Techniques to Monitor Relative Abundance of Coyotes in East Tennessee

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Abstract: Scent stations, passive hair-snaggers and howl surveys were evaluated as possible survey methods for monitoring relative abundance of coyotes (*Canis latrans*) in Great Smoky Mountains National Park (GSMNP) prior to the reintroduction of red wolves (*Canis rufus*) from January 1990 to April 1991. Scent station nights (N = 198), passive hair-snaggers (N = 70), and howl surveys (N = 197) produced 1 (0.5%), 0 (0.0%), and 35 (17.8%) coyote responses, respectively. Scent stations and hair-snaggers proved ineffective for monitoring coyotes at current population levels. Howl surveys elicited responses from approximately 21 coyotes at 12 locations indicating the feasibility of designing and implementing a standardized survey to monitor the relative abundance of coyotes over time or from area to area. Twenty-seven responses were elicited from coyotes in the Cades Cove section of GSMNP for a coyote index of 22.9% and 8 responses from coyotes outside Cades Cove for a coyote index of 10.1%. Preliminary estimates from 2 indices of relative coyote abundance ranged from 1/13.2 km^2 to 1/39.7 km^2. Wildlife managers and researchers must accept a wide margin of error if surveys of relative abundance are used for coyotes and other wide ranging carnivores in the southern Appalachians.

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Coyotes have expanded their range into eastern North America because of human induced manipulation of habitats and extermination of gray wolves (*C. lupus*) and red wolves (Gipson 1978, Nowak 1978, Parker 1988). Logging, production agriculture, and large poultry farms have created ideal habitat for coyotes in the Southeast (Korschgen 1957, Gipson 1974, Hill et al. 1987). Coyotes moved into the Southeast in the last 30 years (Gipson 1978, Kennedy et al. 1986) and

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were observed in the Great Smoky Mountains National Park (GSMNP) in 1985 (K. Delozier, wildlife biologist, GSMNP, pers. commun.). Concerns about potential coyote problems in the Southeast dictate a need for determining relative abundance or trends in coyote populations. Determining the current status of coyotes in GSMNP may help clarify if future red wolf reintroductions are successful and whether red wolves displace resident coyotes from their home ranges.

Methods developed for estimating carnivore populations are crude and often produce estimates with broad confidence intervals (Pelton and Marcum 1975). The problems associated with censusing most carnivores are compounded with coyotes in the Southeast due to low population densities (Linhart and Knowlton 1975, Sharp 1981). Linhart and Knowlton (1975) grouped canid survey methods into 5 categories: (1) direct counts or mark and recapture, (2) counts of dens, tracks or scats, (3) questionnaires and bounties, (4) catch per unit effort, and (5) elicited responses. Due to limited resources and the inability to thoroughly sample large areas, direct counts are impossible in GSMNP. An index of relative abundance often is the only alternative. However, indices are subject to the same limitations as direct counts such as nonrandom distributions, varying seasonal movements and behavioral patterns, and the influence of topography and habitat (Linhart and Knowlton 1975). The researcher or manager must accept these limitations and select a method unbiased by these variables and expect some variation in coyote responses.

Linhart and Knowlton (1975) suggested elicited responses, particularly scent stations and howl surveys, as having the greatest potential for development of a reliable index. Scent station surveys have been used on numerous furbearer populations throughout the United States (Linhart and Knowlton 1975, Johnson and Pelton 1981, Morrison et al. 1981, Nottingham et al. 1989, Roughton and Sweeny 1982, Wood 1959). The siren-elicited howl survey, first described by Alcorn (1946), has been limited to surveying canids (Russell and Shaw 1971, Wenger and Cringan 1978, McCarley and Carley 1979, Sharp 1981, Pyrah 1984, Okoniewski and Chambers 1984).

The objectives of this study were to evaluate techniques to determine relative abundance of coyotes in GSMNP and test for differences in response rates among survey techniques for coyotes.

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Methods

This study was conducted in the western portion of GSMNP in eastern Tennessee between January 1990 and March 1991. Within the study area is Cades Cove, a valley with 748 ha of fescue pastures for cattle and horse grazing and 230 ha of woodlots. Linzey and Linzey (1971) list 59 species of mammals found in

GSMNP; this does not include coyotes that migrated into GSMNP around 1985. Six species are probably extirpated.

Park records containing the locations of reported coyote sightings from 1989 ($N = 7$) were reviewed before initiating field work. These areas were checked for current coyote activity by walking the areas and noting fresh sign (i.e., tracks, scats, and hair snagged in fences). Seven areas were hiked covering a linear total of 54 km. Activity was found only in Cades Cove.

