Numerically Common, Functionally Rare: Difficulties in Detecting Urban Coyotes for Population Monitoring

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ABSTRACT When monitoring wildlife for research and management, researchers must cope with methodological limitations associated with idiosyncrasies of animal behavioral ecology and operational constraints. In addition to wildlife behavioral limitations, urban lands present hurdles to researchers because of fragmentation of land ownership, and limited access to land parcels, which may preclude appropriate sampling strategies. Across the coyote's (*Canis latrans*) range, it is difficult to detect animals for robust, yet inexpensive population monitoring. We tested the efficacy of howling surveys to estimate coyote presence in an urbanized landscape, Westchester County, New York. This was an inexpensive, non-invasive sampling technique that is free of the confines of property access. We evaluated two hypotheses: 1) coyotes would howl less frequently in suburban areas than reported in other studies, and 2) researchers could elicit greater howling responses from coyotes by decreasing the distance between the sound source and known locations for radio-collared coyotes. Additionally, we reviewed several alternative techniques for detecting wildlife, and outlined operational challenges that limit these methods for coyotes in urban areas. We demonstrated that capture-recapture was a difficult technique to sample coyote populations, although it was worthwhile when coupled with radio-telemetry as the goal. Overall, coyotes responded poorly to taped howls (16% ± 17% SD), which was within the range of response rates reported in other studies (9–50%). We found no trends for coyote vocal responses. Howling responses for collared coyotes were abysmally low, and would not serve as a reliable index of abundance. Additionally, howling surveys provided little information beyond simple presence-absence. Eliciting coyote vocalizations from howling surveys would best be used for public outreach and education-oriented naturalist walks.

KEY WORDS abundance, *Canis latrans*, coyote, detection, estimation, index, urban

Monitoring wildlife abundance is desirable to reveal fluctuations in animal numbers, and to assess the effectiveness of management strategies such as harvest regulations or control efforts to reduce human-wildlife conflict (Amstrup et al. 2005, Engemen 2005, Lancia et al. 1994). Researchers must select monitoring methods which minimize limitations associated with idiosyncrasies of animal behavioral-ecology and operational constraints. Beyond limitations imposed by wildlife behavior (e.g., scarce and reclusive carnivores; Harris and Knowlton 2001), urban lands present hurdles to researchers because of fragmentation of land ownership, and limited access to land parcels, which may preclude appropriate sampling strategies for population estimation. This has important implications for wildlife managers seeking informative and reliable methodologies.

Any population estimation method or index of abundance depends on the ability to accurately detect animal presence and perhaps identify individuals (Buckland et al. 2001). The most feasible (i.e., reliable and available) field-data source should be selected and paired with an appropriate analytical technique (e.g., capture-recapture [Otis et al. 1978] or line transect [Burnham et al. 1980]). The approach used to estimate or index animal abundance must balance the cost and effort required to obtain the estimates with the accuracy (both precision and bias) of estimates (Engeman 2005). While single abundance estimates reveal little information about population dynamics, multiple measurements over time

reveal population trajectory (Williams et al. 2002). As such, repeatable field methods are most desirable to ensure that wildlife managers can continue to track population trends and avoid the pitfalls of obtaining a single estimate of animal abundance. Ideally, data collection methods should be cost-effective, easy to deploy, and yield consistent data across years.

Across the coyote's (*Canis latrans*) range, it is difficult to detect individuals for robust, yet inexpensive population monitoring, in part, due to their wide-ranging habits (Way et al. 2002), lower density than many other mammals (Andelt 1985), and shyness of novel objects (neophobia, Harris and Knowlton 2001). Within urbanized landscapes, detecting coyotes is further complicated by limited land access due to fragmented land-ownership and potential for differential habitat use in a heterogeneous landscape. Negative human-coyote interactions may be driven by many environmental conditions, one being coyote abundance. As such, monitoring coyote abundance may be an important predictor for understanding human-coyote conflicts.

We tested the efficacy of howling surveys to index the abundance of coyotes inhabiting an urbanized landscape in Westchester County, New York. This was an inexpensive, non-invasive sampling technique that is free of the confines of property access and can be deployed rapidly with minimal equipment costs. Additionally, we report simple detection rates for direct capture methods, researcher-based visual observations, and detection rates for trail-based fecal collections recorded during an ongoing behavioral ecology study. Lastly, we discuss operational challenges that limit these methods for use in urban areas. Gaining a better grasp of detection rates for these field collection methods is essential for wildlife managers and researchers to base decisions on monitoring protocols. It is vital to understand which field techniques will yield reliable and consistent information.

