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Camera Trapping of Carnivores: Trap Success Among Camera Types and Across Species, and Habitat Selection by Species, on Salt Pond Mountain, Giles County, Virginia

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Abstract - To evaluate trap success among camera types and across species as well as assess habitat selection by target carnivore species, we established 16 infrared-triggered camera stations across a 26.9-km^2 study area located on primarily Jefferson National Forest land in Virginia. We monitored camera stations for 72 days (August to October 2005) for a total of 891 trap nights (TN) of effort. Overall trap success for all animals combined was 40.74 captures per 100 TN. *Procyon lotor* (raccoon) had the highest predator trap success (2.81/100 TN), followed by: *Ursus americanus* (black bear, 1.91/100 TN); *Lynx rufus* (bobcat, 1.46/100 TN); *Canis latrans* (coyote, 1.01/100 TN); and *Urocyon cinereoargenteus* (gray fox, 0.56/100 TN). *Odocoileus virginianus* (white-tailed deer) had the highest overall trap success (21.32/100 TN), followed by *Sciurus carolinensis* (gray squirrel, 6.17/100 TN). Passive camera units, especially DeerCam, had higher trap success than active camera units, and digital camera units (Reconyx) out-performed film cameras. We extracted percent cover of habitat features (% coniferous, % deciduous, % water, % agricultural) from a geographic information system (GIS) using circular buffers around each trap site and compared carnivore-present sites to carnivore-absent sites. We compared carnivore trap success to the distance to the main access road and to trap success of prey species, primarily deer and gray squirrel. We also compared each carnivore's trap success to that of the other carnivore species to determine if carnivore presence or activity levels influenced other carnivores. Black bear, coyote, and raccoon tended to avoid areas with a high percentage of coniferous forest, and only bobcat showed significant avoidance of coniferous forest. Bobcat trap success increased with distance to the main road, and coyote trap success was positively (but weakly) related to gray squirrel trap success. Human foot traffic did not affect carnivore trap success. This study elucidates differences among camera trap systems, and highlights the potential to monitor carnivore species simultaneously and in combination with a GIS to predict occurrence across a landscape.

Introduction

Remote camera trapping allows for the detection and monitoring of elusive wildlife, particularly of carnivores, without their physical capture and handling. The technology also has great potential to increase the spatial and temporal scales across which we can collect data on elusive species. Because of these factors, such studies have increased dramatically in recent years (for reviews, see Cutler and Swann 1999; Kays and Slausen, in press). Camera systems and manufacturers have likewise increased dramatically. However, no studies have compared success rates among camera systems in a field setting. While Swann et al. (2004) compared remote cameras in laboratory

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trials, camera performance must also be evaluated under the often difficult and variable field conditions of rain, humidity, wind, and snow. We evaluated four commonly available camera types.

Most remote camera studies focus on one or two target species and yet often photographs are obtained of multiple species. In fact, the information on non-targets often far outweighs the information obtained on the target species. Careful camera placement can further increase the information obtained on non-target species while still capturing target species. Because of the large number of photographs obtained in remote camera studies, this "extra" photographic information often is filed away and not recorded or analyzed. Simple metrics such as trap success for each species, however, may prove extremely valuable for wildlife monitoring generally or in relationship to the target species. While debate continues over whether trap success can be used as an index of abundance (Anderson 2001, 2003; Carbone et al. 2001, 2002; Engeman 2003; Jennelle et al. 2002; O'Brien et al. 2003), trap-success data across species can, at the least, lead to hypotheses on species occurrence in relation to habitat variables and/or other species. Recent advances in occupancy modeling also can allow us to use presence-absence data obtained from sequential, repeated, remote camera surveys to generate detection probabilities and produce more reliable estimates of species' relative abundance or areas occupied (MacKenzie and Royle 2005, MacKenzie et al. 2003, Royle and Nichols 2003). Therefore, the value of remote camera data will only increase through time, and effort should be expended at the onset to enter non-target species data into a usable format for future analyses.

We targeted all medium- to large-sized carnivores believed to occur in the study site: *Ursus americanus* (black bear); *Lynx rufus* (bobcat); *Canis latrans* (coyote); *Vulpes vulpes* (red fox); *Urocyon cinereoargenteus* (gray fox); *Procyon lotor* (raccoon); and *Mephitis mephitis* Schreber (skunk). We calculated trap success for all species, including the non-carnivores, and present this information as a comparative guide for other researchers on the amount of effort needed to capture each. We combined our information on trap success and presence-absence with a geographic information system (GIS) to evaluate habitat selection by the carnivores. We also examined whether carnivore trap success was influenced by trap success of other species.

