

Progress Report

Research Title:

Population Status and Foraging Ecology of Eastern Coyotes in New York State

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Summary:

This research was initiated to assess the abundance of coyote populations in New York State and evaluate potential impacts of coyote predation on deer populations. Additional monies were secured separately to investigate other aspects of coyote ecology relevant to the DEC's interests, and that research is also summarized herein. Despite deer dominating coyote diets in space and time, coyote use of deer reflects alternate prey availability – driven by snowshoe hare and beaver in the Adirondacks and the composite availability of small mammals and carrion in the southern tier. Predation on adult deer in the southern tier was rare and considered largely compensatory during the relatively mild winters of our study. Fawn predation levels, as assessed by their occurrence in scats, were consistent over time and space – indicative of a uniform functional response across the deer densities observed in the Northeast. Based on GPS backtracking, fawn predation dropped precipitously through June and was greatest for male coyotes, at night, and under certain landcover conditions. Coyote density varied across heterogeneous NY State from 0.5 coyote pairs/10 km² in the Lake Plains to 1 pair/10 km² across the Adirondacks and northern river valleys. Vocalization surveys combined with distance sampling or a standalone detection model provides an efficient and reliable means of tracking changes in coyote density over time and space.

Background

The contemporary expansion of the coyote (*Canis latrans*) into the northeastern United States (Figure 1) has created quite a stir among the public. Coyotes in the Northeast share DNA with eastern wolves due to past hybridization events (Kays et al. 2010¹), are slightly heavier (3 kg on average) than their western and southern counterparts (Gompper 2002), and exhibit increasingly larger skulls with greater mandibular muscle attachment along a gradient from northern Pennsylvania through the northeastern states (Kays et al. 2010). Studies of coyote morphology and genetics have ignited widespread speculation that coyotes are filling the vacant ecological niche of the wolf, implying that coyote predation will limit or regulate deer populations. However, studies on the realized niche of coyotes in the Northeast are lacking with the exception of a few predation studies in the deep snow regions of the Adirondacks, Ontario and Nova Scotia.

In 2007, the DEC initiated research with SUNY-ESF to gain insight into the predation ecology of coyotes in the state, with a specific emphasis on their potential impact on deer populations. Fundamental to understanding the impact of a predator on a prey population is knowledge of predator abundance and per capita predation rates. With a generalist predator like coyotes, which are likely to exhibit prey switching and also are likely to scavenge deer extensively, more detail is required to understand predation impacts. Specifically, insight is needed into whether deer are a primary or secondary prey choice, the degree to which coyotes kill versus scavenge deer, and the degree to which predation mortality may be compensatory for deer.

This research involved intensive radio-monitoring of coyotes to study predation patterns in two focal areas within the southern tier of NY State as well as conduct a survey of coyote abundance statewide. Additional funding was secured (from non-DEC sources) that expanded our research to the Adirondacks to explore long-term trends in coyote diets as well as their niche overlap with other furbearer species. These additional studies compliment the original

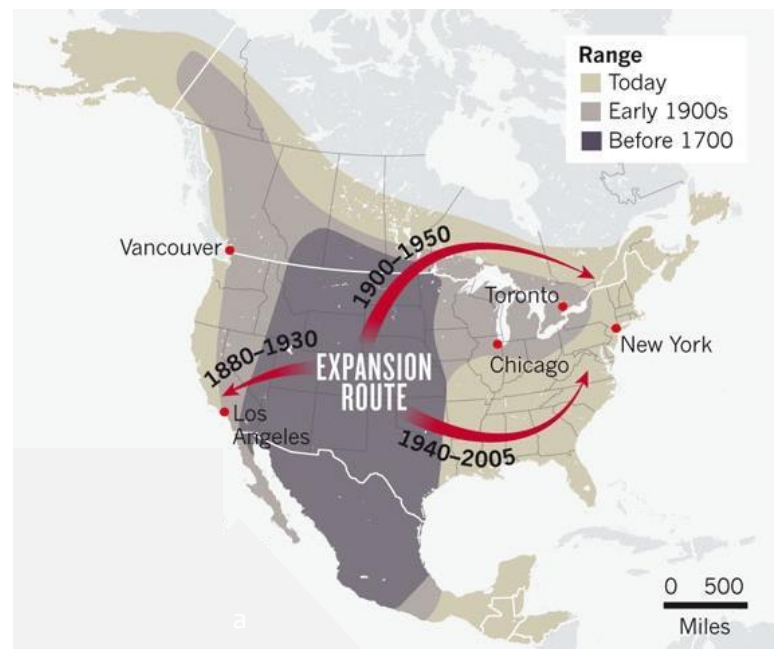


Figure 1. Historic and current range of the coyote (*Canis latrans*) in the America's (Levy 2012).

¹ To conserve space, full literature citations have been excluded. Contact J. Frair for copies of any literature cited.

coyote study and help create a more comprehensive picture of coyote predation patterns on deer and so are also summarized herein.

Effects of alternate prey on coyote use of deer

Throughout their range, coyotes are opportunistic feeders – feeding largely on lagomorphs and small rodents in the southwestern United States (Parker 1995) but having a diet dominated by deer in the Northeast (Messier et al. 1986, Major and Sherburne 1987, Litvaitis and Harrison 1989, Dibello et al. 1990, Brundige 1993). Rare, long-term studies of coyote diets with respect to changes in prey availability in northern regions have documented the prey-switching behavior expected of generalist predators. In particular, changes in the density of snowshoe hare (the primary prey item) have driven changes in consumption of white-tailed deer (a secondary prey item) by coyotes in Nova Scotia (Patterson et al. 1998) and Alaska (Prugh 2005). In the central Adirondacks, studies of coyote foraging ecology over the past 50 years (Hamilton 1974, Chambers 1987, Brundige 1993) have shown that coyote diets have become dominated by white-tailed deer (Figure 2). Coupled with a known long-term decline in snowshoe hare, this was taken partially as evidence of prey specialization on deer by coyotes in this region, which motivated a contemporary diet study.

