April 1991

HOME RANGES AND MOVEMENTS OF COYOTES IN THE NORTHERN CHIHUAHUAN DESERT

V. W. Howard Jr.
New Mexico State University

Gino G. DelFrate
New Mexico State University

HOME RANGES AND MOVEMENTS OF COYOTES IN THE NORTHERN CHIHUAHUAN DESERT

V.W. HOWARD, JR., *Department of Fishery and Wildlife Sciences, New Mexico State University, Las Cruces, New Mexico 88003*

GINO G. DEL FRATE[1], *Department of Fishery and Wildlife Sciences, New Mexico State University, Las Cruces, New Mexico 88003*

Proceedings 10th Great Plains Wildlife Damage Conference
(S.E. Hygnstrom, R.M. Case, and R.J. Johnson, eds.)
Published at the University of Nebraska-Lincoln, 1991.

The coyote *(Canis latrans)* is among the most studied animals in North America. Because of its adaptability and success as a predator, the coyote has flourished and is still expanding its range. Coyotes can now be found throughout most of North America and south into Central America (Voight and Berg 1987).

Studies in recent years have been extensive to understand the interrelationships of prey and coyotes (Shelton and Klindt 1974, Beckoff and Wells 1981), as well as demographic relationships (Davis et al. 1975, Knowlton and Stoddart 1978, Mitchell 1979, Bowen 1981) and feeding strategies (Todd and Keith 1976, Andelt et al. 1987, MacCracken and Hansen 1987, Gese et al. 1988a). With the advance of radio telemetry, researchers have investigated lifestyle characteristics spatially with home ranges or temporally with movements in relation to habitat requirements. Researchers have studied home ranges of coyotes in various regions of the United States (Livaitis and Shaw 1980, Andelt 1981, Springer 1982, Pyrah 1984, Gese et al. 1988a) and Canada (Bowen 1982). Some studies of home range were separated by season (Ozoga and Harger 1966) or relation to nearby food sources (Danner and Smith 1980). Home range analysis in relation to social interactions of coyotes has been either neglected, overlooked, or avoided. Gese et al. (1988a) recognized a transient class of coyote by home range size. Coyote social systems are very complex and can vary by season or locality in addition to some reports of group or pack systems (Hamlin and Schweitzer 1979, Beckoff and Wells 1981, Bowen 1981, Gese et al. 1988b). Coyotes maintain communication with conspecifics through vocal and olfactory signals (Lehner 1987, Bowen and McTaggert Cowan 1980). Social interactions may be by far the most complex and least understood aspect related to coyote ecology.

Coyote movements can be related to many factors including food, water, cover, and social interactions. Movements in relation to food sources are well documented (Fitch 1948, Todd and Keith 1976, Danner and Smith 1980) although reports on movements in relation to water have not been reported, probably because of limited research in desert situations. There has been some mention of coyotes' movements in relation to cover (Wells and Beckoff 1982).

The objectives of this study were to delineate annual and seasonal home ranges, movements, and habitat use of coyotes in the northern Chihuahuan desert.

We thank the New Mexico State University Agricultural Experiment Station for providing funding, the U.S. Department of Agriculture (USDA), Jornada Experimental Range for access to the study area and computer time, Woodstream Corp. for donating a portion of the traps, and to J. Smith and other students who assisted with field work.

STUDY AREA

The study area was located on the northern portion of the 78,266 ha USDA, Jornada Experimental Range (JER) (Fig. 1). The JER is located approximately 40 km (25 mi) north of Las Cruces, New Mexico in the Jornada del Muerto plain. It is bordered on the east by the San Andres mountains and on the southwest by the Dona Ana Mountains. The Jornada plain lies in the northern portion of the Chihuahuan desert. The eastern portion of the JER is managed under joint use agreements with the U.S. Army White Sands Missile Range and the U.S. Fish and Wildlife Service, San Andres National Wildlife Refuge (Fig. 1).