Methods

The study area is located around Mountain Lake Biological Station (MLBS) on Salt Pond Mountain, Giles County, VA (37.375556ºN, 80.522222ºW) and is primarily within the Jefferson National Forest, with some on privately owned land (Fig. 1). MLBS is surrounded by deciduous hardwood forest with stands of *Pinus strobus* L. (white pine), and *Tsuga canadensis* L. (Carr.) (eastern hemlock), at an elevation of 1160 m (3806 ft). Other habitats include mountain streams, successional meadows, a large natural lake, ponds, rocky ridges, sphagnum bogs, and stands of *Picea rubens* Sarg. (red spruce).

We established 15 camera stations, of which one was later moved, and the new location became site 16 in Figure 1. Trap sites were systematically spaced 1 to 1.5 km apart across the study site and placed on existing hiking trails, game trails, and forest service roads. We cleared understory growth at sites to minimize false triggering and allow for unobstructed photographs. We chose sites with natural "funnels" to force animals in front of cameras at a distance of approximately 3–4 m from the lens. We used no lures. Cameras were mounted 30–40 cm above the ground, and care was taken to ensure that each camera would trigger for an animal as small as a bobcat or raccoon, as well as for a deer or bear. When possible, we locked cameras to trees with braided steel cables and padlocks to prevent theft.

We used both active and passive infrared-triggered cameras to survey and evaluate trap success for all animals captured, as well as to determine the effectiveness of different camera types. Active systems consisted of two units: a transmitting unit that sends an infrared beam, and a receiving unit which is set across the target area. A picture is taken when the infrared beam is broken. Passive systems are single units that use heat and motion detectors to trigger the camera. We used the widely available film camera systems: the TrailMaster active (TM1550) system, and the passive systems DeerCam200 and CamTrakker; and one passive digital system, Reconyx (Recreational).

A total of nine TrailMasters, 15 DeerCams, two CamTrakkers and two Reconyx were dispersed among the trap sites. We began with six CamTrakkers, but four malfunctioned and required continual troubleshooting in the field and hence were replaced with DeerCams. At 13 locations we placed two different camera systems on opposite sides of the trail to capture target animals from both sides of their body. This also allowed us to compare the effectiveness of different systems. All systems were programmed with 30-second intervals

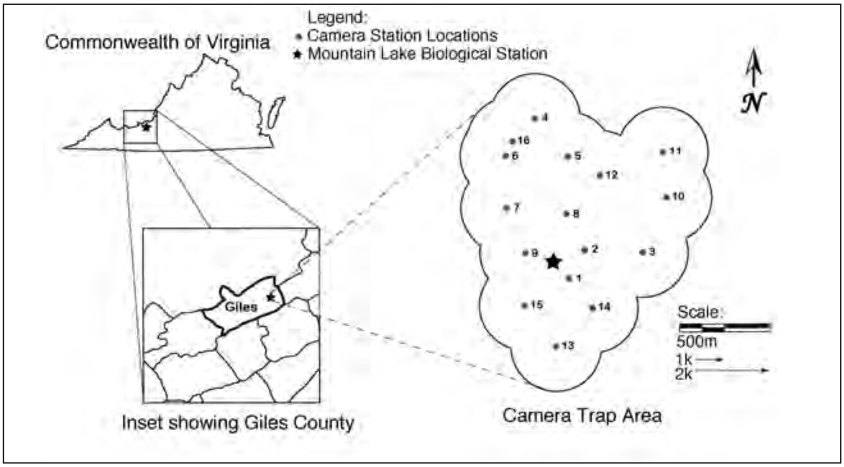

Figure 1. Location of the study site and camera traps, indicated by numbered dots. Camera stations were spaced systematically at 1–1.5 km apart. Buffers of 1 km surrounding each camera station resulted in an effective survey size of 26.91 km^2.

between each camera trip, and cameras were active 24 hours. The Reconyx were set to take three photographs every time the system was triggered.

Cameras operated from August 11 to October 22, 2005, for a 72-day trapping period, which is consistent with other studies that use 60–90 days (Karanth and Nichols 1998, Silver et al. 2004). In addition, this time of year ensured a wide range of environmental conditions, with average monthly temperatures ranging from -2.9 to 26.8 °C and average relative humidity at 85–90%. No snow accumulated during this time. Monthly rainfall accumulation ranged from 22 mm to 111 mm, and average wind speed was 1.3–1.8 m/sec. Because we could only reach half of the stations in one day of hiking, each station was visited for maintenance at least once every 14 days. To determine the approximate survey area, we created a 1-km buffer around each trap station and dissolved buffers using ArcView software to calculate survey area (Fig. 1).

