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MONITORING THE EXPANDING RANGE OF COYOTES IN FLORIDA: RESULTS OF THE 1997-98 STATEWIDE SCENT STATION SURVEYS

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Abstract.—The distribution of the coyote (*Canis latrans*) has expanded throughout much of peninsular Florida during recent decades. Neither the rate of this expansion nor the implications of increasing numbers of coyotes to native wildlife are known. This study represents the first attempt to document and quantify coyote distribution in Florida and the effects of expanding coyote populations on three native predators—gray fox (*Urocyon cinereoargenteus*), bobcat (*Felis rufus*), and raccoon (*Procyon lotor*). During February-March 1997 and 1998 we documented the presence of coyotes in 14 of 19 counties surveyed (n = 830 scent stations) and recorded a mean coyote visitation rate of 3.3% among the 622 scent stations monitored during both years. Visitation rates by coyotes did not differ between years, nor did visits by coyotes influence visits to scent stations by fox, bobcats, or raccoons. The low numbers of coyotes detected at scent stations indicate coyote populations remain low or that our survey methods were not sensitive enough to detect changes between years.

Expansion of the range of coyotes into the southeastern United States has been well-documented (Paradiso 1966, Richens and Hugie 1974) and is thought to have occurred from 1940's through 1970 (Gipson 1978). Today, coyotes are well established throughout the southeastern United States (Crawford et al. 1993). The relatively recent increase in sightings of coyotes in central and southern Florida is believed to be the result of natural range expansion and intentional introductions (Layne 1997, Maehr et al. 1996). Although several cases were documented where small numbers of coyotes (4-30) were intentionally released into Florida by hunters between 1925-1950 (Hill et al. 1987, Layne 1997), the influence of introductions on current day populations of coyotes in Florida is unknown.

Consistent with an eastward expansion, information on the distribution of coyotes in Florida suggest numbers of coyotes are greatest in the northwestern portion of the state, but are increasing southward into peninsular Florida (Brady and Campell 1983, Coates et al. 1998,

Maehr et al. 1996, Wooding and Hardisky 1990). To date, documentation of coyote populations in Florida has been limited to mail surveys (Brady and Campell 1983, Wooding and Hardisky 1990) and a sign survey conducted on several large parcels in southern Florida (Maehr et al. 1996). No systematic surveys using scent stations or other means to document the distribution of coyotes in Florida have been reported in the literature. Consequently, base-line data for monitoring the increase of coyotes or their potential effect on other medium-sized predators is lacking. The objective of this paper is to report the results of a two-year systematic, scent station survey on the relative abundance and distribution of coyotes and three medium-sized predators, the gray fox, bobcat, and raccoon in peninsular Florida.

METHODS

We arranged for scent station surveys to be conducted by state, federal, and private sector cooperators in 19 Florida counties during February-March 1997 and 1998 (Fig. 1, Table 1). We conducted surveys during February-March because coyotes typically are mobile and responsive to odor attractants during this period due to behaviors associated with their reproductive cycle (R. McBride, personal communication). Coyotes typically whelp in May-June in the United States (Kennelly 1978) and information obtained from coyote carcasses suggests reproductive patterns of coyotes are similar in Florida (M. Main, unpublished data).

We supplied cooperators with survey kits that included survey protocol, attractant-treated discs, rubber gloves, and survey and location data sheets. Using the protocol we provided, cooperators selected scent station locations, prepared tracking surfaces, and monitored scent stations for coyote, fox, bobcat, and raccoon tracks. We used modified methods of Linhart and Knowlton (1975) to conduct scent station surveys. Cooperators established permanent scent stations ≥1.6 km apart along the sides of secondary roads and trails in all habitats, but predominantly in pine (*Pinus elliottii, P. palustris*), prairie, and other open habitats including agriculture. To the extent possible, scent stations were established in a systematic grid covering each cooperating study area. Vegetation was classified at each study area according to the Florida Natural Areas Inventory (1990) plant community classification system. Stations were uniquely numbered and established in locations that were described in sufficient detail to make future surveys possible.