STUDY AREA

We examined potential indicators of coyote abundance in Westchester County, New York, directly north of New York City. Westchester County on average is urban, having a population density approximately 750 people/km^2, however a gradient exists with urban ($\geq$650 people/km^2) towns in the south tapering to suburban (<650 people/km^2) towns in the north (U.S. Census Bureau 2008). We focused our research to 4 towns: Greenburgh and Mt. Pleasant representing urban towns in the south, and Yorktown and Somers as suburban towns in the north. Westchester County has 7,348 linear km of roads (road density 5.96 km/km^2). Road densities and urban land cover types decrease from Greenburg in the south to Somers in the north (Table 1). Due to coyote movements, we expanded our effective study area to include portions of the towns of North Castle and New Castle.

METHODS

Within the context of a larger coyote behavioral ecology study (see New York Suburban Coyote Study: www.nycoyote.org), we examined the detection rates of 4 methods used to survey the presence of coyotes. Specifically, we evaluated the efficacy of using howling surveys as an index of coyote abundance. Additionally, we conducted 3 other survey methods which included capture rates, visual observations, and fecal collections to detect coyotes. The latter 3 methods occurred primarily within an ongoing behavioral-ecology study, and more specific information on coyote capture efforts and scat surveys will be reported in other publications.

Table 1. Land use metrics for study towns in Westchester County, New York during 2006–2008.

	Westchester county	Study towns: Greenburgh	Mt. Pleasant	Yorktown	Somers
Land area (km^2)	1232.0	93.1	84.9	102.2	83.2
Land cover type (%)					
Natural habitat	52.1	31.5	43.9	60.6	63.9
Agricultural lands	3.4	0.4	3.8	2.9	8.6
Urban recreational	3.4	5.7	4.4	2.7	2.1
Low intensity residential	23.5	36.4	24.5	21.0	12.6
High intensity developed	8.0	10.7	7.1	6.2	4.0
Other	9.5	15.4	16.3	6.6	8.9
Road density (km/km^2)	5.96	8.10	7.34	4.71	3.91

Howling Surveys

As part of the greater ecology study, 5 ear-tagged and radio-collared coyotes were targeted for an assessment of the effectiveness of howling surveys as an index of suburban coyote abundance. We conducted all howling survey trials during September–November 2008. We selected this period based on recommendations from other studies that identified this period as a peak response season (Crawford 1992, Gaines et al. 1995). Our survey evaluated two hypotheses: 1) coyotes would howl less frequently in suburban areas than reported in other studies, and 2) researchers could elicit greater howling responses from coyotes by decreasing the distance between the sound source and known locations for radio-collared coyotes.

To begin each trial, individual radio-collared coyotes were located using triangulation to estimate their position. Once triangulated, a location proximate to the targeted animal was selected. Typically we used the researcher's last position during the triangulation process. A 30-second coyote group yip-howl call (Lehner 1982) was broadcasted from a FoxPro FX 10 predator caller (FoxPro Inc., Lewiston, PA). A 2.5-minute listening period followed each call. This was repeated 4 times during each trial or until a response was obtained. We recorded the date and time when initiating each trial and assessed the following covariates: percent cloud cover, barometric pressure as changing or steady, and wind speed using the Beaufort scale (National Oceanic and Atmospheric Administration 2005). When a response was elicited, we recorded the species of the animal (coyote or dog [*Canis familiaris*]), the approximate compass bearing of call, whether response was by a group or an individual, and type of call (i.e. howl, yip or bark). We estimated the distance from observer to coyote based on the coordinates from each triangulation.

Individual trials were conducted on evenings with low to no wind and no rain, beginning at approximately sunset (Wenger and Cringan 1978, Crawford 1992, Gaines et al. 1995) and concluded within four hours of sunset (Crawford 1992). We conducted only one trial per individual each day, although we tested multiple animals per evening. Due to small sample size, group responses were converted to a simplified binomial response (0 = no response, and 1 = any coyote vocal response), and we used logistic regression to

analyze individual covariates (e.g., distance, wind and % cloud cover). We used Fisher's exact test to analyze barometric pressure. All statistical analyses were conducted using JMP® 7.0 (SAS Institute, Cary, NC).

Coyote Capture

For the spatial ecology aspect of the coyote study, we used 3 trap types to capture coyotes and equipped them with ear tags and VHF- or GPS-based radio collars. Based on trapper discretion, we used combinations of foothold, cable restraint and Collarum® (Wildlife Control Supplies, LLC, East Granby, CT) traps in attempt to maximize capture efficiency. The exact type of trap was selected specifically for micro-site characteristics. For comparison, we report only overall capture rates in captures per 1,000 trap-nights for each trap-type set during 2006–2008.

Visual Observations

Field researchers recorded all visual observations of tagged and untagged coyotes while operating within Westchester County. Additionally, we recorded daily mileage driven. While some tallied miles were acquired while driving outside the study area, we used the total mileage amounts (km) to calculate observation rates (coyote individuals observed per year divided by annual miles driven). We assumed using total mileage decreased the sighting rate negligibly due to few sightings, and the majority of miles having been accrued within the study area. We report sighting rates for both tagged and untagged coyotes.