Scent stations were operated following the procedures suggested by Linhart and Knowlton (1975) and Roughton and Sweeney (1982); these authors suggested spacing stations at 0.2 to 0.3 km intervals. Scent stations were spaced at 0.5 km to avoid interference from visitors and livestock. Also, scent stations were randomly placed in likely coyote travel corridors and spaced to avoid high visitor and livestock use areas. Scent stations outside Cades Cove were placed along either a road or trail edge approximately 0.5 to 1.5 km apart depending on the topography, slope, and trail condition. All scent stations were operated for only 1 night to minimize the effects of inclement weather.

Scent stations consisted of a 1-m diameter circle of sifted soil. Attractants used included a long distance lure (Russ Carmans Canine Call), coyote urine, sardine oil, and artificial raspberry. Attractants were randomly chosen until each had been used, then the procedure was repeated until completion of the route. All attractants were saturated into a plaster disk approximately 2.5-cm^3 and placed in the center of the substrate.

Scent stations were checked the morning following establishment. Data recorded included scent station route, number of stations, weather conditions in the past 24 hours, date stations were established and checked, location of station, scent used, and species visiting.

Scent stations ($N = 58$) were established in the Cades Cove area from 23 January 1990 to 20 February 1990. Also, scent stations ($N = 52$) were established outside Cades Cove from 13 June 1990 to 6 July 1990. From 4 August 1990 to 25 August 1990, all scent stations were repeated. This effort ($N = 220$) covered approximately 278.0 km of roads and trails. Of the 220 scent station nights, 22 station nights were washed out by rain or disturbed by humans. Of the 198 scent stations, Russ Carmans Canine Call and coyote urine were the scents used at 66 stations each, sardine oil was used at 37 stations, and artificial raspberry was used at 29 stations. Artificial raspberry was used from June to August, when berry crops were present.

Passive hair-snaggers ($N = 70$) were placed approximately 30 cm off the ground approximately every km along well traveled game trails. Hair-snaggers were placed approximately 50 m from main hiking trails, and consisted of 12-gauge barbed wire, cut into appropriate lengths to reach across the game trail. Hair-snaggers were left in place for 5 nights then collected and examined.

Howling surveys were conducted following the procedures suggested by Wenger and Cringan (1978), Sharp (1981), and Okoniewski and Chambers (1984). Sharp (1981) spaced 8 to 14 stations 1.6- to 2.4-km apart depending on topography and proximity to moving water. Wenger and Cringan (1978) and Okoniewski and Chambers (1984) drove from 0.2 km to 4.8 km away from radio-collared coyotes to determine the distance a coyote response was audible. We conducted surveys on clear to partly clear nights and winds less than 15 km/hour. Surveys started 1 hour after sunset and were completed 2 to 4 hours later. Approximately 15 minutes elapsed between station soundings (Wenger and Cringan 1978, Sharp 1981, Okoniewski and Chambers 1984). Howling stations were located from 1.6 to 4.8 km apart depending on topography, vegetation, and distance from moving water. The same stations were used for each survey. The amount of area covered by each station's sounding was determined by conducting sounding trials in and outside of Cades Cove with radio-collared coyotes. Also, Wenger and Cringan (1978) determined that coyote responses could be heard up to 1.6 km away in northeastern Colorado. The average distance a response could be heard in Cades Cove was 3.0 km and approximately 1.6 km outside Cades Cove. Stimuli used were a Smith and Wesson Mark IV siren and human howling.

The siren was mounted on top of the vehicle and directed vertically for omni directional travel of sound. The siren was sounded for 2 complete cycles, approximately 20 seconds, followed by a 2-minute listening period. The siren was sounded again for 2 cycles followed by a 1-minute listening period. Operators wore ear protection; this was removed immediately after each sounding.

Human howls were used to test responses from coyotes. Five to 6 seconds of human howls followed by 2 barks and 5 to 6 seconds of more howls were used per station. A 2-minute listening period followed the howling. The procedure was repeated followed by a 1-minute listening period.

Prior to conducting the surveys, taped coyote, domestic dog, and red wolf vocalizations recorded by John Carley (Dep. Int. Fish and Wildl. Serv.) were reviewed by operators both indoors and outdoors at various distances. Surveys were limited to less than 2 surveys a month to minimize habituation of coyotes.

