diversity on La Copita were typical of most ranches in the region. In recent years, however, clearing of brushland for agricultural purposes has increased.

Eight habitat types were identified based on dominant vegetation structure patterns. Habitat descriptions, modified from Walsh (1985), were as follows 1) motty savannah—mottes (clumps) of brush scattered over native grassland, light to moderate brush cover between mottes; 2) motty brushland—brush mottes scattered over native grassland, extensive low brush cover between mottes; 3) drainage—dense brush bordering an intermittent stream, limited grass and forb production; 4) park—mesquite and huisache forming a dense canopy approximately 3 m over an intermittent stream, lush ground cover of grasses and forbs; 5) thicket—dense stand of upland brush, suppressed grass and forb production; 6) regrown clearing—an area cleared in 1978 that was being re-invaded by brush of varying heights and densities, although grasses still dominated; 7) agricultural field—cultivated fields sown with wheat or grain sorghum and pastures used primarily for hay production; 8) laguna—ground depression containing water for extended periods after heavy rain, dense grass and forb production during wet periods, overstory of mesquite and huisache.

La Copita supported a cow-calf operation of approximately 100 head on a short-duration grazing system and 40 head on a 2-pasture deferred rotation grazing system. The ranch was leased for white-tailed deer (*Odocoileus virginianus*) and northern bobwhite (*Colinus virginianus*) hunting.

Prey items important in the diets of coyotes (fruits, rodents, lagomorphs) and bobcats (rodents, lagomorphs) were abundant on the study area (Drew 1988). Cotton rats (*Sigmodon hispidus*), a dominant item in coyote (Drew 1988) and bobcat (Beasom and Moore 1977) diets in southern Texas, irrupted during 1985–1986 and thus provided an abundant source of prey to coyotes and bobcats during this study.

Trapping and Telemetry

Coyotes and bobcats were captured with offset-jaw or padded leghold traps. Tranquilizer tabs (Balser 1965, Linhart et al. 1981) containing 250 mg acepromazine maleate were attached to the jaws of unpadded traps to minimize injury to the captured animals. Trap sites were located primarily along roads and game trails where predator activity was high based on scent-station data, individual sightings, and predator sign such as tracks and scats.

Captured coyotes and bobcats were sedated with 125 mg of ketamine hydrochloride. Age class (juvenile, adult) was estimated by condition of the teeth and body size. Each animal was fitted with a radio collar and numbered metal ear tags. Collars were of various colors to aid in post-release identification of individuals. Collared coyotes and bobcats were held in cages until they recovered from sedation before being released at the capture site.

Radio-telemetry data were collected from April 1985 through September 1986 using a truck-mounted antenna system. Both null and peak antennas were used during the study. Animal locations were determined by triangulation from any 2–4 of 79 permanent tracking stations. Attempts were made to obtain azimuths at 90° angles. Azimuths at <30° or >150° were excluded from analysis. A computer program designed specifically for this project was used to calculate the x,y-coordinates of the animal locations. Locations determined using 3 or more azimuths resulted in error triangles when the azimuths did not cross at the same x,y-coordinate. Error triangles up to 3 ha in size were accepted, but average size of the error triangles was 0.29 ± 0.01 ha, indicating a degree of system accuracy sufficient for our study. The extensive road network on La Copita allowed us to locate animals from a mean distance of 539 m, resulting in more accurate telemetry locations.

Radio tracking was conducted in 4- to 6-hour blocks for 24-hour periods, 6 to 8 times per month. Mean time interval between radio locations for an individual was 2.4 hours. Thus, data were collected sequentially over 24-hour samples as suggested by Laundre and Keller (1984), although sampling intensity varied with changes in the number of radio-collared individuals, radio antenna malfunctions, road and weather conditions that precluded travel, and other factors. In addition, aerial radio tracking was conducted in January, February, and September 1986 to search for animals that could no longer be located on La Copita. At least twice each month throughout the study period, we also attempted to locate these individuals on La Copita using the ground telemetry system.

Calculations and Data Analyses

The outer 5% of each animal's locations were identified by the 95% harmonic mean option of the microcomputer program McPaal (Stuwe and Blohowiak 1985). These locations were eliminated from home range data sets to reduce the influence on home range size of outlying locations resulting from occasional short-term excursions (Burt 1943, Andelt 1985). Home range sizes were determined by the minimum convex polygon option of McPaal (Stuwe and Blohowiak 1985), which plotted the locations and home range boundaries. We chose this method of home range calculation because it was most comparable to other studies of coyote and bobcat home ranges.

Preference or avoidance of habitats was determined for each animal by comparing the proportion of radio locations within each habitat type to the proportion of the home range composed of each habitat type. These proportions were tested using a Chi-square analysis and the family confidence interval method of Neu et al. (1974).

Relative movement indices were determined by dividing the distance moved between successive locations by the time interval between those locations. Locations obtained less than 6 hours apart were considered successive.

Home range sizes were compared by analysis of variance. All means are presented as mean ± SE. Correlations were determined by Spearman's rank order correlation.

Results and Discussion

Trapping

Six male coyotes, 6 female coyotes, 3 male bobcats, and 4 female bobcats were captured on La Copita in 1,424 trap nights. The relatively high capture success of 1.1 coyotes/km^2 and 0.6 bobcats/km^2 may be attributed primarily to the high density of coyotes (Andelt 1985, Knowlton et al. 1986) and bobcats (Beasom and Moore 1977) in this region, as well as the lack of human exploitation of these populations. One adult male bobcat was re-captured because of a failing transmitter.