Fecal Collections

As part of a diet study component of the behavioral ecology study, we conducted monthly scat collections along standardized trail-transects during 2008. We report the percent of total monthly transects with ≥ 1 detection, and the range of number of scats collected along trails, to highlight the uneven distribution of scats collected among selected trails (urban recreational parks versus natural park settings). This analysis does not take into account the number of scats collected per length of transect as this information will be used for subsequent detailed analyses and publication. No measure of human and pet visitation along trails was obtained.

RESULTS

Howling Surveys

We conducted 5 trials each on 5 individual coyotes for a total of 25 trials. Mean coyote response rate for all trials was 16% as only 3 (60%) coyotes responded, of which only 1 coyote responded during 2 separate trials. Individual response rates ranged from 0–40%. Estimated response distance between observer and triangulated coyote averaged 248 m. No relationship was found between howling response and distance, wind and % cloud cover ($P \geq 0.138$) or barometric pressure ($P = 0.540$) indicating coyotes infrequently and randomly responded to our coyote howling playback.

Coyote Capture

We captured a total of 40 coyotes using foothold, cable restraint and Collarum traps during 2006–2008. Foot-hold traps captured 13 animals in 2,761 trap-nights, cable restraints captured 21 coyotes in 3,482 trap nights and Collarum traps captured 6 individuals in 611 trap nights. Standardized capture rates were 4.7, 6.0, and 9.8 captures per 1,000 trap nights for foot-hold, cable restraint and Collarum traps, respectively.

Visual Observations

We seldom observed radio-marked and unmarked coyotes during the ecology study (Table 2). During the 3-year intensive field study, researchers drove 148,543 km and observed 10 tagged coyotes and 17 untagged

coyotes. Considering both tagged and untagged coyotes, we found an overall visual detection rate of 0.18 coyotes/1,000 km driven.

Fecal Collections

During 2008, we collected scat samples along 17 trail-transects distributed throughout the 4 study towns for a total of 204 sampling occasions. Transects averaged 2.3 km (min = 0.2 km; max = 6.2 km) and totaled 44.2 km. Overall, we detected ≥ 1 scat among 28.9% of sampling occasions. Three trails (75%) in Greenburg did not yield scat samples, as did one trail (20%) in Yorktown and one trail (33.3%) in Somers. All trails in Mt. Pleasant yielded scat samples.

DISCUSSION

Detecting coyotes for estimating abundance in any landscape is not a simple or easy endeavor. Our study and brief regional-based literature review indicated some methods perform better than others, but none provided a satisfactory estimate of population size. The objective of this paper was to report our test of a howling survey as an abundance index, and relate this information to other means of detection. However, the howling response rate was for known-location animals while all other detection methods were not. Our coyote response rates were within the range reported in other studies (Wenger and Cringan 1978, Lehner 1982, Okoniewski and Chambers 1984, Crawford 1992, Gaines et al. 1995); however, howling responses could be far lower when systematically or randomly sampled across an urban study area. Coyote response will depend on the sample spacing, territorial spacing and coyote-detection distance. Our study found coyotes responded at a distance of 0.14 times less than the estimated maximum response distance (1.6 km) for many other studies, indicating urban areas may require more frequent sample spacing than in other landscapes.

Dunbar and Giordano (2003) used the maximum number of coyotes counted during a month and divided by the estimated effective sampling area. The effective sampling area is the area surrounding the call-back location in which coyotes can possibly hear and will respond to the playback. This technique did not account for detection errors when coyotes were present yet did not respond. However, the authors do acknowledge this issue. Despite this caveat, they believed the method was suitable for tracking population changes in a localized area (Dunbar and Giordano 2003). Others caution on the use of howling surveys (Wenger and Cringan 1978).

We determined that fecal (scat) collections along standardized trail-transects were most likely to detect coyote presence. While this method can assess presence, it is difficult to determine if absence of scat was

Table 2. Visual observations by field researchers of both tagged and untagged coyotes while conducting field operations during a behavioral-ecology study in Westchester County, New York, during 2006–2008.

Year	Researchers	Tagged coyotes	Coyote sightings		Annual km driven
			Tagged	Untagged	
2006	3	22	3	1	55,585
2007	7	18	2	11	43,587
2008	4	6	5	5	49,362
Total	10[1]	38[2]	10	17	148,534

[1] One researcher worked throughout 3 years and two others overlapped 2 years.
[2] Column does not sum due to animals being tracked over multiple years.

a result of not present versus not detected. This issue could be alleviated by simultaneously using a second detection method.