We compared coyote diets in 2009-11 to historical diet records on the Huntington Wildlife Forest in Newcomb, NY to assess the continued importance of deer in the coyote diet. We further compared the amount of deer in coyote diets to changes in both deer and alternate prey populations over time to evaluate the potential for prey switching or prey specialization.

We conducted scat searches and analysis as described in the prior studies. To compare results across time periods, we first calculated the percentage of scats containing white-tailed deer remains. Although the percent of scats approach is known to bias results in favor of larger-bodied prey, this bias should be consistent across the time periods.

We identified a total of 14 different prey items from 174

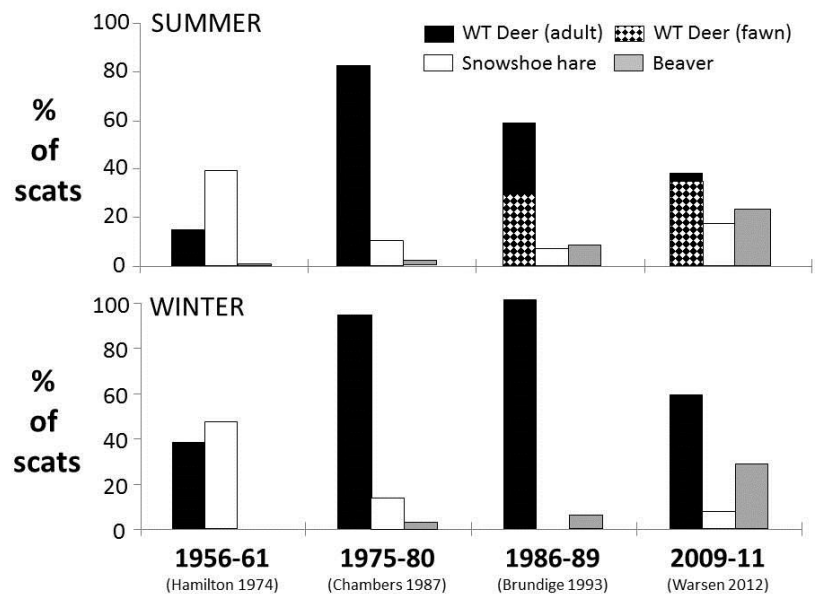


Figure 2. Temporal comparison of the percent of scats containing adult white-tailed deer (black), fawns (striped), snowshoe hare (white), and beaver (gray) at the Huntington Wildlife Forest, Newcomb, NY.

coyote scats from winter 2009-11 and summer 2010-11. Whereas white-tailed deer was the most prevalent single food item (59% of scats in winter and 49% in summer), consumption of deer declined 42-59% depending upon season in comparison to the previous studies (Figure 2). In summer, fawn use remained similar between the Brundige (1993) study and ours but use of adult deer in summer dropped substantially. Although use of deer in our study remained higher than observed in the 1950s, the earliest and most recent diet studies showed greater balance between deer and alternate prey compared to the intervening two study periods.

We compared the percent occurrence of deer in scats to relative deer density (based on buck harvest) and to alternate prey abundance. Sage et al. (1983) indicated that deer population levels were correlated to the fall buck harvest in our study area (WMU 5F), and so we used the buck harvest as an index to deer abundance. For snowshoe hare we also used harvest records, but for beaver we used the number of active beaver lodges recorded in standardized surveys on the Huntington Wildlife Forest (because beaver are not harvested on the HWF).

Winter severity appears to have driven the observed patterns in the deer population over time (GLS regression with AR1 serial correlation of average buck harvest against winter severity index, $R^2 = 0.56$, $P < 0.01$; Figure 3). The precipitous decline in the population in the early 1970s coincided with a series of severe winters combined with liberal harvest limits. The deer population rebounded to a lower apparent carrying capacity by the late 1980s.

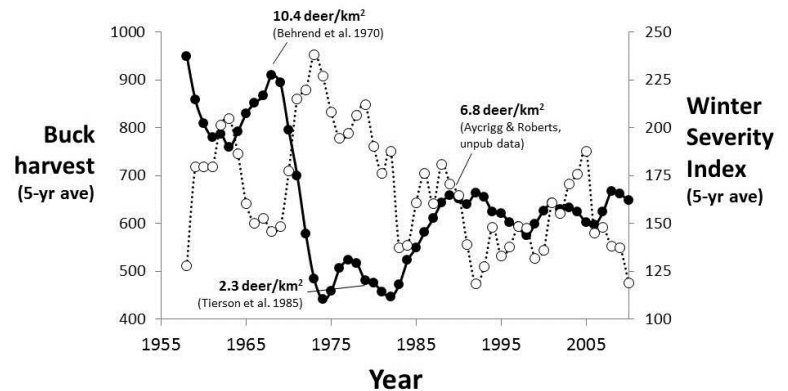


Figure 3. Temporal comparison of deer population trend (WMU 5F) against winter severity (Huntington Wildlife Forest).