Four of the 12 coyotes and 3 of the 7 bobcats were captured in a single drainage. Although the uneven distribution of the trapping effort may have influenced the capture success rate in this drainage, it was of interest to note that of 3 coyotes and 1 bobcat that moved off La Copita and were later located by airplane up to 17 km from the ranch, 2 coyotes and the bobcat still were associated with the same narrow drainage system surrounded by agricultural lands. Thus, drainages appeared to be important to coyote and bobcat movements through open habitats in southern Texas. Studies conducted in various geographic areas have demonstrated the importance of stream or riparian habitats as travel corridors to coyotes (Andelt and Andelt 1981) and bobcats (Lawhead 1984, Shiflet 1984). The use of drainages and riparian strips as travel corridors by coyotes and bobcats could prove especially important as the southern Texas brushlands become increasingly fragmented by agricultural development.

Home Ranges

Of the 19 predators captured, 11 coyotes and 5 bobcats were radio-collared. A total of 2,122 radio locations was obtained for these 16 individuals (Table 1). However, based on observation-area curves (Odum and Kuenzler 1955), sufficient data were obtained to determine home range sizes for only 6 coyotes and 4 bobcats (N = 2,039 locations). Figure 1 illustrates observation-area curves for an individual whose home range was not adequately defined (a) and for an individual whose home range was defined (b). The mean number of radio locations obtained for each individual was 25 ± 1/month and data were distributed evenly throughout the tracking period of each animal.

Mean home range sizes were 3.07 ± 0.77 km^2 for male coyotes (N = 4) and 3.01 ± 0.22 km^2 for female coyotes (N = 2) (Table 1). The male bobcat that was re-captured shifted its home range after the second trapping experience. This bobcat's 2 home ranges were averaged for analysis. Mean home range size for 3 male bobcats was 3.45 ± 0.09 km^2 (Table 1). The home range size of 1 female bobcat was 1.16 km^2 (Table 1). Male and female coyote home range sizes were not different ($P > 0.05$). Combining the sexes, coyote and bobcat home range sizes were not different ($P > 0.05$). Home range estimates were not correlated with the number of radio locations ($r = 0.35$, $P > 0.20$). Although small sample sizes did not permit statistical analyses of seasonal home ranges, no major shifts in home range size or

Table 1. Summary of telemetry data on coyotes and bobcats at La Copita Research Area, 1985–1986.

Id. No.	Capture date	Species	Sex	Age class[a]	Length of residence	*N*[b]	Status[c]	Home range (km^2)	Date of last signal on area	Dispersal distance
1060	30 Jan 85	Coyote	M	A	239 days	142	Res./disp.	4.74	Oct 85	3 km
1262	16 Apr 85	Coyote	M	A	149 days	62	Res./unk.	1.29	Sep 85	?[d]
1570	17 Jan 86	Coyote	M	A	14 days	12	Res./unk.	ID[e]	Feb 86	?
1540	22 Jan 86	Coyote	M	A	81 days	81	Res./unk.	3.84	Apr 86	?
1628	26 Apr 86	Coyote	M	A	36 days	50	Res./unk.	ID	Jun 86	?
0700	17 Aug 85	Coyote	M	J	354 days	351	Resident	2.40	—[f]	—
1460	10 Apr 85	Coyote	F	A	0 days	4	Non-resident	ID	NL[g]	13 km
1590	1 May 86	Coyote	F	A	0 days	0	Unknown	ID	NL	?
0746	3 Feb 86	Coyote	F	A	266 days	211	Res./unk.	3.23	Aug 86	?
1600	28 Mar 86	Coyote	F	A	153 days	193	Resident	2.79	—	—
0767	29 Nov 85	Coyote	F	J	2 days	14	Non-resident	ID	Dec 85	17 km
0722	22 Nov 85	Bobcat	M	A	140 days	110	Res./unk.	3.58	Apr 86	?
1642	16 Apr 85	Bobcat	M	A	499 days	403	Resident	3.49	—	—
1553	28 Feb 86	Bobcat	M	A	210 days	238	Resident	3.29	—	—
1510	27 Jan 85	Bobcat	F	A	0 days	3	Non-resident	ID	NL	11 km
1522	28 Jan 86	Bobcat	F	A	241 days	248	Resident	1.16	—	—

[a]A = adult, J = juvenile.
[b]Number of locations, including ground telemetry locations, aerial telemetry locations, and sightings.
[c]Res./Disp. refers to an animal that dispersed from the study area after a period of residence. Res./unk. refers to animals that were residents of the study area, but final status was unknown after loss of radio contact.
[d]Never located after loss of radio contact on La Copita.
[e]Insufficient data to determine home range size.
[f]Did not disperse from the study area.
[g]Never radio located on La Copita after release.

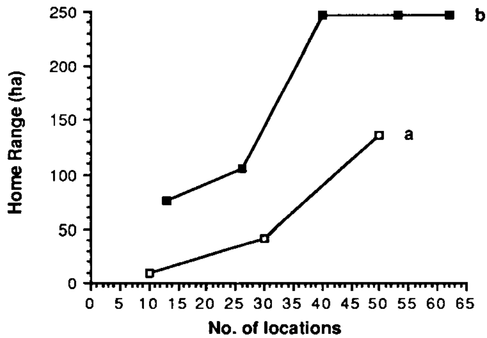

Figure 1. Example of observation-area curves for (a) an undefined home range and (b) a defined home range.

location associated with biological seasons as defined by Smith et al. (1981) were noted for any of the predators. Andelt (1985) reported that seasonal home ranges of resident adult coyotes on the Welder Wildlife Refuge did not differ.