Tracking surfaces at each scent station were 1-m diameter circles raked clean of vegetation and debris and brushed smooth with a soft-bristle brush or covered with sifted soil using 0.3-0.6 cm framed hardware cloth to facilitate track identification. We used Fatty Acid Scent (FAS, Pocatello Supply Depot, Pocatello, Idaho), a commercial attractant impregnated into small plaster disks, as the odor attractant at scent stations. Scent baits were kept in airtight bags and removed with forceps or gloves and placed in the center of the scent station. Scent baits were used only once. Scent stations were inspected the following day by cooperators who identified and recorded tracks within the 1-m scent station circle. Evidence of visitation for each species was recorded as a single animal regardless of the number of tracks observed.

The proportion of visits to total number of scent stations was calculated for each species at each cooperating study area as an index to relative abundance. Stations that were unreadable due to weather, trampling, or other factors, were eliminated from analyses. If ≥50% of the scent stations from a study area were unreadable the survey was either repeated using new scent baits or the study area was eliminated from analyses. Survey re-

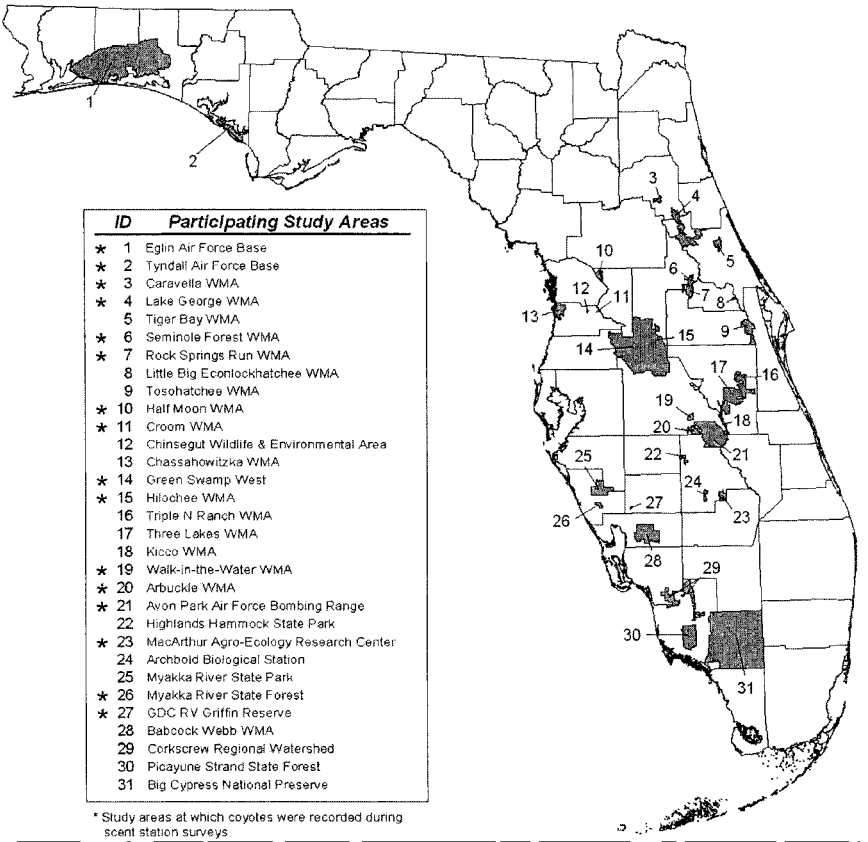

Fig. 1. Participating study areas where scent surveys were conducted during 1997 or 1998. Study area boundaries and locations were established using state geographic information system coverages.

sults were compiled from all study areas during both years. Analyses of data from study areas that successfully collected data during both 1997 and 1998 were used to evaluate whether 1) visits to scent stations by coyotes significantly increased or decreased between years and, 2) whether visits to scent stations by coyotes were negatively or positively related to visits by raccoons, fox, or bobcats. Study areas consisting of only one year of data were eliminated from comparisons between years to avoid bias. Visitation rates for each species at each study area were treated as estimated binomial proportions. Data were analyzed using a generalized linear model (SAS) that allowed comparison of binomial proportions between years for each species for those study areas with data for both 1997 and 1998, despite different numbers of scent stations at some study areas during each year (Nelder and Wedderburn 1972). To evaluate whether a relationship existed between visitation rates to scent stations by coyotes and other predators, coyotes were added to the general linear model as a covariate in the analyses of between year visits by fox, bobcats, and raccoons. Analyses of the generalized linear model with both Chi-square and approximate F-test statistics produced identical results, so only F-test statistics are reported.