Elevations on the study area range from 1260 m (4200 ft) to 1530 m (5100 ft) with the majority below 1350 m (4500 ft). The climate is variable with precipitation mostly occurring in summer months, a wide range of day and night temperatures, hot summers and mild winters, and low humidity. The Chihuahuan desert is higher in elevation and generally wetter and cooler than the Sonoran desert (Brewer 1988). There is a bimodal distribution in precipitation with most of the rain occurring in July, August, and September predominantly from high-intensity localized, convective thunderstorms. Periodic droughts occur with that of 1951-1956 being the most severe within the last 350 years (Herbel et al. 1972). Average annual precipitation since 1915 is 23 cm (9.05 in) (Kunkel et al. 1988).

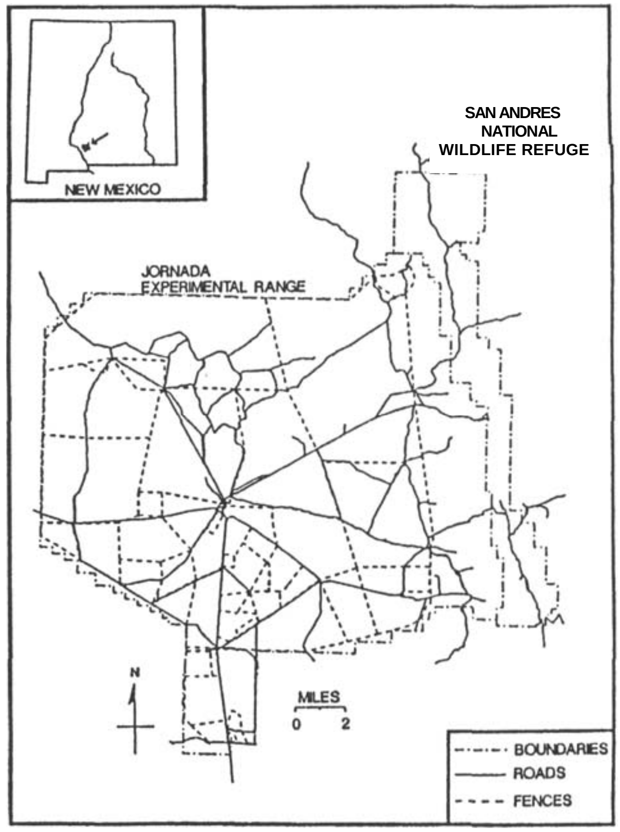

Fig. 1. Jornada Experimental Range showing the network of roads and fences.

Vegetation has been classified as semi-desert grassland by Buffington and Herbel (1965). Although classified as black grama *(Bouteloua eriopoda)* climax, the Jornada has been invaded by mesquite *(Prosopis glandulosa)* in the sandy soils, tarbush *(Florensia cernua)* in the heavier clay and silt soils, and creosote bush *(Larea tridentata)* on the coarser gravely soils.

Coyotes in the JER study area are an exploited population. Although the JER is closed to sport hunting, coyote numbers are reduced in response to depredation on livestock. In 1988, a minimum of 53 coyotes was shot, poisoned, or trapped by either USDA Animal Damage Control (ADC) personnel (49) or JER personnel (4). In 1989, 38 coyotes were removed by ADC and at least 12 by JER personnel or visitors. Public or private land borders 3 sides of the

JER and coyotes are pursued for sport or control measures on these areas also. Control work on or near the JER was responsible for deaths of 3 of the 11 coyotes with radio collars.

METHODS

Coyote Trapping

Coyotes were captured and processed using standard trapping techniques (Del Frate 1990). Trapping began on 5 October 1988 and continued until 11 radio collars were deployed on 10 February 1989. Coyotes were captured with Soft-Catch padded jaw traps (Woodstream Corp., Lititz, PA). To account for multiple traps set at an individual site, each trap night would be defined as a trap site functioning overnight.

Each coyote was immobilized with ketamine hydrochloride (Ketaset, Bristol-Meyers Co., Syracuse, NY), measured according to Hall (1962), and aged using tooth eruption and tooth wear patterns (Rogers 1965). All coyotes were eartagged with metal locking eartags (National Band and Tag Co., Newport, KY). Adults were fitted with radio transmitters (Telonics Inc., Mesa, AZ) color coded with cloth tape.