The home range sizes determined in this study are among the smallest reported, especially for coyotes. Andelt (1985) summarized data indicating that small home range sizes are a function of high coyote densities related to abundant food resources and suitable habitat. Andelt (1985) reported slightly larger home range sizes for resident adult coyotes on Welder Wildlife Refuge. Using 95% of the locations, mean minimum area home range sizes were 4.7 km^2 for males and 4.3 km^2 for females. Other researchers have obtained mean home range estimates of 8.8 km^2 to 68.7 km^2 for resident adult coyotes (Andelt and Gipson 1979, Litvaitis and Shaw 1980, Bowen 1982, Roy and Dorrance 1985, Bekoff and Wells 1986). Variation in results can be dependent on the home range estimation procedure, although social organization, coyote densities, and prey densities also influence coyote home range sizes (Camenzind 1978, Bowen 1982, Andelt 1985).

Bobcat home range estimates also vary by home range estimation procedure, bobcat densities, and prey densities (Marshall and Jenkins 1966, Bailey 1974, Kitchings and Story 1978, Litvaitis et al. 1986). Hall and Newsom (1976) estimated mean home range sizes of 4.94 km^2 for adult males and 0.98 km^2 for adult females in Louisiana. For a dense bobcat population in chaparral habitat in California, Lembeck (1986) reported mean home range sizes of 0.84 km^2 for resident females and 1.55 km^2 for resident males.

Home range sizes of male bobcats are typically 2 to 3 times larger than those of females (Bailey 1974, Hall and Newsom 1976, Kitchings and Story 1978, Major 1983, Shiflet 1984, Lembeck 1986, Litvaitis et al. 1986). This likely is a function of the mating system of bobcats. Movements of female bobcats are restricted by litter-rearing responsibilities. A male bobcat's home range, however, encompasses as many females as he can successfully breed (Bailey 1974). Although only 1 female bobcat was radio-tracked in this study, her home range was one-third the average home range size of 3 male bobcats.

The home range shift noted above for an adult male bobcat (ID No. 1642)

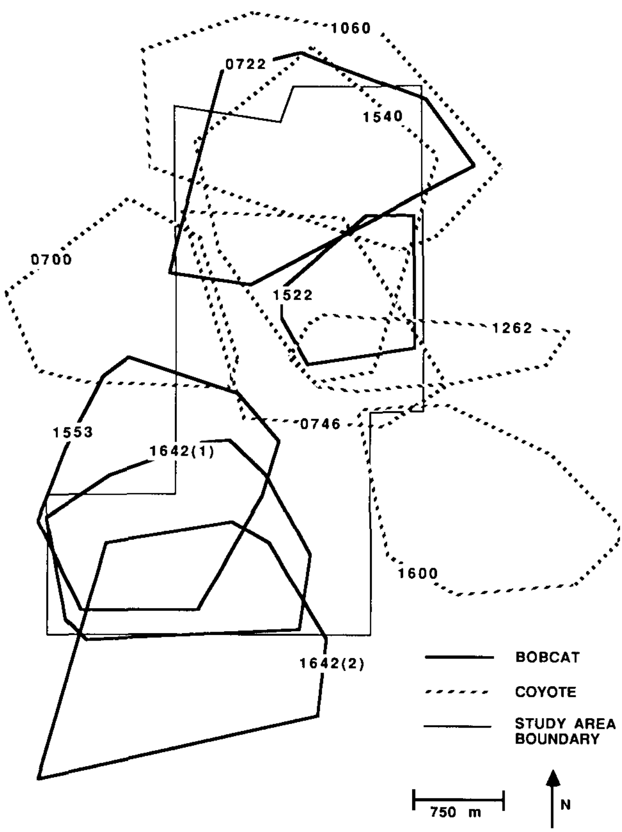

Figure 2. Home ranges of coyotes and bobcats radio-tracked on La Copita Research Area, 1985–1986.

occurred during March 1986. This individual had been radio-tracked for 9 months (N = 195 locations) within a stable, 3.12-km² home range (Fig. 2, 1642[1]). After its re-capture and release, the bobcat's home range shifted to the south, but overlapped the original area by 38%. The new home range (Fig. 2, 1642[2]) of 3.86 km² was maintained until termination of the study 6 months later (N = 188 locations). Apparently the shift was not of a seasonal nature.

We propose 2 possible explanations for this shift. Trapping may have caused the animal to shift its home range to avoid the capture site. This behavior has been suggested by Hibler (1977) and Laundre and Keller (1983) for coyotes. The male bobcat's home range shift in this study corresponded temporally with its re-capture, and the area surrounding the re-capture site was used less intensively after the shift, but this area was still within the boundaries of the new home range. A second possible explanation for the home range shift of 1642 was the displacement of this individual by another adult male bobcat (ID No. 1553) that was captured within

1642's home range just 3 days before 1642's re-capture. If 1642 had maintained its original home range boundaries, the ranges of these 2 individuals would have overlapped 57%–60% (Fig. 2). By shifting its home range, 1642's use area overlapped 1553's by only 17%. Thus, displacement of 1642 by 1553 seemed a plausible explanation.

Although Bailey (1974) reported no abandonment of home ranges by resident adult bobcats in Idaho, Lembeck (1986) reported that some individuals of a dense bobcat population in California were stable residents for up to 4 years before suddenly leaving the area. The abandoned home ranges were immediately occupied by area bobcats. Fendley and Buie (1986) suggested that at high densities resident bobcats may be unable to maintain their territories from intrusion by contiguous intrasexual territorial individuals, thus leading to eventual dispersal of some residents.

Habitat Use

Of the 10 predator home ranges, all contained ≥5 of the 8 habitat types, with 4 home ranges encompassing all 8 types. However, none of the coyotes or bobcats occurred in all habitat types in proportion to their availability within the home ranges. Male coyotes preferred motty brushland habitat and avoided park habitat ($P < 0.05$), while females avoided agricultural fields ($P < 0.05$) (Table 2). No other habitat types were avoided or preferred by coyotes.