Table 1. Summary of counties, study areas, and cooperators participating in scent station surveys and the proportion of scent stations visited by coyotes, foxes, bobcats and raccoons at each study area during 1997 and 1998. Data recorded as NA (not available) for study areas and years when surveys were not successfully conducted.

			No. scent stations[1]		Proportion of visits to scent stations by species and year							
					Coyote		Fox		Bobcat		Raccoon	
County	Study Areas	Cooperators	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Bay	Tyndall Air Force Base	USAF[2]	21	22	0.24	0.18	0	0.18	0.05	0.05	0	0.06
Charlotte	Babcock Webb Wildlife Management Area (WMA)	FGFC[3]	33	33	0	0	0.36	0.36	0	0	0.15	0.40
Collier	Big Cypress National Preserve	NPS[4]	0	10	NA	0	NA	0	NA	0.02	NA	0.40
Collier	Picayune Strand State Forest	FDOF[5], FGFC	29	30	0	0	0.04	0	0.04	0.03	0.17	0.13
Collier/Lee	Corkscrew Regional Watershed	SFWMD[6], FGFC	10	11	0	0	0.10	0.09	0	0.18	0.60	0.36

[1]Station count refers to the number of stations that could successfully be checked for tracks.
[2]U.S. Air Force.
[3]Florida Game and Fresh Water Fish Commission.
[4]U.S. National Park Service.
[5]Florida Division of Forestry.
[6]South Florida Water Management District.
[7]Southwest Florida Water Management District.
[8]Archbold Biological Station.
[9]MacArthur Agro-ecology Research Center (Affiliate of ABS).
[10]Florida Dept. of Environmental Protection.
[11]St. Johns River Water Management District.
[12]Mean proportion of visits to available scent stations.
[13]Standard deviation of the mean.

Table 1. (Continued) Summary of counties, study areas, and cooperators participating in scent station surveys and the proportion of scent stations visited by coyotes, foxes, bobcats and raccoons at each study area during 1997 and 1998. Data recorded as NA (not available) for study areas and years when surveys were not successfully conducted.

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					Coyote		Fox		Bobcat		Raccoon	
County	Study Areas	Cooperators	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Desoto	RV Griffin Reserve	SWFWMD[7]	14	0	0.29	NA	0	NA	0	NA	0.21	NA
Hernando	Croom WMA	FGFC	15	15	0	0.07	0	0.07	0	0.07	0	0.13
Hernando	Chassahowitzka WMA	FGFC	14	11	0	0	0.07	0.09	0	0	0.57	0.09
Hernando	Chinsegut Wildlife and Environmental Area	FGFC	6	6	0	0	0	0	0	0	0	0.17
Highlands	Archbold Biological Station	ABS[8]	10	10	0	0	0.10	0	0.10	0.20	0.40	0.40
Highlands	MacArthur Agro-ecology Research Center	MAERC[9] (ABS)	15	15	0	0.07	0	0.07	0	0.07	0.47	0.47
Highlands	Highlands Hammock State Park	FDEP	9	0	0	NA	0	NA	0	NA	0.33	NA

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					Coyote		Fox		Bobcat		Raccoon	
County	Study Areas	Cooperators	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Highlands, Polk	Avon Park Air Force Range	USAF	49	40	0	0.05	0.04	0	0	0.08	0.31	0.68
Lake	Seminole Forest WMA	FGFC	14	11	0	0.09	0	0	0	0	0.07	0.09
Lake	Hilochee WMA	FGFC	0	10	NA	0.10	NA	0	NA	0.20	NA	0.40
Manatee, Sarasota	Myakka River State Park	FDEP	30	0	0	NA	0	NA	0	NA	0.07	NA
Orange	Tosohatchee WMA	FDEP[10], FGFC	14	14	0	0	0.14	0.21	0.43	0	0.43	0.29
Orange, Lake	Rock Springs Run WMA	FGFC	16	0	0.44	NA	0	NA	0.31	NA	0.63	NA
Osceola	Three Lakes WMA	FGFC	30	25	0	0	0	0	0.067	0	0.23	0