Radio Telemetry

At least 10 days were allowed for the coyote to recover from the trauma of trapping and to reduce any biases associated with handling. Radio-collared coyotes were located by triangulation from known locations. Numerous dirt tanks, windmills, and a network of roads facilitated accurate locations of coyotes. Two methods of triangulation were used concurrently; the loudest signal method (Mech 1983), and by bisecting null signals (Kolenosky and Johnston 1967). We attempted to locate each coyote once or twice weekly and collect data for each. Most radio tracking was conducted in the early morning, up to 2 hours after sunrise. Radio-telemetry information was processed similar to methods described by Schwartz and Franzmann (1991). Each time a coyote was located we attempted to identify the specific vegetation type, activity, time of location, and pinpoint the location on a 1:25,000 scale map. Because of vegetation, sightings occurred in only 16% of locations. Bearings from 2 or more locations were recorded in field notes and then plotted on USGS topographic maps using the Universal Transverse Mercator (UTM) system. Four aerial searches 18 April, 7 May, 17 October, and 22 November) were conducted to locate coyotes out of the study area.

Home Range Estimation

All locations for each coyote were digitized into a computer system using Arc Info Software (Environmental Research Systems Institute, Redlands, CA). Minimum convex polygon methodology (Dalke and Sime 1938, Mohr 1947) was chosen because it is the most widely used and accepted method for coyote home range determination. Jenrich and Turner (1969) acknowledged the minimum convex polygon method for its graphic simplicity, historical use, and relative statistical stability. Also, the least number of assumptions are violated. The assumptions for minimum convex polygon home range estimation include that locations are independent of other locations (Dunn and Gipson 1977), and the probability of being located is constant for each animal.

At least 10 locations per season were used to delineate seasonal home ranges (Toweill 1986). Swihart and Slade (1985) found a bias of 0.59 for samples of 10 and the bias decreases with increased sample sizes. Because of this high bias, all seasonal home ranges have the tendency to be underestimated.

Laundre and Keller (1984) noted that coyotes' use of their home range can vary during the year. They also cautioned that the solar seasons do not necessarily follow environmental conditions. Weather in the Chihuahuan desert was divided into 3 periods. April, May, and June were characterized by hot, dry and windy conditions, July through October were months when 50% of annual precipitation occurred, and November through March were generally characterized by cool, dry weather with a slight peak in precipitation in December. We identified these 3 periods as "hot dry," "hot wet," and "cool" seasons, respectively. These seasons coincide closely with the reproductive activities of the coyote. Coyotes mate and breed during the cool season while they den during the hot dry period and rear and wean pups during the hot wet season.

RESULTS

Thirteen coyotes (11 adults and 2 pups) were trapped during 1,306 trap nights for an average of 10 coyotes/1,000 trap nights. This compares with 18.6 coyotes/1000 trap nights on the Welder Wildlife Refuge (Andelt 1980), 5.6 coyotes/1,000 trap nights in Nebraska (Andelt et al. 1979), and 4.3/1,000 in Alberta (Skinner and Todd 1990). Two pups (1 male and 1 female) were released with only eartags. The 11 adults (5 males and 6 females) were radio-collared with color coded transmitters. One radio-collared coyote (004) died 67 days after it was trapped and the collar was redeployed. The coyote was apparently trampled by cows in a pen near water, however, complications from trapping were probably a factor.

Radio-collared coyotes were located 294 times between 22 October 1988 to 14 January 1990 while uncollared coyotes were observed 49 times. Most observations (55.9%) occurred between 1 hour before until 2 hours after sunrise. Number of locations used to determine annual home range varied from 17 for coyote 002, that was collared <5 months, to 69 locations for no. 006. Of trapped coyotes, 6 are known dead; 1 suspected of dispersal was shot 46.4 km (29 mi) from the trap location, 1 shed its collar, and 2 pups with only eartags were never seen again.

Two classes of coyotes (resident and nomad) were recognized based on movements and annual and seasonal home range size. Home ranges were estimated for coyotes with 10 or more locations in 1 season and with all locations annually. Two distinct sizes of home ranges were determined; those with small annual and seasonal home ranges were identified as resident while those with large home ranges, especially during hot seasons were identified as nomads (Table 1).