Comparisons of habitat use studies are difficult to interpret because of variation in available habitat types among geographic regions. No other studies are available that address coyote habitat use in the brushland habitats of southern Texas. In general, studies of coyote habitat use have noted that coyotes prefer habitats supporting the highest prey densities (Ozoga and Harger 1966, Litvaitis and Shaw 1980, Andelt and Andelt 1981). In Oklahoma, preferred coyote habitats were savannah and prairie creeks, where the abundance of small mammals and fruit was high relative to prairie habitats avoided by coyotes (Litvaitis and Shaw 1980). In our study, high prey densities, abundant fruit, and the opportunistic feeding strategy of coyotes apparently minimized habitat selection by coyotes.

Male bobcats in our study preferred drainage and thicket habitats and avoided agricultural fields, motty savannah and parks ($P < 0.05$) (Table 3). The female bobcat preferred drainage habitat and avoided motty savannah and motty brushland ($P < 0.05$). Her home range did not include agricultural fields.

Bobcats appeared to be more selective than coyotes in their habitat use patterns. They avoided habitats with open understories and apparently required thicket or drainage habitats for home range establishment as well as for dispersal movements. Bobcat home ranges contained 34%–52% drainage and thicket habitat types, and every individual ($N = 4$) preferred ($P < 0.05$) 1 of these habitat types. No other habitat type was preferred by bobcats.

Heller and Fendley (1986) reported that bobcats in South Carolina preferred bottomland hardwoods, a habitat type characterized by high cover density and greater consistency of cover in the mid- and over-stories. Buttrey (1979) noted that bobcats in Tennessee apparently preferred rugged stream gorges and associated

Table 2. Occurrence of coyote locations in 8 habitat types within coyote home ranges on La Copita Research Area, southern Texas, 1985–1986.

Location	Male coyotes (N = 4)			Female coyotes (N = 2)		
	% habitat[a]	% locations	CL	% habitat	% locations	CL
Motty savannah	10.8	8.8	5.6–12.0	14.8	11.4	7.0–15.8
Motty brushland	27.8	35.6	30.2–41.0(+)[b]	8.5	12.5	7.9–17.1
Drainage	17.8	15.0	11.0–19.0	8.1	10.6	6.3–14.9
Park	1.6	0.0	0.0– 0.0(−)	0.7	0.3	−0.5– 1.1
Thicket	16.2	16.1	12.0–20.2	11.8	14.5	9.6–19.4
Regrown clearing	0.7	0.3	−0.3– 0.9	28.2	31.7	25.2–38.2
Agric. field	23.6	22.6	17.9–27.3	27.1	17.7	12.4–23.0(−)
Laguna	1.4	1.5	0.1– 2.9	0.8	1.3	−0.3– 2.9

[a]Proportion of each habitat type represents expected proportion of coyote locations as if coyote locations occurred in each habitat in exact proportion to availability within the home range.

[b](+) and (−) indicate preference and avoidance, respectively ($P < 0.05$).

Table 3. Occurrence of bobcat locations in 8 habitat types within bobcat home ranges on La Copita Research Area, southern Texas, 1985–1986.

Location	Male bobcats (N = 3)			Female bobcat (N = 1)		
	% habitat[a]	% locations	CL	% habitat	% locations	CL
Motty savannah	14.7	7.4	4.7–10.1(−)[b]	30.2	7.2	2.8–11.6(−)
Motty brushland	25.0	22.7	18.4–27.0	16.4	7.2	2.8–11.6(−)
Drainage	16.8	22.3	18.0–26.6(+)	40.5	74.3	66.8–81.8(+)
Park	0.9	0.3	− 0.3– 0.9(−)	0.9	0.4	− 0.7– 1.5
Thicket	27.7	39.4	34.4–44.4(+)	10.3	9.7	4.6–14.8
Regrown clearing	5.0	3.4	1.5– 5.3	—[c]	—	—
Agric. field	8.4	1.7	0.4– 3.0(−)	—	—	—
Laguna	1.5	2.8	1.1– 4.5	1.7	1.3	− 0.6– 3.2

[a]Proportion of each habitat type represents expected proportion of bobcat locations as if bobcat locations occurred in each habitat in exact proportion to availability within the home range.
[b](+) and (−) indicate preference and avoidance, respectively ($P < 0.05$).
[c]Habitat type did not occur within home range.

areas. As with studies of coyotes, many studies of bobcat habitat use have noted the relationship between preferred habitats and high prey densities (Kitchings and Story 1978, Rolley and Warde 1985, Litvaitis et al. 1986). However, Kruuk (1986) suggested that the hunting strategy of felids also influences habitat preferences. All felids hunt by stalking and then rushing their prey or by ambushing their prey. This hunting strategy necessitates that the predator remain undetected (Kruuk 1986). Thus, adequate cover is essential for bobcats to hunt successfully. In our study, the preference of bobcats for the 2 most dense habitat types on the study area likely was a result of both the prey and cover available in those areas. The long-term effects of clearing drainage and thicket habitats on bobcat populations in this region warrants further investigation.

Home Range Overlap

Figure 2 illustrates the home ranges of all coyotes and bobcats radio-tracked on La Copita. However, these home ranges were not known to all be occupied at the same time. Thus, intra- and interspecific overlap is reported here only when it was known to occur both spatially and temporally.