Before initiating howl surveys, radio-collared coyotes were located to determine if the collared animals responded. For each survey, the date, route, station number or location, time, type of stimulus, type of canid responding, number responding, estimated distance and azimuth were recorded. Before each survey, the weather conditions and moon phase were noted. If the exact number of animals responding could not be determined, a conservative estimate was recorded. A total of 197 stations, covering 364.0 km of roads, were surveyed.

Response indices and coyote indices were calculated for Cades Cove and outside of Cades Cove to compare the 2 areas. The response index was calculated by dividing the number of stations with a response by the total number of stations. The coyote index was determined by dividing the number of coyotes responding by the total number of stations.

Indices of relative abundance were calculated for GSMNP using 2 formulas used by Sharp (1981). The first index was determined by dividing the number of coyote responses by the estimated area surveyed then multiplying by 2. The second index was calculated by dividing the estimated number of coyotes responding by the estimated area surveyed then multiplying by 2. These indices were multiplied by 2 as a correction factor for coyotes that did not respond (Sharp 1981). Both Alcorn (1971) and Wenger and Cringan (1978) reported that only half of the radio-collared coyotes surveyed responded to the stimulus.

Statistical analyses were performed using the Statistical Analysis System (SAS Inst. Inc. 1985). Chi-square tests for independence were performed to test differences in response rates for coyotes to sirens and human howls and responses to human howls in Cades Cove and outside Cades Cove.

Results and Discussion

Only 1 coyote visit was recorded in 198 scent station nights. Other species included black bears (*Ursus americanus*) (36; 18.2%), white-tailed deer (*Odocoileus virginianus*) (24; 12.1%), raccoons (*Procyon lotor*) (10; 5.1%), bobcats (*Lynx rufus*) (9; 4.5%), and domestic dogs (6; 3.0%). Species with fewer than 3 visits were red fox (*Vulpes vulpes*), wild boar (*Sus scrofa*), skunk (*Mephitis spp.*), gray fox (*Urocyon cinereoargenteus*), and cottontail rabbit (*Sylvilagus floridanus*). Scent stations appear to have limited potential as an index for coyotes in GSMNP.

Possible explanations for the low coyote response rates to scent are: (1) low density of coyotes in GSMNP, (2) early coyote visits were masked by other species, (3) poor weather conditions washed out responses, (4) high human and horse traffic on trails; and/or (5) scents used for stations were also used for trapping. Andelt et al. (1985) noticed coyotes that had been trapped were less likely to respond to scent stations than nontrapped coyotes. Andelt et al. (1985) believed that trapping caused a negative experience, thus decreasing response rates.

Only hair samples from black bears (N = 10) were collected on the hair-snaggers. Due to the lack of human resources, time constraints and no success, this method was abandoned after 2 trials.

Thirty-five howl responses (17.8%) were recorded from approximately 21 coyotes at 12 different stations. The estimated number of coyotes responding was determined by adding the estimated number of uncollared coyotes responding to the number of collared coyote responding. Radio-collared coyotes responding during surveys were only counted once even if they responded on more than 1 survey. A total of 20 (10.2%) responses were elicited from domestic dogs at 8 different stations (Table 1). Radio-collared coyotes were close enough to respond to the stimulus during 15 of 23 surveys. Six (3.0%) responses from radio-collared coyotes were elicited during 5 surveys from 5 different stations. One radio-collared animal responded twice during the same night from different locations. Fourteen (7.0%) of the 20 domestic dog responses were from private property adjacent to the Foothills Parkway which is North of Cades Cove.

Responses were elicited from coyotes at 14 station soundings (14/197 x 100%) for a response index of 7.1%; domestic dogs responded at 12 station soundings (12/197 x 100%) for a response index of 6.1%. Coyote responses were greatest in October (22%), November (33%), and February (29%). Twenty-seven coyote re-

Table 1. Responses elicited from howl surveys in Great Smoky Mountains National Park from March 1990 to April 1991.

Month & year	No. stations	Length of route (km)	No. Responses dog	coyote	Estimated No. of coyotes responding uncollared	collared
Mar 90	9	17.6				
Apr 90	45	43.2				
May 90	9	17.6				
Jun 90	9	17.6		6	5	1
Jul 90	17	28.8				
Aug 90	9	17.6				
Sep 90	7	17.6				
Oct 90	9	17.6		8	3	1
Nov 90	9	17.6		11	3	1
Dec 90	9	17.6				
Jan 91						
Feb 91	17	30.4	5	5	4	1
Mar 91	25	64.0	7	2	2	
Apr 91	23	57.6	8	3	2	1
Total	197	364.8	20	35	19	5

sponses were elicited in Cades Cove for a coyote index (27/118 x 100%) of 22.9% and 8 coyote responses were elicited for a coyote index (8/79 x 100%) of 10.1%.