Coyote 005 made 2 distinct movements well outside his normal home range. The first occurred shortly after the water source dried up in his normal home range. The second was apparently due to a void created by a federal trapper controlling coyotes to protect domestic goats. This animal (005) was eventually killed in the goat enclosures by pulling a m-44 (a sodium cyanide-filled device used in predator control).

Table 1. Annual and seasonal home ranges (km^2) for coyotes collared on the Jornada Experimental Range, New Mexico, 1988-1990.

			Home Range (km^2)			
Coyote	Sex	Age	Hot Dry	Hot Wet	Cool	Annual
002	F	6+	*	*	14.08	14.84
005	M	3-4	4.14	*	25.41	28.92
006	M	2	6.14	7.10	15.15	15.46
007	M	2-3	8.39	*	*	12.27
	Resident	Mean	6.22		18.21	17.87
		SD	2.17	*	6.25	7.49
009	F	3-4	39.98	21.29		53.64
010	M	4-5	*	*	42.07	81.54
013	M	2-3	*	8.51	*	35.85
	Nomad	Mean	*	14.90	*	57.01
		SD	*	9.04	*	223.03

Coyote 003 disappeared shortly after it was collared on 29 October 1988 and was never located in the study area. On 16 March 1990 she was shot 46.4 km (29 mi) northwest of the original trap site. We believe that 003 was in the process of dispersing when she was captured. After she was released, she continued to the area where she was eventually killed.

Coyote 007 's home range appears small but is probably incomplete. On 3 occasions 007 was not relocated within its home range for periods of 38, 40, and 60 days. Coyote 013 displayed a similar pattern and disappeared for long periods (32 days, 76 days, and 32 days). These periods of absence caused underestimated actual home range size. The relatively large home range in conjunction with large movements in the hot dry season suggest this animal (013) should be classified with the nomads. Conversely, 007's small annual home range and also a small seasonal home range suggest this animal should be classified as a resident.

Estimated resident annual home ranges averaged 17.87 + 7.49 (standard deviation) km^2 which are smaller than nomad home ranges of 57.01 + 23.03 km^2 (t = 3.27, P < 0.05). Resident coyotes restricted their movements during both hot seasons to small areas that coincide with denning and rearing periods. Resident coyote home ranges during the cool season were larger than the hot dry season (t = 3.14, P < 0.05). The difference between cool season and annual home range was insignificant. Nomads also appeared to restrict their movements during the hot periods but there was insufficient information to determine significance. For example, during the entire hot period (hot wet and hot dry) coyote 010's home range was 58.28 km^2. Coyote 009's seasonal home ranges were 39.98 and 21.29 km^2 for hot dry and hot wet, respectively. During the cool season both classes of coyotes moved greater distances with each of the residents covering an average of 93.6% (« = 3) of their total home range while coyote 010 covered only 51.6% of its total home range during the cool season. Restriction of area covered during hot period can be beneficial in 2 ways. Coyotes can protect vulnerable young and can conserve energy and water reserves.

Vegetation type (198 locations) was determined by dominant plant species (and in the case of mesquite-dune type, obvious topographic features). Habitat use was determined when coyotes were observed or radio-located (including trap locations). Since study animals were seldom observed, habitat use was recorded for only those coyotes where the specific location could be attributed to a specific vegetation type while in the field. The percentage of use was highest in the mesquite dune (35.4%) and mesquite-dominant vegetation (32.8%). Grassland occurred with 21.3% use while other vegetation types combined totaled 10.6%.