Intraspecific home range overlap of the coyotes and bobcats varied between individuals but generally was not extensive. Intraspecific overlap between coyotes ranged from 3.0% to 48.0% ($\bar{x}$ = 17.6 ± 8.6%) of an individual's home range area. Known periods of overlap ranged from 95 to 205 days ($\bar{x}$ = 151 ± 32 days). No overlap occurred between the ranges of collared male coyotes. Overlap occurred for 3.0% of the home ranges of female coyotes 0746 and 1600. Overlap between male and female coyotes occurred twice; the home ranges of 0700 and 0746 overlapped 4.5%–6.0% and the home ranges of 1540 and 0746 overlapped 41.0%–48.0%. Andelt and Gipson (1979) found a lack of coyote home range overlap for adults of the same sex. Roy and Dorrance (1985) found that coyote home ranges overlapped slightly but estimated that only half of the coyote population on his study area was collared. Litvaitis and Shaw (1980) reported variable degrees of home range overlap between female coyotes and between male and female coyotes in Oklahoma. Andelt (1985) reported home range overlaps of 88%–99% between adults within a pack, but home ranges of the breeding adults from adjacent packs overlapped only 0%–32% for males and 0%–7% for females.

Sightings of uncollared coyotes on the ranch indicated that intraspecific home range overlap was more common than indicated by the home ranges of the radio-collared coyotes. Uncollared coyotes were often sighted within the home ranges of collared individuals. We estimate that less than half of the resident coyote population on La Copita was radio-collared. Several observations suggested that a proportion of the coyote population maintained a pack social structure. Collared coyotes were observed twice in groups of 3 and 4 coyotes, and sightings of groups of up to 5 uncollared coyotes were common. One male coyote (ID No. 0700), trapped at ≤4 months of age, was sighted with 2 juvenile coyotes (assumed to be siblings) and maintained a stable home range for >1 year, indicating that this individual remained within its parental home range (Bekoff and Wells 1986). Also, 2 adult male coyotes

(ID No.'s 1540 and 1570) were trapped in the same area within a 5-day period and were subsequently located together 12 times over a period of 14 days before contact was lost with 1570. Sightings of groups of coyotes occurred at various times throughout the year but were most common during late summer, a period when most juveniles are still associated with their siblings or parents and have not dispersed from the parental home range (Andelt 1985).

Possibly because of small sample sizes, intraspecific overlap between bobcat home ranges was minimal with the exception of the 17%–20% overlap between male bobcats 1642 and 1553. Several sightings of adult bobcats and kittens confirmed the presence of at least 2 uncollared resident adult bobcats on the study area. Overlap between home ranges of female bobcats could not be addressed because only 1 female bobcat was radio-collared. The home ranges of male bobcat 0722 and female bobcat 1522 overlapped 0.5%–2.0%. Bailey (1974) found that female-female bobcat home ranges overlapped very little (0.1%), and that male-female bobcat home ranges overlapped considerably (15%–23%). Lawhead (1984) reported overlap values of 0%–35% for female-female bobcat home ranges, 36%–42% for male-male home ranges, and 1%—93% for male-female home ranges.

Interspecific home range overlap of the collared predators occurred 8 times between 3 bobcats (ID No.'s 1522, 0722, and 1553) and 4 coyotes (ID No.'s 0746, 1060, 1540, and 0700). Overlap between species ranged from 1% to 80% ($\bar{x}$ = 34 ± 8%). Known periods of overlap ranged from 51–204 days ($\bar{x}$ = 135 ± 19 days) and occurred throughout the year. Based on home range analysis there was no indication of spatial avoidance by the 2 species on La Copita. The generalist behavior of coyotes in habitat selection and food habits may have limited competition with bobcats, thus permitting the coexistence of these 2 predator species in high densities in this region of abundant suitable habitat and prey. Major (1983) also found no evidence of competitive exclusion by coyotes and bobcats in Maine. Berg (1979) noted that bobcat home ranges in Minnesota overlapped those of coyotes and grey wolves (*Canis lupus*) and there was no evidence of aggression or avoidance between bobcats and coyotes. However, bobcat densities in Wyoming and Colorado increased following coyote control (Robinson 1961), suggesting that competitive or aggressive interactions between coyotes and bobcats may have been limiting bobcats in those geographic regions.

Movement Indices

Mean movement indices were 139 ± 8 m/hour for male coyotes (N = 364 locations), 212 ± 17 m/hour for female coyotes (N = 195 locations), 160 ± 7 m/hour for male bobcats (N = 434 locations), and 91 ± 9 m/hour for the female bobcat (N = 132 locations). The highest movement index recorded during a single tracking period was 1.3 km/hour for a female coyote. These movement indices are lower than those recorded for coyotes at the Welder Wildlife Refuge (Andelt 1985). Movement indices undoubtedly would have been higher if successive locations had been recorded at shorter time intervals. Despite this limitation, the relatively low movement indices and small home range sizes in this study suggested that prey needs were easily met for coyotes and bobcats on La Copita. Drew (1988) also suggested that coyotes on La Copita were not limited by prey availability.

Hourly samples sizes ranged from 3 to 58 locations ($\bar{x}$ = 23 ± 2) for each predator species. Although sample sizes were related to the sampling scheme and therefore peaked every 4 to 6 hours, sample size was not correlated to the mean hourly movement indices of coyotes ($r = -0.09$, $P > 0.50$) or bobcats ($r = 0.19$, $P > 0.30$). Movement indices exhibited a crepuscular pattern for coyotes (Fig. 3a) and bobcats (Fig. 3b). The similar activity patterns of coyotes and bobcats suggested no temporal segregation between these predators. Activity peaks were slightly higher at dawn than at sunset in contrast to studies of coyotes on the Welder Wildlife Refuge (Andelt 1985). However, a dawn peak in vocalizations by coyotes also was recorded at La Copita (Walsh and Inglis 1989).

Movement was recorded at all times of the day for both species and sexes. Daytime activity indicated a high behavioral tolerance for human disturbance, because daily construction, automobile traffic, and other human disturbances were common on this area. Daytime movements by coyotes (Gipson and Sealander 1972, Andelt 1985) and bobcats (Kitchings and Story 1978) occur most commonly in unexploited populations.