Despite large fluctuations in the deer population over time, deer abundance was not positively correlated with deer occurrence in coyote diets ($r = -0.84$ to -0.92 , $P \geq 0.08$). Use of deer by coyotes peaked coincident with the lowest deer population density (1975-80; Figure 4). Harsh winter conditions may have made deer especially vulnerable to predation during that time, or provided an abundance of deer as carrion, which may have driven the increased use of deer by coyotes in those years. Interestingly, use of deer by coyotes remained high through 1986-89 while the deer population was rebounding. It is possible that coyote predation has played a role in setting a lower carrying capacity for deer in the region, but this effect is confounded by the long-term decline in habitat conditions for deer due to the maturing forest and lack of early seral habitats. The deer population has remained relatively stable since the Brundige (1993) study, yet we observed a substantial decline in use of deer by coyotes in our study.

The trend in deer use by coyotes in the central Adirondacks seems better explained by prey switching driven by the availability of alternate prey (Figure 4). Deer use by coyotes was lowest coincident with abundant hare populations (1956-61 study), peaked during the periods of low overall alternative prey abundance (1975-1989 studies), and declined more recently following the apparent saturation of the landscape by beaver (the current study). Had coyotes become specialists on deer, we expected use of deer to remain high unless deer populations dropped below a threshold that made it unprofitable for coyotes to continue to pursue them (May 1981). Instead, coyotes seem to be switching among prey items based on their relative profitability. The rather steady decline in snowshoe hare abundance is likely due to declines in habitat quality associated with the maturing forest (McGee et al. 2007, Hodson et al. 2011). However, periodic increases in hare abundance may occur, with such an uptick potentially contributing in part to the decline in deer use in this study. Even so, beaver seem to be playing an increasingly important role in coyote diets in the region.

In 1903 only a single beaver colony was known to persist in NY State (Saunders 1989), but following trapping regulations and reforestation beaver populations have steadily rebounded, appearing to have stabilized on the Huntington Wildlife Forest in recent decades. Beaver still would have been scarce in the 1950s when coyotes colonized the Adirondacks, which explains their absence from coyote scats in the earliest study. In subsequent studies the amount of beaver showing up in the diet has steadily increased along with the growing beaver population. In fact, after correcting for prey biomass differences, we observed for the first time that coyotes consumed more biomass from beaver than from white-tailed fawns in summer. This trend of increasing use of beaver as beaver populations recovered also has been observed for coyotes in Quebec (Samson and Crete 1997), coyote-wolf hybrids in Ontario (Sears et al. 2003), and wolves in Algonquin Provincial Park, Ontario (Voigt et al. 1976, Forbes and Theberge 1996). Biomass corrections also helped clarify the relative importance of

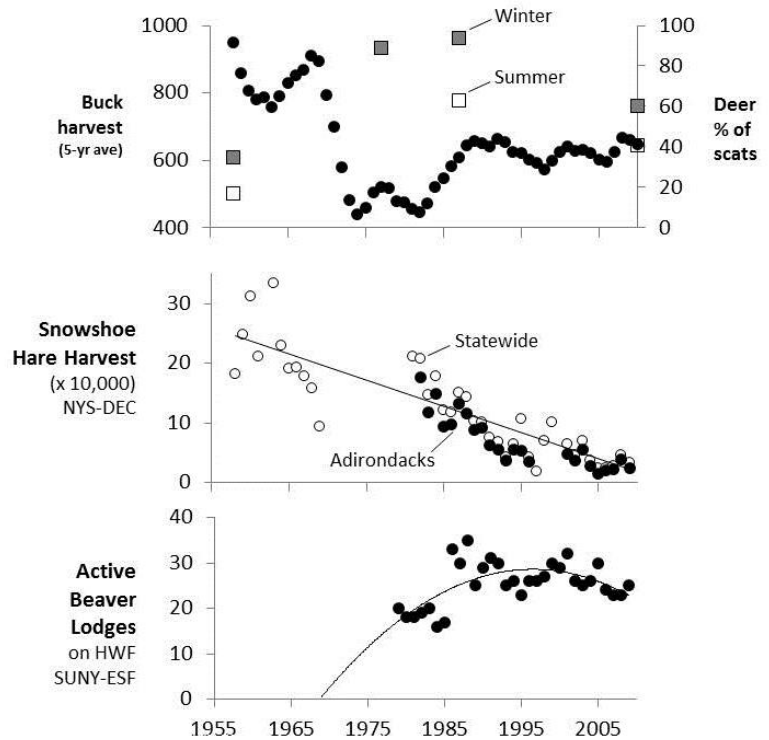


Figure 4. Historical trends in deer, hare, and beaver populations. The top panel also shows the percent occurrence of deer in coyote scats in winter (gray boxes) and summer (white boxes). Note that in the early 1900s there was considered to be only 1 remaining active beaver lodge in the Adirondacks although the data documenting their early recovery is sparse.

beaver over snowshoe hare to coyotes in the current study, with 18-51% of the biomass consumed in winter and summer, respectively, consisting of beaver compared to $\leq 3.3\%$ of the biomass consumed in each season consisting of snowshoe hare.

Warming trends in the Adirondacks also may play a role in the relative availability of beaver and deer to coyotes. Warmer winters may lead to reduced snowpack and thus less energetically compromised deer – making predation less likely and, given a reduced winter kill, reducing scavenging opportunities for coyotes. In contrast, the period of time lakes are covered with ice has become progressively shorter (Beier et al. 2012), which may increase the vulnerability of beaver to coyote predation.

Substituting space for time

Taking a broader look across heterogeneous NY State, we compared coyote diets in three regions that differed in terms of deer availability (Figure 5, top panel). Use of deer remained relatively stable across the three sites in summer but declined with increasing deer density in winter (Figure 5, bottom panel). In contrast to our observations in the Adirondacks, there was no single prey species driving prey-switching for coyotes in the southern tier of NY State. The bulk of the biomass consumed in the southern tier consisted of a more diverse suite of species than observed in the Adirondacks despite a similar number of overall prey items appearing in scats. In the southern tier, cottontails were used more in winter and woodchuck more in summer whereas microtine rodents and scavenged livestock were used consistently in both seasons.