DISCUSSION

The flat open terrain with good road access on the JER facilitated radio tracking. Virtually all radio signals <*l* km away could be received. By climbing windmills, this distance was increased at least 2-fold and radio signals were occasionally audible up to 13 km (8 mi). The flat, open terrain also had its drawbacks. Coyote behavior could easily be influenced by human activity and hence bias the telemetry data. On several occasions we encountered coyotes moving quickly away as a vehicle approached. Since we were alone in the study area, we have to assume our actions were influencing coyote movements. Therefore, continuous 24-hr monitoring was not conducted because of the probability of biasing the data. Smith et al. (1981) showed that coyotes were active in the morning for up to 2 hrs after sunrise, therefore radio tracking was concentrated during this time. Coyotes would generally rest during the day within any area of their home range, and most locations were spaced throughout the calculated home ranges (Smith et al. 1981). Daytime grassland locations were sparse but coyote tracks from Del Frate's (1990) scent station study showed a significantly higher frequency of occurrence in grass. All coyote home ranges encompassed some grassland and coyotes probably traveled or hunted in grassland at night and occupied the taller brush during the day. Number of locations varied for both classes of coyotes. Residents' home ranges were small and a minimum amount of effort was needed to locate them. Nomads, however, were more likely to be missed because of the larger area in which they might be and the corresponding likelihood that their signal would not be received. The probability of missing a coyote on any given day was greater for nomads than for residents. Because of the difficulty in locating far-ranging individuals, fewer locations for nomad coyotes were recorded, resulting in an underestimation of actual home range sizes. As stated before, all calculated home ranges should be considered minimal.

There is a large variation in the literature of home range size of coyotes. Livaitis and Shaw (1980) found average home ranges to be 68.7 km^2 for adult females and 31.3 km^2 for adult males in southwestern Oklahoma. Some of this variation in size could be due to a social subgroup of coyotes combined with actual residents. These are referred to as transients or nomads. Transient coyotes appear to occur in many areas of the U.S. Camenzind (1978) defined a nomad as a coyote that was consistently observed within an area but did not defend a specific geographical area. He also stated that home ranges of nomads overlap territories of resident coyotes which was also found on the JER. Therefore, we delineated 2 classes of coyotes on the JER excluding dispersers or young of the year. The first class consists of resident animals that were probably territorial and maintain conspicuous boundaries. The second group were nomads that occupy much larger areas both seasonally and annually. By comparison Bowen (1982) found an average home range for both males and females to be 13.7 km^2 in Jasper National Park, Alberta, Canada, excluding 1 animal with an exceptionally large home range. Major (1983) excluded a coyote with large movements in western Maine from home range calculations. Without that animal, Maine coyotes averaged 43.3 km^2. Gese et al. (1988a) separated 2 classes of home ranges of coyotes in southeastern Colorado; resident home ranges averaged 11.3 km^2 and transient home ranges averaged 106.5 km^2. Resident coyotes on the JER mean home range was larger than Gese et al. (1988a) but nomad home ranges were smaller. All the above studies used the minimum convex polygon method to estimate home ranges.

Authors who combine nomads with residents give inflated mean home ranges while others leave out exceptionally large home ranges from analysis as outliers. Gese et al. (1988a) defined a transient class of coyote and found that 22% of their population displayed nomadic behavior. Camenzind (1978) classified 15% of these coyotes as nomads in the National Elk Refuge near Jackson, Wyoming. Three (43%) of the 7 coyotes on the JER exhibited nomadic behavior. Both home ranges and seasonal movements were large during the hot seasons for nomads. Resident coyotes restricted their movements during the hot seasons but utilized fin average of 93% of their total range during the cool season.

Coyote 007 had the smallest calculated home range (12.27 km^2). We suspect 007 was occupying 2 distinct areas and would travel between both because the coyote would leave the area for long periods, during which we did not locate it. The home range size of 8.39 km^2 is typical of a resident coyote occupying a small area during the hot periods. Because 007's hot dry home range was small, and it returned to this area after each absence, this animal exhibits resident characteristics.

Home range size and movements by coyotes are related to the requirements of reproduction (Burt 1943, Laundre and Keller 1981). Habitat requirements (food, water, and cover) are essential to a healthy animal population. J?rey, including black-tailed jackrabbit *(Lepus californicus),* cottontail *(Sylvilagus audubonii),* and numerous species of rodents appear to be abundant from scent station work (Del Frate 1990). Water on the JER is available seasonally from dirt tanks and perennially from steel tanks filled from wells. During July, 005 moved out of his normal range, apparently for water, as this was shortly after the dirt tanks in his area went dry. He first moved north and then south of his home range to areas that had permanent sources of water. By 2 August 1989 when rains had partially filled the tanks in his original area, he returned. These were the only apparent movements relative to water stress because the JER has abundant and diverse sources of water. Cover was abundant and did not appear to limit coyote movement. Daytime activities of coyotes were concentrated in dense brush or the mesquite dune areas, even though all home ranges included large portions of grassland. This suggests coyotes spent their night-time hours in the open. Results from scent station data also indicated high visitation rates by coyotes to the grassland areas (Del Frate 1990).