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					Coyote		Fox		Bobcat		Raccoon	
County	Study Areas	Cooperators	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Osceola	Triple N Ranch WMA	FGFC	17	16	0	0	0	0	0.06	0.06	0.53	0.19
Pasco	Green Swamp West	SWFWMD	23	23	0.09	0.04	0	0	0.04	0.04	0.44	0.09
Polk	Walk in the Water WMA	FDOF, FGFC	0	8	NA	0.13	NA	0.13	NA	0	NA	0.38
Polk	Arbuckle WMA	FDOF, FGFC	0	11	NA	0.27	NA	0.09	NA	0	NA	0.18
Polk/Osceola	Kicco WMA	SFWMD, FGFC	0	9	NA	0	NA	0	NA	0.11	NA	0.11
Putman	Caravelle WMA	FGFC	12	12	0.08	0.08	0.2	0	0	0	0.20	0.17
Santa Rosa	Eglin Air Force Base	USAF	0	43	NA	0.33	NA	0.07	NA	0	NA	0.02
Sarasota	Myakka River State Forest	SWFWMD	10	0	0.20	NA	0	NA	0.10	NA	0.20	NA

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					Coyote		Fox		Bobcat		Raccoon	
County	Study Areas	Cooperators	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Seminole	Little Big Econlockhatchee WMA	FDOF, FGFC, SJRWMD[11]	10	10	0	0	0.2	0	0.10	0.10	0.40	0.20
Sumter	Half Moon WMA	FGFC	10	10	0.10	0.30	0	0	0.10	0	0.20	0.10
Volusia	Lake George WMA	FDOF, FGFC	16	0	0.19	NA	0	NA	0.38	NA	0.50	NA
Volusia	Tiger Bay WMA	FDOF, FGFC	10	0	0	NA	0	NA	0.40	NA	0.20	NA
All (19)	All (31)	All (41)	437	393	0.07[12] (0.12)[13]	0.07 (0.10)	0.06 (0.09)	0.07 (0.09)	0.07 (0.14)	0.05 (0.07)	0.28 (0.20)	0.23 (0.17)

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RESULTS

Cooperators included 7 state and 2 federal agencies, and 1 non-governmental organization that monitored 830 scent stations at 31 study areas during 1997-1998 (Table 1). Study areas were located in 19 counties, primarily in central and southern Florida (Fig. 1). The number of study areas that completed surveys and total number of scent stations differed between years and included 25 study areas (n = 437 scent stations during 1997) and 24 study areas (n = 393 scent stations during 1998) (Table 1). Coyotes were documented at 59 of the 830 scent stations during the 1997-98 surveys, confirming their presence at 16 study areas in 14 counties. Numbers of coyotes, fox, and bobcats recorded at scent stations were similar during both years (Table 1). Six of the cooperators that participated during 1998 did not participate during 1997 and eight of the original cooperators from 1997 did not complete surveys during 1998 due to extremely wet conditions associated with El Niño weather events.

Seventeen study areas successfully completed consecutive surveys during both years (n = 320 stations; median survey date 25 February 1997; n = 302 stations; median survey date 25 March 1998). Overall rates of visitation to scent stations by coyotes were low. Only 21 visits by coyotes were recorded for 622 scent stations at study areas that conducted surveys during both 1997 and 1998, resulting in a mean visitation rate of 3.3%. Despite a 175% increase in the rate of visits by coyotes and a 123% increase in the rate of visits by fox during 1998, visitation rates did not differ statistically between years for coyotes, fox, bobcats, or raccoons (Table 2). There was no relationship detected between rate of visitation by coyotes and rates of visitation by fox, bobcats, or raccoons (Table 2).