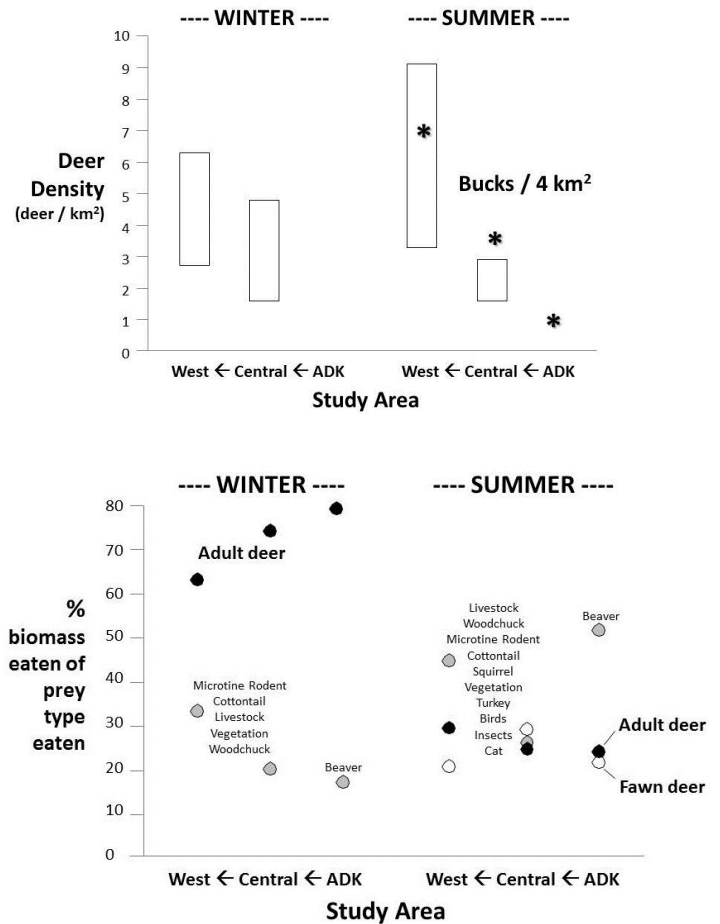


Figure 5. Top panel: deer density in the central Adirondacks (Newcomb), central NY (Worcester), and western NY (Bath) focal areas. Deer density is shown both from distance sampling (white bars; Boser 2009) as well as harvest based estimates (black stars; NYS DEC) where available. Bottom panel: species comprising 95% of the total biomass consumed by coyotes in each region, highlighting adult deer (black), fawns (white), and alternate prey (gray). In the southern tier, alternate prey were combined across sites and listed in declining order of prevalence.

We know livestock to have been scavenged because during the course of our study we had no reports of coyote-killed livestock, and in our back-tracking trials (see predation section to follow) we observed several carcass dumps that coyotes frequented.

Coyote predation on white-tailed deer

To document kill rates on adult and fawn white-tailed deer, we backtracked 15 GPS-collared coyotes for two summers (2008, 2009) and 11 coyotes for two winters. In summer, collars were monitored from 24 May – 26 July to coincide with the window of fawn vulnerability to predation. Collars were programmed to take 20-minute locations in summer and 20-30-minute locations in winter depending upon the year. Any two consecutive locations within 50-m of each other were identified as “clusters” and potentially investigated in the field to search for prey remains.

A total of 1,800 winter clusters were investigated (about 44% of all GPS locations collected). We documented remains of livestock and deer at 24 and 62 sites, respectively. All livestock carcasses were considered scavenged as we received no reports of coyote-killed livestock during the period of our monitoring, and livestock dumps were commonly visited by our collared coyotes. We were able to definitely determine cause of death for 39 (63%) of the deer

carcasses, of which 3 had been killed by coyotes (8%) and the rest were scavenged (92%). Importantly, all 3 of the coyote-killed deer had pre-existing leg injuries (severe arthritis or broken joints) that increased their vulnerability to predation.

Table 1. Comparison of relative biomass of prey species consumed in summer as identified from scats versus GPS backtracking following the approach of Bacon et al. (2011).

Prey item	Prey weight (kg)	Correction factor (kg/scat)	% in scats	SCATS Relative biomass consumed (%)	Kills	KILLS Relative biomass consumed (%)
Fawn	14.0	0.369	18.0	73.8	33	76.6
Woodchuck	5.5	0.298	4.8	15.7	13	11.8
turkey	7.0	0.315	3.0	10.5	10	11.6

Source: Robbins & Moen (1979) Kays & Wilson (2002) Source: Kelly (1991) Source: Boser (2009) Source: R. Holeyvinski (unpub. data)

In summer, 61% of the GPS locations collected for coyotes were searched yielding a total of 56 kill detections.

Fawns were the dominant prey item (33 kills) followed by woodchuck (13 kills), and turkey (10). The rank order of species choice as well as the total biomass consumed (relative to the three main prey species) was comparable between our backtracking and scat-based diet efforts (Table 1), indicating that our detected kills were representative of the general coyote diet.

We used an algorithm to more objectively identify potential kill clusters, and used a binary mixed logistic model to discriminate kill from non-kill clusters. Our best model indicated that the probability of a cluster being a fawn kill was 2 times greater for males compared to females, 7.5 times greater between 7 pm and 10 am compared to other times, and 4.8 times greater in unplowed fields and 13.3 times greater in wetlands compared to other cover types. Importantly, and not surprisingly, the probability of a cluster being a fawn kill declined precipitously with Julian day, becoming essentially zero by the first week of July (Figure 6).