Coyote social systems may play an important role in population regulation where habitat requirements are available and plentiful. In a high-density situation, space may become the limiting factor. Coyote communication is among the most complex of all mammal species (Lehner 1978). Lehner describes communication as the action of 1 or more coyotes that affects the behavior of others. Social status of coyotes may be maintained through auditory and olfactory communication and movements of coyotes may be socially related. Two forms of movements can be related to the sociability of coyotes on the JER. First, nomadic movements appear to be social in nature because nomads are a subordinate group of coyotes (Camenzind 1978). Nomads can remain in an area while avoiding other coyotes through complex communications. Wolves *(Canis lupus)* communicate through howling, scent marking, aggression, and avoidance in many areas of North America (Peters and Mech 1975, Harrington and Mech 1979, Ballard et al. 1987) Coyote communications probably utilize many of the same mechanisms. Secondly, 2 resident coyotes made distinct movements following the deaths of other coyotes. Coyote 006 was maintaining a home range just north of 002 and on 2 occasions (28 December 1988 and 7 January 1989) was seen with 002 just before breeding season. On 5 March, 002 was killed. Shortly after, 006 enlarged its home range to include the area previously occupied by 002. Coyote 005 also made 2 moves in relation to the deaths of other coyotes. In late September 1989 he moved north of his original home range. This corresponded with the death of 009. Coyote 005 remained in the vicinity of 009 's mortality site for 3 weeks. Near the end of these 3 weeks ADC personnel conducted 2 days of aerial gunning in a sheep and goat enclosure 6.6 km (4 mi) to the south. Within 5 days of this event 005 was found inside the enclosure. He remained there for 2 months until he was killed. Following the death of an individual, other coyotes appear to investigate this new void. Social status would inevitably play a role in the distribution of coyotes. Social interactions among wolves with wolves from other packs have been linked with territory delineation and distribution (Peters and Mech 1975, Ballard et al. 1987) Results from research on the behavior of other canids can be a valuable tool towards the management of coyotes.

Nomadism

Nomadic movements or transient wandering occurred with at least 2 radio-collared coyotes on the JER. Two radio-collared coyotes had home ranges of 53.64 km^2 and 81.54 km^2. Both coyotes occupied large defined areas and these areas overlapped other resident coyotes. Beckoff (1989) described animals that actively avoid social encounters, which appears to be the case with nomads. A third coyote (013) had a calculated home range of 35.85 km^2 but would spend a large amount of time off the study area which accounts for the small sample size (27). Nevertheless, the large movements during the hot dry season suggest nomadic behavior for this animal.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Shortages in food, water, cover, or space can affect coyote's behavior and survival. In the Chihuahuan desert, water may be critical during the hot dry season when temporary water sources are unavailable. In areas where water sources are scarce, water may be a limiting factor to population growth.

Home range size and movements of coyotes is not strictly related to habitat requirements. Two sizes of home ranges were identified. Annual home ranges for residents averaged 17.87 + 7.49 km^2 while overlapping home ranges for nomads averaged 57.01 + 23.03 km^2. Resident home ranges with the exception of 002 and 006 that ran together on occasion were independent of each other while nomad home ranges overlapped with each other and with residents. Space may be the limiting factor in a high density situation. When space is limiting, coyotes must adjust their activities to compensate for less than optimum living conditions in order to maximize its fitness.

Nomad coyotes appear to be a surplus of subordinate animals that remain in an area already saturated with territorial animals. There are probably some ecological and evolutionary benefits to nomadism. For example, by remaining close to territorial animals, these nomads can be the first to claim an area when it is vacated by the death of the territorial resident. Also, a nomad does not have to expend any energy defending a territory until it is to the individual's advantage. Studies need to determine the ultimate fate of nomads and to test the biological and social significance of nomadic coyotes.