DISCUSSION

Coyotes have expanded their range into peninsular Florida (Maehr et al. 1996) and have been reported as far south as southern Collier County (M. Owens, personal communication). Increased numbers of coyote sightings and reports of damage to livestock from cattle ranchers suggests coyote populations have increased in south Florida during recent years (Layne 1997, M. Fanning, personal communication) and may continue to increase in Florida as they have done elsewhere in the southeastern United States (Crawford et al. 1993). Information that simultaneously monitors coyote populations and the populations of other native predators will provide valuable insight as to the potential ecological effects that coyotes may exert on native fauna and on Florida ecosystems should coyote densities increase in the future.

Table 2. Comparison of annual rates of visitation to scent stations and effects of coyotes on rates of visitation by fox, bobcat, and raccoon between 1997 and 1998. Analyses limited to study areas with survey data collected during both 1997 and 1998. Rates of visitation and effects of coyotes on rates of visitation calculated from generalized linear model using year and coyote as parameters.

	Rate of visits/station (%)		Annual comparisons of visitation rates			Effects of coyotes on other species			Model parameter estimates	
Species	1997	1998	*F*	df	*P*	*F*	df	*P*	Intercept	Coyote[2]
Coyote	2.5	4.3	0.58	1, 32	0.45	—	—	—	-3.10	—
Fox	7.5	9.1	0.12	1, 31[1]	0.74	0.83	1, 31	0.37	-2.30	-0.27
Bobcat	4.6	4.5	0.001	1, 31	0.97	0.02	1, 31	0.90	-3.05	0.03
Raccoon	28.7	27.0	0.54	1, 31	0.82	0.38	1, 31	0.55	-0.99	-0.09

[1]Degrees of freedom (df = 1, 31) differ from coyote analyses (df = 1, 32) because coyote was included as a covariate in the generalized linear model for fox, bobcat, and raccoon.

[2]Coyotes were included as a covariate in analyses of fox, bobcat, and raccoon to measure effects of coyotes on visitation rates by these species.

Potential effects of increasing coyote populations on native predators in Florida, such as fox, bobcat, and raccoon, can only be speculated upon at this time. It is known from other studies that coyotes compete for food resources with gray fox (Cypher 1993, Smith and Danner 1990) and coyotes also have been documented as direct sources of mortality to gray and red fox (Dekker 1989, Wooding 1994). The potential exists, therefore, for coyote populations to exert a negative influence on existing populations of gray fox in Florida. As opportunistic predators of white-tailed deer (*Odocoileus virginianus*) and small mammals, coyotes also have the potential to compete with bobcats. The omnivorous diet of the coyote provides a competitive edge over the bobcat, an obligate carnivore (Wassmer et al. 1988). The influence of coyotes upon raccoon populations is likely to be less intense, as both species have catholic diets, high reproductive potential, and raccoons coexist throughout the range of the coyote.

Our study confirmed the presence of coyotes at 16 of the 31 study areas, 14 of which occur in peninsular Florida (Fig. 1). The absence of coyotes at some study areas does not necessarily indicate coyotes do not occur in these areas, but provides baseline data that suggests coyote densities are not high. Hence, even the failure to record coyotes at study areas provides important baseline data for monitoring coyote populations at these sites. Results also confirmed that coyotes were using the same habitats used by fox, bobcat, and raccoon. The rate of visitation by coyotes to scent stations was low (mean = 3.3%) and, although the number of coyotes that visited scent stations increased during 1998 by 175%, this increase was not significant due to the low overall rate of visitation.

Our results suggested that coyotes currently exist at low numbers in south and central Florida, or that our survey techniques were not sensitive enough to adequately measure population trends and should be modified to increase sample size by extending the length of time that scent stations remain active. The same recommendations apply for detecting changes in population trends for fox, bobcats, and raccoons. We recommend future surveys check scent stations both at 1- and 5-day intervals after scent station establishment. Modifying surveys in this manner will provide data that can be compared with the 1997-98 surveys (1-day check) while providing a new set of data (5-day check) that will be more sensitive to detecting coyote presence and, therefore, more sensitive to measuring future changes in abundance of coyotes and other species. We also recommend expanding the survey to include additional study areas. Finally, we recommend continued cooperation in maintaining a long-term scent station survey program to monitor the relationship between populations of coyotes and other predators in Florida. Data from long term monitoring efforts may provide insight

into competitive interactions and provide the basis for hypothesis testing through ecological studies should relationships in population sizes between coyotes and other predators change in the future.

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