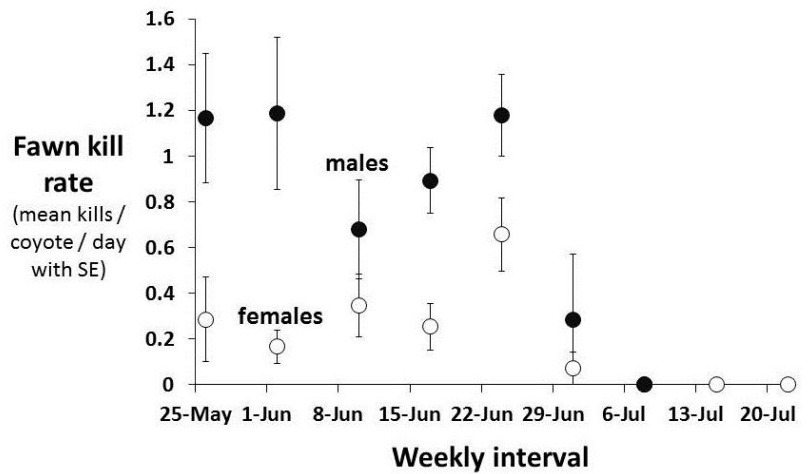


Figure 6. Crude fawn kill rates by male and female coyotes in our two focal areas.

Some key insights into coyote predation on deer

The percent biomass of fawns consumed ranged 20-30% across our three focal sites, which represents a consistent use of the fawn resource despite gross differences in deer density among regions. Moreover, these values are also consistent with the Brundige (1993) study from 20 years ago in the Adirondacks as well as studies in Nova Scotia (Patterson et al. 1998, Patterson and Messier 2003). This conspicuously consistent use of fawns by coyotes over time and space could be explained by effective predator swamping, i.e. coyotes are handling limited by an abundant but ephemeral fawn resource. These observations provide strong evidence for a uniform functional response for fawn predation across the deer densities observed in the Northeast, meaning that per capita kill rates are not expected to vary as a function of fawn density in this region. Therefore the primary variable predicting the total kill of fawns by coyotes (given total kill = functional × numerical response) will be the number of coyotes. Of course the impact of the total kill on the deer herd will be a function of the proportion of the fawn crop removed by coyotes, the combined effect of other sources of mortality, and the degree to which coyote predation may be compensatory.

Importantly, the number of coyotes is expected to vary as a function of alternate prey availability, which in the Adirondacks includes beaver and snowshoe hare. Beaver are not known to cycle in the manner that snowshoe hare have demonstrated, meaning that coyote populations dependent upon beaver may be relatively stable over time. In the southern tier a high level of diet subsidy occurs in the form of scavenged livestock and deer, which may also buffer coyotes against the cyclic nature of prey populations and maintain a more stable coyote population over time. Of interest then will be whether coyote numbers are high enough that spillover predation onto fawns may influence the ability of the deer population to absorb

coyote predation. This may be of particular concern following a harsh winter, as predation on fawns may slow population recovery.

With respect to predation on adult deer, our results indicated predation to be largely compensatory in the southern tier. This contrasts with previous studies in the Adirondacks (Brundige 1993), Ontario (Messier et al. 1986) and Nova Scotia (Patterson et al. 1998, Patterson and Messier 2003) that indicated coyote predation to be largely additive. Harsh winter conditions are known to make deer more vulnerable to predation, and winter conditions are reliably severe from the Adirondacks northward. Winters are comparatively mild in the southern tier, although a harsh winter that tips predation to a more additive source of mortality is possible. The availability and common use of livestock dumps by coyotes may provide a subsidy that buffers deer from coyote predation or, alternatively, that artificially elevates coyote abundance with spillover predation concerns.

Quantifying coyote abundance

Accurately and efficiently monitoring changes in coyote numbers over space and time is challenging due to their being widespread, common, highly vagile, not individually-identifiable, active primarily at night, and generally elusive. Moreover, that most coyotes occupy private land in NY State makes monitoring their populations particularly difficult. For this reason monitoring of coyotes has primarily involved indices of abundance, i.e., raw counts of animals or their sign uncorrected for detectability, which can be unreliable if the detectability of animals or their sign varies over space and time. We evaluated a novel means of estimating coyote density involving vocalization surveys where call detectability was estimated (and corrected for) either empirically using distance sampling or modelled as a function of sound spread. We tested various assumptions of our approach in the field at our focal study sites and ultimately applied the design statewide to provide a baseline assessment of coyote abundance across NY State. The key considerations and insights are summarized here, but see Hansen (2013) for full details of the sampling and modeling process.