Site Fidelity

Radio contact was lost with 3 coyotes and 1 bobcat almost immediately after their release (Table 1). Three of these individuals were located later by aerial telemetry 11, 13, and 17 km from the ranch. Once located, each individual was relocated in the same area on 2 to 3 subsequent occasions, suggesting that they may have maintained stable home ranges in those areas. These 3 individuals were classified as non-residents of La Copita at the time of their capture on the ranch; they may have been transient individuals (wandering over a large, unstable area), dispersing (moving from 1 home range to another), or wandering from a home range on a short-term excursion. Status of the fourth individual was unknown.

Radio contact was lost with 7 individuals after periods of residence on La Copita of 14 to 266 days (Table 1). One of these individuals (ID No. 1060) was later located on 2 occasions 3 km from the ranch and was classified as a disperser. This classification was based on the fact that this individual had been a resident of La Copita for at least 239 days and apparently established a new home range that did not overlap the original home range. Of the 6 other individuals, 3 showed evidence of dispersal, such as expansion of the home range away from La Copita and increased wandering behavior, before radio contact was lost. Similar pre-dispersal behavior was noted for bobcats by Griffith and Fendley (1986). Although final status of these 6 animals could not be determined and transmitter failure may have resulted in loss of radio contact with some of these individuals, all were thought to have dispersed. These predators were never sighted on the ranch after signal reception ceased, whereas sightings of collared residents were common.

Five of the 16 collared predators were residents of La Copita when radio track-

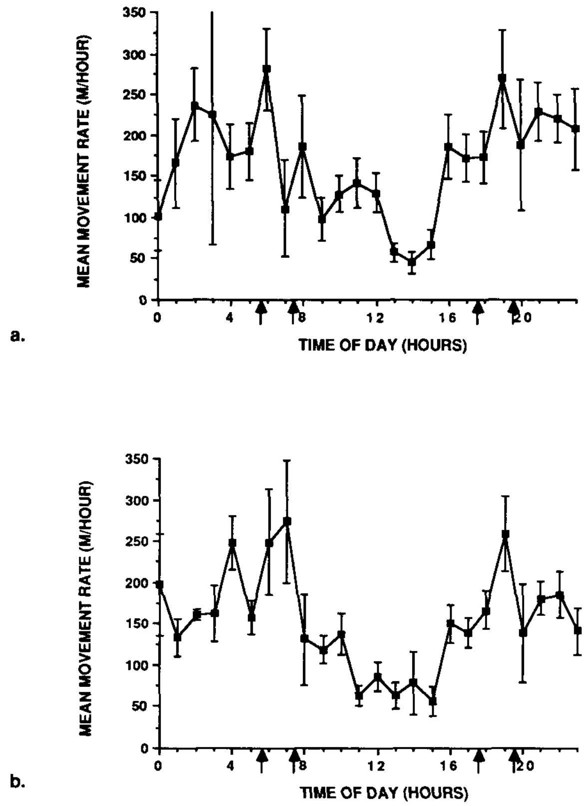

Figure 3. Hourly movement indices ($\bar{x}$ ± SE) of (a) coyotes and (b) bobcats at La Copita Research Area, 1985–1986. Arrows indicate range of sunrise and sunset times.

ing ended in September 1986 (Table 1). These individuals had maintained stable home ranges on La Copita for periods of 153 to 499 days.

Two of 3 non-resident individuals and the disperser in this study were adults. All of the 7 individuals for which final status was unknown (6 assumed dispersers and 1 assumed non-resident) were adults (Table 1). Loss of radio contact on La Copita occurred at various times throughout the year. These results indicated that predator movements from and through La Copita were not related to the typical fall dispersal of juveniles noted by Bekoff and Wells (1986) for coyotes. Andelt (1985) reported a total dispersal rate of 23% for suspected and known dispersals of adult and juvenile coyotes on the Welder Wildlife Refuge in southern Texas, and timing of dispersals in that study were distributed throughout the year. Bowen (1982) reported the dispersal of 7 of 18 adult and 5 of 8 juvenile coyotes in Alberta, for a total dispersal rate of 46%. Dispersal of juvenile bobcats was reported by Kitchings and Story (1978) and Bailey (1974), and Lembeck (1986) reported the dispersal of resident adult bobcats at high bobcat densities.

The large number of temporary residents and non-resident individuals captured on La Copita may have been related to the high density of predators. Based on the small home range sizes and the extent of home range overlap, space probably was a limiting factor regulating predator populations in the region. Apparently, many individuals were forced to wander in search of available space for home range establishment, and population pressures may have been forcing resident predators to abandon their home ranges. The home range shift exhibited by 1642 in apparent response to intrusion by 1553 supports this hypothesis. Lidicker (1962) and Davison (1980) suggested that dispersal was a population-regulating mechanism, with individuals moving from high density to low density areas. These hypotheses warrant further investigation in southern Texas.

Outlying Locations

In this study, home range estimates were reduced 22%–67% ($\bar{x}$ = 38 ± 7%) for coyotes and 8%–35% ($\bar{x}$ = 23 ± 6%) for bobcats by eliminating 5% of the locations. Andelt (1985) reported home range sizes that averaged 58% smaller when the outer 5% of the locations were removed from home range estimations. Mean coyote home range sizes were reduced 50% and 55% for males and females, respectively, in Nebraska (Andelt and Gipson 1979).

The majority of the outlying locations occurred during March (*N* = 18) and June (*N* = 19); the fewest occurred September through January (*N* = 0–2/month). Forty percent of these locations were recorded during the day, 39% during crepuscular periods, and 21% at night. Outlying locations primarily occurred in agricultural fields (30%) and thickets (26%) for coyotes and in thickets (27%) and drainages (23%) for bobcats. Average distance of the outlying locations from the home range were 0.27 ± 0.05 km for male coyotes, 0.60 ± 0.11 km for female coyotes, 0.39 ± 0.05 km for male bobcats, and 0.06 ± 0.01 km for the female bobcat.