We must not only understand the habitat requirements of coyotes but spatial and temporal factors as well. It is widely accepted that coyotes are opportunistic by nature. This characteristic must be considered when coyote management is desired and the planning process implemented. We must first determine management objectives and then develop strategies to achieve them. Therefore, it is important that we recognize the needs of coyotes, and more importantly, what the limiting factors are before we can implement proper management.

LITERATURE CITED

Andelt, W. F. 1980. Capturing coyotes for studies of their social organization. Wildl. Soc. Bull. 8:252-254.

____. 1981. Habitat use by coyotes in southeastern Nebraska. J. Wildl. Manage. 45:1001-1005.

____, D. P. Altoff, and P. S. Gipson. 1979. Movements of breeding coyotes with emphasis on den site relationships. J. Mammal. 60:568-575.

____, J. G. Kie, F. F. Knowlton, and K. Cardwell. 1987. Variation in coyote diets associated with season and successional changes in vegetation. J. Wildl. Manage. 51:273-277.

Ballard, W. B., J. S. Whitman, and C. L. Gardner. 1987. Ecology of an exploited wolf population in south-central Alaska. Wildl. Monogr. 98. 54 pp.

Beckoff, M. 1989. Behavioral development in terrestrial carnivores. Pages 89-124. in J. L. Gittleman ed. Carnivore behavior ecology and evolution. Cornell Univ. Press, Ithaca, NY.

_____ , and M. C. Wells. 1981. Behavioral budgeting by wild coyotes: the influence of food resources and social organization. Anim. Behav. 29:794-801.

Bowen, W. D. 1981. Variation in coyote social organization: the influence of prey size. Can. J. Zool. 59:639-652.

_____. 1982. Home range and spatial organization of coyotes in Jasper National Park, Alberta. J. Wildl. Manage. 46:201-216. _, and I. McTaggert Cowan. 1980. Scent marking in coyotes. Can. J. Zool. 58:473-480.

Brewer, R. 1988. The science of ecology. Saunders College Publ. Philadelphia, PA. 922pp.

Buffington, L. C. and C. H. Herbel. 1965. Vegetational changes on a semidesert grassland range from 1958 to 1963. Ecol. Monogr. 35:139-164.

Burt, W. H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24:346-352.

Camenzind, F. J. 1978. Behavioral ecology of coyotes in the National Elk Refuge, Jackson, Wyoming. Pages 267-294 in M. Beckoff ed. Coyotes biology behavior and management. Academic Press, New York, NY.

Dalke, P. D. and P. R. Sime. 1938. Home and seasonal ranges of the eastern cottontail in Connecticut. Trans. Third North Am. Wildl. Conf. 3:659-669.

Danner, D. A. and N. S. Smith. 1980. Coyote home range, movement, and relative abundance near a cattle feedyard. J. Wildl. Manage. 44:484-487.

Davis, C. A., J. A. Medlin, and J. P. Griffing. 1975. Abundance of black-tailed jackrabbits, desert cottontail rabbits, and coyotes in southeastern New Mexico. N. M. Agric. Exp. Sta. Res. Rep. 293.

Del Frate, G. G. 1990. Home range, movements, and characteristics of a coyote population in the Northern Chihuahuan Desert. M. S. Thesis. New Mexico State Univ., Las Cruces. 85pp.

Dunn, J. E. and P. S. Gipson. 1977. Analysis of radio telemetry data in studies of home range. Biometrics. 33:85-101.

Fitch, H. S. 1948. A study of coyote relationships on cattle range. J. Wildl. Manage. 12:73-78.

Gese, E. M., O. J. Rongstad, and W. R. Mytton. 1988a. Home range and habitat use of coyotes in southeastern Colorado. J. Wildl. Manage. 52:640-646.

_____, _____, and _____. 1988Z). Relationship between coyote group size and diet in southeastern Colorado. J. Wildl. Manage. 52:647-653.

Hall, E. R. 1962. Collecting and preparing study specimens of vertebrates. Univ. Kans. Mus. of Nat. Hist. Misc. Pub. 30. 46pp.