Sharp (1981) reported a response rate of 0.95% to 7.4% at Land Between the Lakes and Blanton (1988) reported response rates of 12.5% to 33.3% on wildlife management areas in Mississippi and Alabama. The 7.1% response rate for GSMNP is probably high due to the large number of surveys conducted in Cades Cove. The higher response rates for October and November correspond with other studies conducted by Sharp (1981) and by Knowlton (1972) in which coyote numbers were highest in summer through the fall and declined in late fall through winter. The decline was likely due to dispersal of animals. Surveys in the fall should provide an estimate during the highest point in the coyote population cycle. Social behavior may play an important part in responses. If coyotes transmit information for social behavior by howling, the seasonal need for information would influence the amount of howls elicited throughout the year (Laundre 1981).

Indices of relative abundance were calculated using the methods described by Sharp (1981). Index 1 produced relative abundances of 1 coyote/13.2 km^2 (0.08 individuals/km^2) in Cades Cove and 1 coyote/39.7 km^2 (0.03 individuals/km^2) outside Cades Cove. Index 2 produced relative abundances of 1 coyote/21.0 km^2 (0.05 individuals/km^2) in Cades Cove and 1 coyote/39.7 km^2 (0.03 individuals/km^2) outside of Cades Cove.

Based on number of howl responses, observations of collared and uncollared animals, and trapping information, it appears only 1 family group occupies Cades Cove. Therefore, density estimates based on Index 1 are feasible for Cades Cove.

Surveys in Cades Cove were intensive and the entire area was covered during each survey. On 10 occasions, radio-collared coyotes were close enough to respond to the stimulus, but did not. Only a small area was surveyed outside of Cades Cove. Also, not all areas overlapped due to topography and moving water; this hampered hearing responses. The response index, coyote index, and all relative abundance estimates were higher in Cades Cove than outside the Cove which suggests the Cove has higher densities; this is expected due to the open habitats and available prey in Cades Cove.

If these indices are extrapolated to the entire GSMNP, the number of coyotes would range from 52 to 160. This range is considered possible due to the colonization of GSMNP during the last 6 years and the number of reported sightings of coyotes by park employees in past years.

The response rate of coyotes to siren and human howls is not independent ($X^2 = 19.8$; $P < 0.0001$; df = 1) based on 14 observations, 11 of which were responses to human howls and 3 to sirens. It appears that coyotes respond more to human howls than an electronic siren because howls of experienced humans more closely resemble coyote howls. McCarley (1975) and Okoniewski and Chambers (1984) felt that human howling was a better alternative to the siren because human howling more closely resembles coyote howls and is less likely to elicit responses from distant animals.

The response rate of coyotes to human howls in Cades Cove compared to the surveyed area outside of Cades Cove was independent ($X^2 = 1.8$; $P = 0.178$; df = 1); of 197 attempts at howl responses, 118 were in Cades Cove and 79 were outside of Cades Cove with 8 and 6 responses, respectively.

Fifty-four percent of the responses were group-howls involving 4 or more coyotes. It is difficult to determine the exact number of coyotes howling in a group and direction of all animals responding. The aid of a tape recorder and sound spectrograph analysis may help produce a better estimate of the total number of animals responding. We had 2 or more people available to determine number and location of coyotes responding during 7 of 8 surveys, and we recommend this procedure.

Coyote responses to various surveys are difficult to compare among areas because of differences in methods, individual researchers, interpretations of the data, and the individual animal's response to the stimuli. Variables such as topography, vegetation, moving water, and weather may also affect the researcher's ability to elicit or record coyote responses.

Future use of scent stations in GSMNP appears limited but may be improved if stations were established along major roads and surveys were conducted in fall of the year with scents that were not used for trapping. However, due to the amount of labor, time, potential visitor interference, and inclement weather, we suggest scent stations not be used for measuring relative abundances of coyotes in GSMNP or under similar circumstances.

The howl survey appears to have more potential as a coyote index in GSMNP and the southern Applachians. Howl surveys were less labor intensive, easier to distinguish between coyote and domestic dog howls than coyote and dog tracks, and were not influenced by inclement weather, masking of tracks, human interference, or the differential response to lures by animals with trap exposure. Howl surveys also may be useful after red wolves are released in GSMNP by calibrating response rates of coyotes with known red wolf densities. In the future, howl surveys may be used to compare relative densities among areas as well as annual indices, provided that experiments are designed carefully to assess the relationship between measured densities and response rates between years.

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