The lack of obvious trends in traveling behavior by species, sex, age, or season limits the interpretation of the function for this behavior. These excursions usually take the individual into neighboring home ranges, posing a risk to the individual of meeting a conspecific in an aggressive encounter. Predators outside their normal use areas also are more vulnerable to trapping (Hibler 1977, Knowlton et al. 1986, this study). Excursions would be advantageous to the traveling individual, however, if the neighboring home range was discovered to be vacant, thus providing the opportunity to expand or shift its home range into more favorable habitat. This hypothesis was supported by evidence that the individuals exhibiting the most wandering behavior in this study were the same individuals that later dispersed. Each collared individual was ranked for wandering behavior based on the percent reduction in home range size resulting from eliminating outlying locations from the home range calculation. Higher values represented a greater frequency of wandering behavior. Of the 4 collared individuals that traveled the most (home range size reduction of 34%–67%, $\bar{x}$ = 46 ± 8%), 1 was known to have dispersed and 3 were assumed to have dispersed from the area. Of the 6 collared individuals that traveled the least (home range size reduction of 8%–30%, $\bar{x}$ = 23 ± 3%), all but 1 were still residents of La Copita when the study was terminated.

Summary and Conclusions

Coyote and bobcat populations on our study area were characterized by high densities, many non-residents and temporary residents, small home range sizes of residents, and considerable inter- and intraspecific home range overlap. Because all predators on the ranch were not radio collared, even more intensive use of space by predators must have occurred. Minimal spatial or temporal segregation of coyotes and bobcats was observed, indicating that coyote and bobcat populations in this region were not limited by competitive or aggressive interactions.

The frequency of wandering outside the home range varied among individuals. Based on the apparent relationship between travel tendency and subsequent dispersal, this behavior may have served to keep predators aware of unoccupied habitat or some other important resource in the general area.

Groups of coyotes apparently were present on some coyote home ranges, and transient, dispersing, or wandering individuals of both species frequently traveled through the area. Adults with stable home ranges dispersed to new areas during any season. This short-term home range fidelity may have been related to population pressures. The dense, highly mobile coyote and bobcat populations in southern Texas suggest that any unoccupied suitable habitat in the region would be colonized quickly.

Of particular importance in this study was the observation that both coyotes and bobcats used drainages for travel corridors. A shift in home range necessitated by habitat loss or population pressures would be facilitated by drainage habitats. Thus, drainage habitats will become increasingly important to both coyotes and bobcats as reduction and fragmentation of the southern Texas brushland intensifies.

Coyotes exhibited limited habitat selection within their home ranges. The opportunistic use of available habitats and prey by coyotes suggests that moderate fragmentation of southern Texas brushlands would not severely impact resident coyote populations if drainage habitats were available for dispersal movements. Bobcats were more limited by the availability of dense habitat types. Reduction of thicket and drainage habitats could limit bobcat populations in this region.

Literature Cited

Andelt, W. F. 1985. Behavioral ecology of coyotes in south Texas. Wildl. Monogr. 94:1–45.

——— and S. H. Andelt. 1981. Habitat use by coyotes in southeastern Nebraska. J. Wildl. Manage. 45:1001–1005.

——— and P. S. Gipson. 1979. Home range, activity, and daily movements of coyotes. J. Wildl. Manage. 43:944–951.

Bailey, T. N. 1974. Social organization in a bobcat population. J. Wildl. Manage. 38:435–446.

Balser, D. S. 1965. Tranquilizer tabs for capturing wild carnivores. J. Wildl. Manage. 29:438–442.

Beasom, S. L., and R. A. Moore. 1977. Bobcat food habit response to a change in prey abundance. Southwest. Nat. 21:451–457.

Bekoff, M. and M. C. Wells. 1986. Social ecology and behavior of coyotes. Adv. Study Behav. 16:251–338.

Berg, W. E. 1979. Ecology of bobcats in northern Minnesota. Pages 55–61 *in* L. G. Blum and P. C. Escherich, eds. Bobcat Research Conference Proceedings. Natl. Wildl. Fed., Sci. Tech. Ser. 6, Washington, D.C.

Bowen, W. D. 1982. Home range and spatial organization of coyotes in Jasper National Park, Alberta. J. Wildl. Manage. 46:201–216.

Burt, W. H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24:346–353.

Buttrey, G. W. 1979. Food habits and distribution of the bobcat, *Lynx rufus rufus* (Schreber), on the Catoosa Wildlife Management Area. Pages 87–91 *in* L. G. Blum and P. C. Escherich, eds. Bobcat Research Conference Proceedings. Natl. Wildl. Fed., Sci. Tech. Ser. 6, Washington, D.C.

Camenzind, F. J. 1978. Behavioral ecology of coyotes on the National Elk Refuge, Jackson, Wyoming. Pages 267–294 *in* M. Bekoff, ed. Coyotes: Biology, Behavior, and Management. Academic Press, New York.

Davison, R. P. 1980. The effect of exploitation on some parameters of coyote populations. Ph.D. Diss., Utah State Univ., Logan. 153pp.

Drew, G. S. 1988. Coyote-prey interactions on an intensively managed south Texas ranch. M.S. Thesis, Texas A&M Univ., College Station. 88pp.

Fendley, T. T. and D. E. Buie. 1986. Seasonal home range and movement patterns of the bobcat on the Savannah River Plant. Pages 237–259 *in* S. D. Miller and D. D. Everett, eds. Cats of the World: Biology, Conservation, and Management. Natl. Wildl. Fed., Washington, D.C.

Gipson, P. S. and J. A. Sealander. 1972. Home range and activity of the coyote in Arkansas. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 26:82–95.