We summarized the total number of photographs taken, identifiable animals in photographs (events), and trap-nights of effort after subtracting days where cameras malfunctioned or ran out of film or batteries. We calculated trap success as the number of trap events per 100 trap-nights. Camera malfunctions were usually easy to discern upon developing film and consisted of either a camera that did not take any photos, or one that triggered randomly in quick succession until all the film was exposed (usually within a single day). Animals that could not be individually distinguished and were captured within 30 minutes of each other at the same station were considered to be the same event. After 30 minutes, they were arbitrarily considered to be a new photographic event, which is consistent with protocols of Kelly (2003) and Silver et al. (2004). Care was taken not to double-count animals as two separate events when two cameras on opposite sides of a trail triggered simultaneously. The date and time stamp on each photograph, as well as animal position or individual marks, facilitated in separating events and in eliminating double counting. We then compared trap success among stations and camera types for each species. We used analysis of variance (ANOVA) and Student's t-tests to analyze differences in trap success among camera types. Rigid head-to-head comparisons of camera systems were not possible because camera malfunctions were commonplace, and we had to remove cameras and replace them on a weekly basis with other cameras that were not always the same system as the one removed.

We created circular buffers with radii of 100, 250, 500, and 750 m surrounding each camera trap. The smaller radii addressed habitat selection at a scale relevant to the smaller carnivores. We did not use radii larger than 750 m due to the autocorrelation that would occur because of the distances between camera traps. For each buffer area, we extracted the percent cover of deciduous forest, coniferous forest, row crops, agricultural land, and water from the 1992 National Land Cover Dataset (NLCD). We also calculated the distance of each station to the main access road, a high-use dirt road (Rt. 613). For each of the buffer radii, we used Student's t-test to determine whether locations capturing target species had a different percent cover of habitat types than locations without target species. Due to the small sample sizes for t-tests, we used an alpha value of 0.10 as our significance level. We further examined habitat associations across camera stations using linear regression to determine if carnivore trap success was influenced by cover type or distance to the main access road. We calculated trap success for humans, and used linear regression (alpha of 0.05 for significance) to determine if human use influenced animal trap success. We also used linear regression to compare trap success of prey animals (deer and gray squirrel) for which we had adequate data to that of the carnivores, and to compare carnivores' trap success to other carnivores to determine if they avoided each other across the landscape.

Results

We recorded 363 trap events with a total of 499 animal photographs in the 72-day trapping period (Table 1). After subtracting those days for malfunctioning cameras, the total number of trap nights was 891 and the overall trap success for animals captured was 40.74 per 100 trap nights (TN). Of the 363 trap events, the majority were *Odocoileus virginianus* (white-tailed deer; 52.34%), and *Sciurus carolinensis* (gray squirrel; 15.15%), followed by raccoon (6.89%), black bear (4.68%), bobcat (3.58%), and coyote (2.48%).

Trap success varied significantly among animals (ANOVA: F = 9.439; $p < 0.001$) (Fig. 2). White-tailed deer had the highest trap success (21.32/100 TN), and was photographed at all but one station (Fig. 2). Gray squirrel was second highest (6.17/100 TN), but this was largely driven by high trap success of it by the Reconyx system. Trap success per 100 TN for target carnivores was: raccoon (2.81), black bear (1.91), bobcat (1.46), coyote (1.01), and gray fox (0.56). Cameras also captured *Sylvilagus floridanus* (eastern cottontail), *Accipiter striatus* (Sharp-shinned Hawk), *Bonasa umbellus* (Ruffed Grouse),

Table 1. Trap events, number of photographs of animals, and trap success for the 72-day trapping period.

Species (common name)	Total number of trap events	Total number of animal photographs
Odocoileus virginianus Zimmerman (white-tailed deer)	190	286
Sciurus carolinensis Gmelin (gray squirrel)	55	59
Procyon lotor Storr (raccoon)	25	30
Usus americanus Pallas (black bear)	17	42
Lynx rufus Schreber (bobcat)	13	14
Tamias striatus Linneaus (eastern chipmunk)	13	13
Meleagris gallopavo Linnaeus (Wild Turkey)	10	13
Canis latrans Say (coyote)	9	9
Urocyon cinereoargenteus Schreber (gray fox)	5	6
Didelphis virginiana Kerr (opossum)	4	4
Sylvilagus floridanus Allen (eastern cottontail)	1	2
Bonasa umbellus Linneaus (Ruffed Grouse)	1	1
Accipiter striatus Vieillot (Sharp-shinned Hawk)	1	1
Unknown	19	19
Grand Total	363	499
Total number of trap nights	891	
Total trap success (trap events/trap nights * 100)	40.74	

and *Meleagris gallopavo* (Wild Turkey) but in low frequency (Fig. 2). No red fox or skunk were captured, and other animals, labeled as "unknown" due to poor quality photographs, made up a small percentage (5.2%) of events.