Our fecal collection analysis used only yes ($\geq$1) or no (=0) information for scats detected along trails. Scat yield ranged widely among trails and survey replicates. Indeed, scat counts collected along trails can be normalized and used to index coyote abundance (Kays et al. 2008). Coupling scat collection with fecal DNA analyses reveals individual identification that can be used for population abundance estimation (Kohn et al. 1999, Prugh 2005, Kays et al. 2008).

While not tested during our study, Kelly and Holub (2008) found camera traps detected coyotes at a rate of 1.01 captures/100 camera-trap nights. They cautioned to adjust for camera misfires and times when cameras malfunctioned (Kelly and Holub 2008). Gompper et al. (2006) reported a low probability of detection by camera traps, and long latency before coyotes were photographed, as few cameras recorded a coyote within the first 10–15 days of deployment. In a comparative test of detection methods, Gompper et al. (2006) recommend using scat collections due to the low detection rates by cameras. They also cautioned about the risk of stolen camera equipment, particularly in suburban and urban lands.

Direct capture is time-intensive (1 trap check/day), and requires skill and specialized equipment, along with permits for animal handling. Low capture rates, and high unlikelihood of recapture (Bogan 2004) prevent this method from being used solely to estimate abundance, unless used to deploy radio collars or other biological surveys. Hair-snare detection rates for canids (Long et al. 2007) had even lower detection success (2.9 canids/1,000 trap nights) than our animal capture efforts. Long et al. (2007) reported incidental captures of 5 general canid species and 1 gray fox (*Urocyon cineroargenteus*). Coyotes and other canids were not targeted species for the study and were not genetically identified to species. This canid category could include wolf (*Canis lupus*), coyote or dog. Detection (capture) rates for hair snares and direct capture methods are similarly low as both require the animal to make physical contact with the trap device.

Track stations are not a viable technique for urbanized landscapes given impervious substrates, and the abundance of domestic dogs. In suburban Albany, New York, track stations missed 17% of encounters when coupled with camera traps (Gompper et al. 2006). Researchers could combine scat collections along trail-transects with track stations. However, in urbanized landscapes track stations may necessitate the additional use of camera traps (third technique) to reconcile the issue of missed tracks and domestic dogs.

We visually detected coyotes while operating in our study area. Despite having radio-transmitters on coyotes, we seldom obtained visual observations. Our visual detection rates were extremely low, indicating this is not a suitable detection method.

MANAGEMENT IMPLICATIONS

Understanding animal detection rates is important on two levels. First, it is beneficial for wildlife researchers and managers to have comparable results across years and among study areas. Secondly, understanding the rate at which people may detect animals is beneficial for determining how to respond to reports, perhaps complaints, of human-wildlife interactions. Claims of "often" are not informative and are unscientific. Using standardized methods while measuring sampling effort can lead to unbiased estimates of detection rates, and help shape

management responses to urban wildlife issues.

What is "often" or "common"? Our information may shed light on stakeholder perceptions of frequent wildlife interactions. Based on our visual sightings, one might expect to observe a coyote approximately once per 6,000 km (about 3,700 miles) driven in the study area. While this might seem common for a resident, this relative frequency provides little use for abundance estimation or taking management actions.

Aside from visual searches, we pursued howling surveys as the only sampling method free from the constraints of property access. While other methods obtained greater detection rates, these methods require access to private property in many cases. Howling surveys are generally easy to conduct. Scat routes require moderate effort to repeatedly walk or hike trail-transects. Capture (animal or hair) requires substantial time and effort by field crews. Despite limited funding and other logistical constraints, we question whether howling surveys could be used as a rough index for coyote abundance or presence. Accuracy will likely be compromised, especially given the asymptotic nature of perceived howls (difficult to differentiate ≥3 individual voices; see Gibbs 2000). Given the low response rates we observed with known collared coyotes, eliciting howling responses may be best used for public education and outreach purposes, and not for abundance estimation. Scat collections coupled with DNA analysis offer the best option for detecting real changes in abundance. The time required to obtain access to sufficient properties is an important factor when selecting monitoring strategies. Cost and effort must also be considered versus accuracy of any method. These factors must be considered when working out logistics (Lancia et al. 1994).

ACKNOWLEDGMENTS

We thank New York State Department of Environmental Conservation, Bureau of Wildlife for providing funding and logistical support. We thank all the members of the DEC fur management team for their contributions and involvement with our research. Thank you to Mike Losito and SUNY Cobleskill for providing student interns. Thanks to the following field assistants for assisting with field research and other aspects of the ecology study: N. Tregger, D. Dominesey, R. Reisner, V. Bosch, and R. Howard. We also express our gratitude to our project cooperators and the helpful staff of Westchester County Parks, Recreation and Conservation and the towns of Greenburgh, Mt. Pleasant, Yorktown and Somers, Cornell Cooperative Extension of Westchester County and the Department of Natural Resources, Cornell University.

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