Gould, F. W. 1975. Texas plants, a checklist and ecological summary. Texas Agric. Exp. Sta., Texas A & M Univ., College Station. 121pp.

Griffith, M. A. and T. T. Fendley. 1986. Pre and post dispersal movement behavior of subadult bobcats on the Savannah River Plant. Pages 277–289 *in* S. D. Miller and D. D. Everett, eds. Cats of the World: Biology, Conservation, and Management. Natl. Wildl. Fed., Washington, D.C.

Hall, H. T. and J. D. Newsom. 1976. Summer home ranges and movements of bobcats in bottomland hardwoods of southern Louisiana. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 30:427–436.

Heller, S. P. and T. T. Fendley. 1986. Bobcat habitat on the Savannah River Plant, South Carolina. Pages 415–423 *in* S. D. Miller and D. D. Everett, eds. Cats of the World: Biology, Conservation, and Management. Natl. Wildl. Fed., Washington, D.C.

Hibler, S. J. 1977. Coyote movement patterns with an emphasis on home range characteristics. M.S. Thesis, Utah State Univ., Logan. 125pp.

Kitchings, J. T. and J. D. Story. 1978. Preliminary studies of bobcat activity patterns. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 32:53–59.

Knowlton, F. F., L. A. Windberg, and C. E. Wahlgren. 1986. Coyote vulnerability to several management techniques. Pages 165–176 *in* D. B. Fagre, ed. Proc. 7th Great Plains

Wildl. Damage Control Workshop. Agric. Comm., Texas A&M Univ., College Station.

Kruuk, H. 1986. Interactions between Felidae and their prey species: A review. Pages 353–374 *in* S. D. Miller and D. D. Everett, eds. Cats of the World: Biology, Conservation, and Management. Natl. Wildl. Fed., Washington, D.C.

Laundre, J. W. and B. L. Keller. 1981. Home range use by coyotes in Idaho. Anim. Behav. 29:449–461.

——— and ———. 1983. Trappability of coyotes relative to home range boundaries. Can. J. Zool. 61:1932–1934.

——— and ———. 1984. Home range of coyotes: A critical review. J. Wildl. Manage. 43:127–139.

Lawhead, D. N. 1984. Bobcat (*Lynx rufus*) home range, density, and habitat preference in south-central Arizona. Southwest. Nat. 29:105–113.

Lembeck, M. 1986. Long term behavior and population dynamics of an unharvested bobcat population in San Diego County. Pages 305–310 *in* S. D. Miller and D. D. Everett, eds. Cats of the World: Biology, Conservation, and Management. Natl. Wildl. Fed., Washington, D.C.

Lidicker, W. Z. 1962. Emigration as a possible mechanism permitting the regulation of population density below carrying capacity. Am. Nat. 96:29–33.

Linhart, S. B., G. J. Dasch, and F. J. Turkowski. 1981. The steel leg-hold trap: techniques for reducing foot injury and increasing selectivity. Pages 1560–1578 *in* J. A. Chapman and D. Purlsey, eds. Worldwide Furbearer Conf. Proc., Vol. III. Worldwide Furbearer Conf., Inc., Frostburg, Md.

Litvaitis, J. A. and J. H. Shaw. 1980. Coyote movements, habitat use, and food habits in southwestern Oklahoma. J. Wildl. Manage. 44:62–68.

———, J. A. Sherburne, and J. A. Bissonette. 1986. Bobcat habitat use and home range size in relation to prey density. J. Wildl. Manage. 50:110–117.

Major, J. T. 1983. Ecology and interspecific relationships of coyotes, bobcats, and red foxes in western Maine. Ph.D. Diss., Univ. Maine, Orono. 64pp.

Marshall, A. D. and J. H. Jenkins. 1966. Movements and home ranges of bobcats as determined by radio-tracking in the upper coastal plain of west-central South Carolina. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 20:206–214.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541–545.

Odum, E. P. and E. J. Kuenzler. 1955. Measurement of territory and home range size in birds. Auk 72:128–137.

Ozoga, J. J. and E. M. Harger. 1966. Winter activities and feeding habits of northern Michigan coyotes. J. Wildl. Manage. 30:809–818.

Robinson, W. B. 1961. Population changes of carnivores in some coyote-control areas. J. Mammal. 42:510–515.

Rolley, R. E. and W. D. Warde. 1985. Bobcat habitat use in southeastern Oklahoma. J. Wildl. Manage. 49:913–920.

Roy, L. D. and M. J. Dorrance. 1985. Coyote movements, habitat use, and vulnerability in central Alberta. J. Wildl. Manage. 49:307–313.

Shiflet, B. L. 1984. Movements, activity, and habitat use of the bobcat in upland mixed pine-hardwoods. M.S. Thesis, Louisiana State Univ., Baton Rouge. 91pp.

Smith, G. J., J. R. Cary, and O. J. Rongstad. 1981. Sampling strategy for radio-tracking coyotes. Wildl. Soc. Bul. 9:88–93.

Soil Conservation Service. 1979. Soil survey of Jim Wells County, Texas. U.S. Dep. Agric., Soil Conserv. Serv. and Tx. Agric. Expt. Sta., College Station. 111pp.

Stuwe, M. and C. E. Blohowiak. 1985. Microcomputer programs for analysis of animal locations, Version 1.2. Smithsonian Inst., Washington, D.C., 18pp.

Walsh, P. B. 1985. Habitat use and population fluctuations of white-tailed deer at La Copita Research Area, Jim Wells County, Texas. M.S. Thesis., Texas A&M Univ., College Station. 131pp.

——— and J. M. Inglis. 1989. Seasonal and diel rates of spontaneous vocalization in coyotes in south Texas. J. Mammal. 70:169–171.