Call-response surveys formed the backbone of our density estimates. The

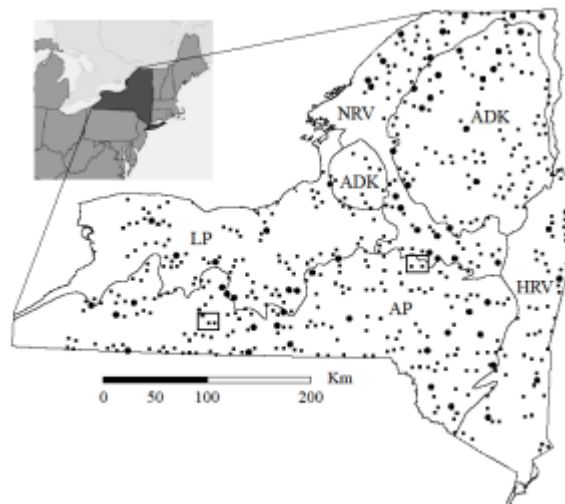


Figure 7. The study area for coyote distance sampling in New York State. Map indicates generalized ecoregions (LP = Lake Plains, AP = Allegheny Plateau, NRV = Northern River Valleys, ADK = Adirondack Mountains, HRV = Hudson River Valley), focal study areas containing GPS-collared coyotes (boxes), and survey locations and outcomes (● coyote response detected, ■ no coyote response detected).

data we used to estimate density came from a statewide survey conducted simultaneously by three field crews June-August 2010 (Figure 7). A total of 541 surveys were conducted, avoiding urban and heavily trafficked areas (interstates and main highways). Points were separated by ≥ 6 km to ensure independence on a single survey night. Surveys were conducted between dusk and dawn on wind-free nights.

Importantly, we took a cue counting approach in which independent detections of coyote vocalizations were considered to represent a single breeding pair based on evidence that territorial coyotes were 4 times more likely to vocalize than transients (Mitchell 2004). This assumption provided a scope of inference limited to the number of territorial pairs in the study area, which is appropriate assuming that the number of territories in a given area reflects the local carrying capacity. Combined with estimates of annual pup productivity, our estimates can provide insight into peak abundance prior to the fall harvest season. Using vocalizations as our means of detecting coyote presence required an additional correction for availability reflecting that coyotes will respond vocally to broadcasted calls only 48% of the time (Fulmer 1990, Mitchell 2004). We considered coyote availability fixed and estimated the probability of detecting a calling coyote in a survey as described below.

Distance sampling - Distance sampling is based on the assumption that our ability to detect animals, but not animal density *per se*, degrades with distance from a survey point or transect, and uses the number of detected individuals (or groups) over space as a means of estimating the detection probability (Buckland et al. 2001). The most important component of distance sampling is obtaining an accurate measurement of the distance between an observer and a detected animal. To estimate this distance we triangulated calling animals using 3-person field crews, with 1 observer stationed at the central “broadcast” point and the other 2 stationed 500 m away in opposing directions. When a vocalizing coyote was heard, broadcasts were stopped and the crew recorded a bearing, ultimately providing a straight-line estimate of distance to the calling coyote from the central observer. Locations were considered successful when three bearings crossed or when two crossing bearings produced an error ellipse < 0.01 km², which yielded a linear mean error of ± 119 m in field trials. Given that coyotes were reliably detected up to 1.8 km distant from the central observer, the precision of triangulated distances was sufficient for estimating the detection probability with precision (Figure 8).

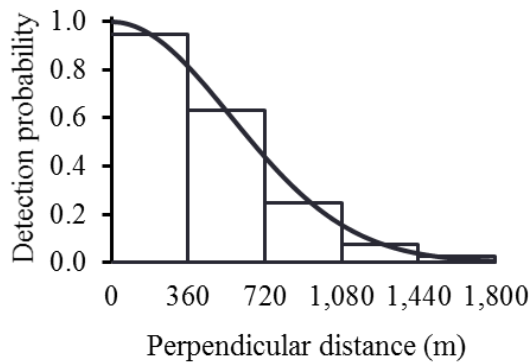


Figure 8. Probability of detecting a vocalizing coyote (\hat{p}) given distance from observer ($n = 66$).

We estimated a probability of detection (\hat{p}) of 0.19 (0.03 SE), which yielded 1.3 coyote pairs/10 km² for a statewide population estimate of 14,310 coyote pairs (8,719-22,887 95% CI).

Sound spread modeling – We sought to eliminate the need for three-person field crews (a major field limitation) as well as the 60+ detections needed to estimate a study area specific \hat{p} (a major sampling limitation) by creating a spatially-explicit and standalone model for the probability of detecting a coyote call based on the first principles of sound spread.

Using SPreAD-GIS (Reed et al. 2009), we modeled how land cover and terrain influenced sound attenuation over space. More specifically, for a given point 198 virtual coyotes (spaced 250-m apart to 1.8 km distant) were used to estimate the probability of detection as the number of calls detected at the central observation point / 198 attempts.

Here, detection was determined by the decibel level of the coyote call reaching the central observer, which must remain above ambient noise to be detected. SPreAD-GIS predictions of \hat{p} correlated well with empirical detections in blind field trails (Cohen's $W = 0.88$, $P < 0.01$, $N = 132$). We applied this process to 101 survey points statewide, representing a range of site conditions and yielding \hat{p} values of 0.08-0.91. The modeling process was too computer intensive to complete for every possible survey location. Instead, we regressed \hat{p} from these 101 locations against landscape covariates – terrain ruggedness and proportion of area forested measured to 2-km distant, elevation of the observer, and ecoregion – to estimate a model of \hat{p} applicable to any potential survey location in the state (Figure 9).