Hamlin, K. L. and L. L. Schweitzer. 1979. Cooperation by coyote pairs attacking mule deer fawns. J. Mammal. 60:879-850.

Harrington, F. H., and L. D. Mech. 1979. Wolf howling and its role in territory maintenance. Behaviour. 68:207-249.

Herbel, C. H., F. N. Ares, and R. A. Wright. 1972. Drought effects on a semidesert grassland range. Ecol. 53:1084-1094.

Jenrich, R. I. and F. B. Turner. 1969. Measurement of non-circular home range. J. Theoret. Biol. 22:224-237.

Knowlton, F. F. and L. C. Stoddart. 1978. Coyote population mechanics: another look. Northwest Sec. The Wildl. Soc. Symp. Nat. Regul. of Animal Populations. 31pp.

Kolenosky, G. B. and D. H. Johnston. 1967. Radio-tracking timber wolves in Ontario. Am. Zool. 7:289-303.

Kunkel, K. E., N. R. Malm, and R. A. Earl. 1988. Climate guide, Las Cruces, 1851-1987. N. M. State Agric. Exp. Sta. Res. Rep. 623. 32pp.

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

_____ and _____. 1984. Home-range size of coyotes: a critical review. J. Wildl. Manage. 48:127-139.

Lehner, P. N. 1978. Coyote communication. Pages 127-162 in M. Beckoff ed. Coyotes biology behavior and management. Academic Press. New York.

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

MacCraken, J. G. and R. M. Hansen. 1987. Coyote feeding strategies in southeastern Idaho: optimal foraging by an opportunistic predator? J. Wildl. Manage. 51:278-285.

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

Mech, L. D. 1983. Handbook of animal radio-tracking. Univ. Minn. Press, Minneapolis, MN. 92pp.

Mitchell, C. D. 1979. Some demographic characteristics of a coyote population in southwestern New Mexico. M.S. Thesis, New Mexico State Univ., Las Cruces. 36pp.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midi. Nat. 37:223-249.

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

Peters, R. P. and L. D. Mech. 1975. Scent marking in wolves. Am. Sci. 63:628-637.

Pyrah, D. 1984. Social distribution and population estimates of coyotes in north-central Montana. J. Wildl. Manage. 48:679-690.

Rogers, J. G. 1965. Analysis of the coyote population of Dona Ana County, New Mexico. M. S. Thesis, New Mexico State Univ., Las Cruces. 39pp.

Schwartz, C. C, and A. W. Franzmann. 1991. Interrelationship of black bears to moose and forest succession in the northern coniferous forest. Wildl. Monogr. 113. 58pp.

Shelton, M. and J. Klindt. 1974. Interrelationship of coyote density and certain livestock and game species in Texas. Tex. A and M Agric. Exp. Sta. Rep. MP 1148. 12pp.

Skinner, D. L. and A. W. Todd. 1990. Evaluating efficiency of footholding devices for coyote capture. Wildl. Soc. BuU. 18:166-175.

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

Springer, J. T. 1982. Movement patterns of coyotes in south central Washington. J. Wildl. Manage. 46:191-200.

Swihart, R. K. and N. A. Slade. 1985. Influence of sampling interval on estimates of home-range size. J. Wildl. Manage. 49:1019-1025.

Todd, A. W. and L. B. Keith. 1976. Responses of coyotes to winter reductions in agricultural carrion. Alta. Rec. Parks and Wildl. Wildl. Tech. BuU. No. 5. 32pp.

Toweill, D. E. 1986. Resource partitioning by bobcats and coyotes in a coniferous forest. Ph.D. Thesis, Oregon State Univ., Corvalis. 167 pp.

Voight, D. R. and W. E. Berg 1987. Coyote. Pages 343-356 in M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch eds. Wild furbearer management and conservation in North America. Ont. Ministry of Nat. Resour.

Wells, M. C. and M. Beckoff. 1982. Predation by wild coyotes: behavioral and ecological analysis. J. Mammal. 63:118-127.

Young, S. P. and Jackson, H. T. 1951. The clever coyote. Univ. Nebr. Press. 411pp.

'Current Address: 3482 Kalifornsky Beach Rd., Suite B, Soldotna, AK 99669.