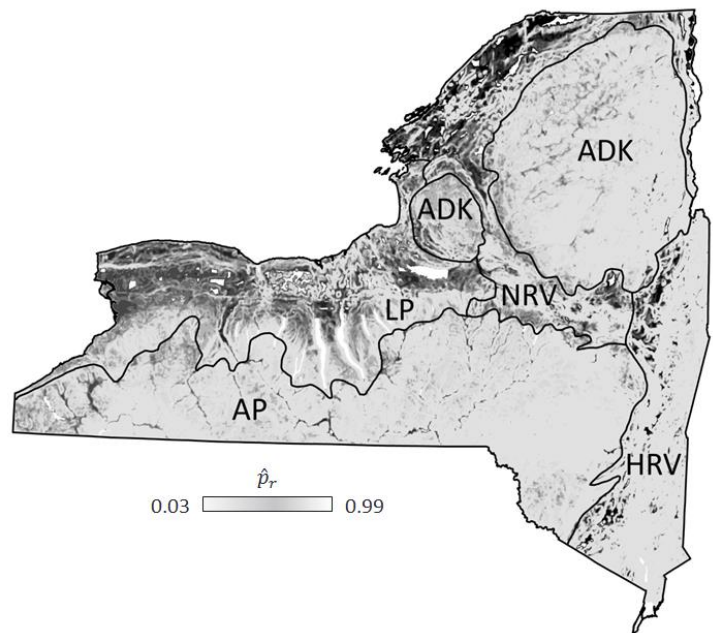


Figure 9. The predicted probability of detecting a calling coyote.

Extracting our 541 actual survey points yielded a mean value for \hat{p} of 0.27 (2.7% CV), which was significantly higher and more precise than our distance sampling estimate of 0.19 (13.15% CV; $t = 2.96$, $df = 75$, $P < 0.01$). Substituting the spatially-explicit estimate of \hat{p} yielded 0.87 coyote pairs / 10 km² (0.64-0.94 95% CI), an estimate that was lower and more precise than acquired using the statewide mean \hat{p} estimated using distance sampling (1.3 pairs/10 km², 0.8-2.1 95% CI). Moreover, using the spatially-explicit model for \hat{p} we were able to obtain more accurate and precise estimates of coyote density by ecoregion (Figure 10).

Take home points – Distance sampling requires a minimum of 60 detections to achieve a reasonable estimate of \hat{p} . We achieved that with very wide-spread samples and estimated a single detection probability for the state. This is not a limitation of distance sampling *per se*, but rather a consequence of our statewide survey design. A region-specific estimate of \hat{p} is achievable with distance sampling, but would require more intensive survey effort to achieve the needed 60 detections and must be conducted in a manner that does not acclimate the survey population to the broadcast efforts (which could change coyote availability). Even so, our modeling demonstrated how highly variable sound spread is across heterogeneous NY State. Importantly, given the same controlled survey conditions (time of year, wind conditions, etc.) our model would remain applicable for future surveys, which would allow for a greatly streamlined survey effort (1 observer recording whether or not they heard a coyote at each survey location).

Conspecific competition

Funding from the Northeastern States Research Cooperative enabled a study of niche competition among coyotes and sympatric carnivores in the Adirondacks, focused in particular on coyotes, red fox, gray fox, and bobcat. For this study we looked at isotopic niche space, in which the position of a species in a plot of two different isotopes, specifically carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$), indicates their degree of niche overlap.

The carbon signature is considerably enriched for corn (a C_4 plant) relative to temperate (C_3) plants – providing a distinctly “human” signature in animal diets in temperate environments. The lack of agriculture in the Adirondacks helped isolate the source of corn as coming from human-dominated areas through refuse, compost, pet food, or bird seed. In contrast, the nitrogen signature changes in a predictable manner with trophic level. Aquatic systems tend to have more trophic linkages and therefore mammals accessing aquatic prey would be expected to have a higher nitrogen signature. However, a direct relationship has also been observed between increasing amounts of animal protein in the diet and increasing nitrogen isotope values.

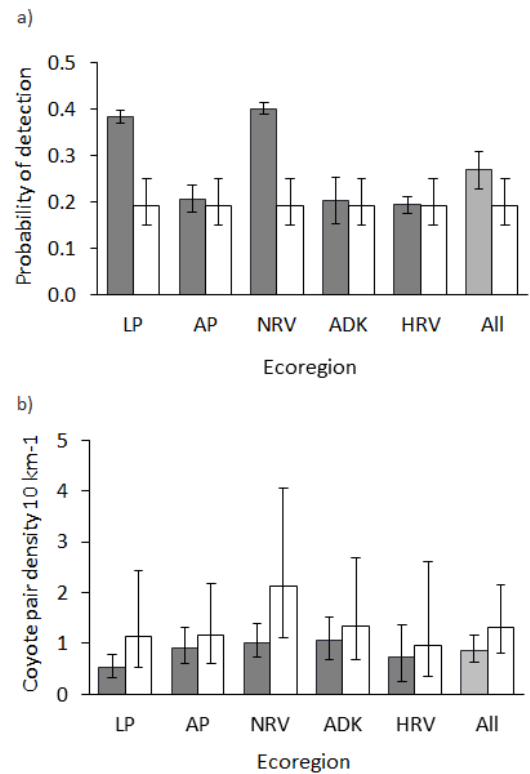


Figure 10. Estimated probability of detection (a) and estimated coyote density (b) by generalized ecoregion. Shown are the differences between estimates using distance sampling (white) and sound-spread modeling (gray). The last column indicates pooled, statewide estimates.

Because we expected a high degree of overlap among our four focal species in terms of their diet, we focused on species rankings along the two isotope scales rather than on statistically significant differences. Based on their reported tolerance for human activities and human-dominated landscapes, we expected the carbon isotope signature to rank red fox > coyote and gray fox > bobcat. Based on bobcat being the only obligate carnivore of the group, combined with the differential consumption of plant matter by these species, we expected the nitrogen isotope signature to rank bobcat > coyote and red fox > gray fox. Although our hypotheses were specific to the four species we expected to exhibit the greatest degree of competition, we collected samples from the full suite of available furbearers. From trappers we acquired a minimum of 10 samples per species from across the Adirondacks.

As expected, otter, mink and weasel that are known to rely on aquatic sources of food exhibited higher nitrogen isotope positions relative to the other species (Figure 11). Moreover, black bear, the most omnivorous species of those considered, exhibited the lowest nitrogen signature - lending support to our expectation that a vegetation heavy diet might pull the nitrogen signature downward. However, we did not observe the expected rankings for our four focal species. In fact, bobcat showed the lowest and most variable nitrogen signature of our focal species.

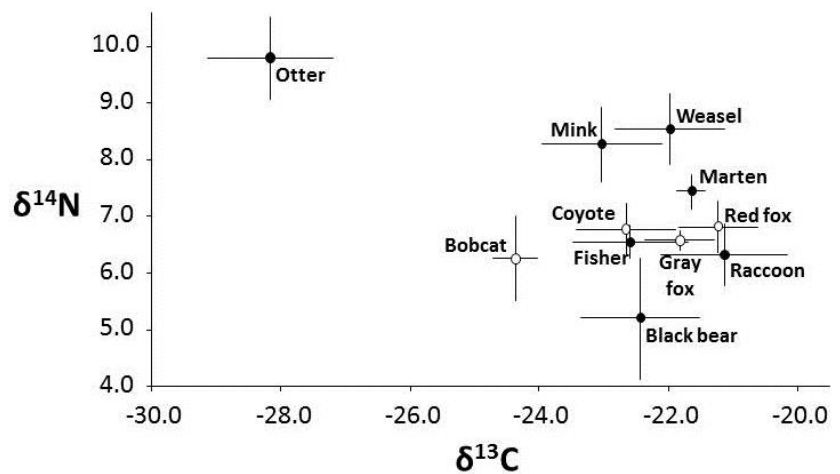


Figure 11. Isotopic niche space of furbearers in the Adirondack Park.

We did observe our hypothesized rankings on the carbon scale (Figure 11) – reflecting access to human sources of food. The bobcat isotope value was consistent with expectations for a secondary consumer feeding almost exclusively on wild (non-anthropogenic foods). That our bobcat samples were largely collected along the periphery of the park (in contrast to the other species whose samples were more centralized), and so had access to corn fields, further substantiates bobcat avoidance of human sources of food. Red fox shared a similar isotope value to raccoons, a species known to thrive in urban environments. An interesting question is whether red fox would fall further to the left on the carbon scale in the absence of coyotes or whether they are being pushed to extremes by coyote competition.

Not surprisingly, the highest degree of isotopic niche overlap was observed for coyote and gray fox. But of interest is the high degree of niche overlap observed between coyotes and fisher. Like coyotes and foxes, fisher also heavily scavenges deer – and access to scavenged deer may be the great equalizer of isotopic signatures in this landscape.

Importantly, we need to recognize that the relationship between isotopic and ecological niches is not necessarily straight-forward and isotopic niche can yield deceptive estimates of ecological niche width or breadth. For example, the relatively small variance in nitrogen values for gray fox does not mean they occupy a smaller, or more restrictive, ecological niche compared to the other species – in fact it indicates the opposite. Populations of dietary generalists tend to have narrower isotopic niche breadth compared to specialists because they sample broadly and “average” their diets. However, generalists also may show a high degree of individual specialization depending upon local resource availability, which could conceivably widen apparent isotopic niche breadth. This may be the case with bobcat who exhibited the largest variance in nitrogen signature of our four focal species by having individuals with the lowest and highest overall nitrogen values.

Ongoing or new research

Analyses are still ongoing from the GPS backtracking efforts for modeling kill rates and impacts on deer populations. This is primarily led by R. Holevinski and is part of her Ph.D. dissertation work.

Genetic data were collected from coyotes across NY State to ascertain whether there is a discernable “dividing line” among the original invading coyote fronts that might correspond to differences in their behavior on the ground. These data were used by Roland Kays and others in their work. Landscape genetic analyses are ongoing with these data, led now by Leah Berkman (post-doc at the US Forest Service, Rhineland, WI) as part of another research collaboration.

A new study is getting underway at Fort Drum that is focused on coyote and red fox interactions. This study will involve detailed analyses of coyote and fox movement and habitat use (from GPS collars) as well as a comparison of diets (from scats and stable isotopes) across a gradient of high- to low-human activity in the landscape. Trapping to deploy collars will begin this spring.

Research products

Boser, C.L. (2009) Diet and hunting behavior of coyotes in agricultural-forest landscapes of New York State. M.S. Thesis, SUNY ESF.

Hansen, S.J., Frair, J.L., Underwood, H.B., and Gibbs, J.P. (in review) Pairing call-response surveys and distance sampling for a mammalian carnivore. *Journal of Wildlife Management*.

Hansen, S.J.K. (2013) Estimating density of coyotes from call-response surveys using distance sampling and soundshed models. M.S. Thesis, SUNY ESF.

Warsen, S.A., Frair, J.L., and Teece, M.A. (2014) Isotopic investigation of niche partitioning among native carnivores and the non-native coyote (*Canis latrans*). *Isotopes in Environmental and Health Studies*, DOI: 10.1080/10256016.2014.897946.

Warsen, S.A. (2012) Evolving niche of coyotes in the Adirondack Mountains of New York: long-term dietary trends and interspecific competition. M.S. Thesis, SUNY ESF.

Other publications

SUNY-Environmental Science and Forestry studies coyotes' impact on deer. Page 12 of the New York Hunting & Trapping, 2010-11 Official Guide to Laws & Regulations (vol 4, issue no. 1, October 2010. Drafted by J. Frair, edited by NYS DEC.

Presentations

Aspects of this research have been presented by J. Frair or graduate students at 17 local, regional, and national scientific conferences as well as 38 different public venues around NY State.

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