There was high variability in trap success among the individual trap sites, which ranged from 0.0/100 TN (station 10) to nearly 134.7/100 TN (station 15) (Fig. 3). Trap success varied significantly among camera systems (ANOVA: F = 8.441, p = 0.0005), ranging from 8.9/100 TN for TrailMaster to 96.4/100 TN for Reconyx (Fig. 4). Trap success for DeerCam was significantly higher than for TrailMaster (n = 15/100TN vs. 9/100 TN, respectively; mean = 32.43 vs. 8.93; t = 2.07, p-value = 0.017). We did not compare Reconyx and Camtrakker statistically because of the small sample sizes. We note that one of the two Camtrakkers failed completely, while the other had a 45.0/100 TN trap success.

Cameras varied in their capabilities to capture different species, with no clear pattern of highest trap success for any one camera system across all species (Fig. 5). However, Reconyx appears to have higher trap success for smaller species such as raccoon, gray fox, Wild Turkey, and, in particular, gray squirrel, which were the main driver for Reconyx's overall higher trap success as illustrated in Figure 3. All camera systems photographed deer in groups of two or three, while only DeerCam photographed groups of two bear and two bobcat; both cases were a female and her young. Only Reconyx photographed groups of turkey, raccoon, gray fox, and gray squirrel. Reconyx's high sensitivity and ability to take several photographs in a row with one triggering event most likely lead to higher trap success for medium and small species, especially those that travel in groups. For larger or more solitary animals such as deer, bear, or bobcat, trap-success rate was more similar across camera systems.

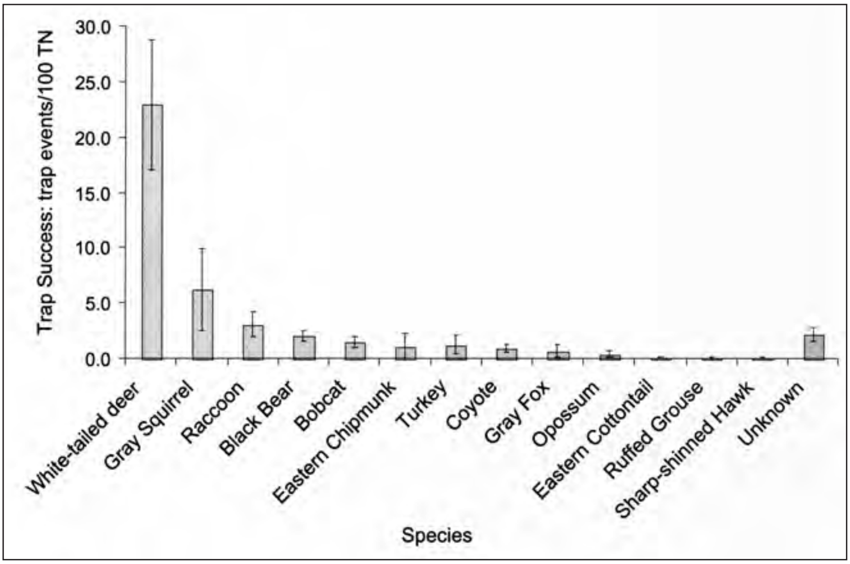

Figure 2.Trap success (and standard errors) for each species averaged across the camera stations.

Gray fox was recorded at only two sites, and no rigorous comparison of habitat preference was possible. Raccoon and black bear were present at

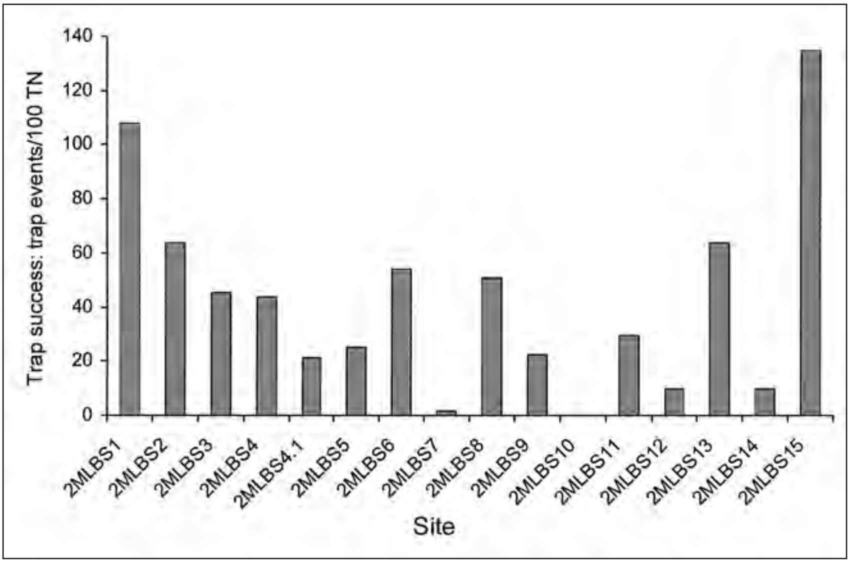

Figure 3. Trap success (number of photographic events of all animals per 100 trap nights) for camera stations across the study site.

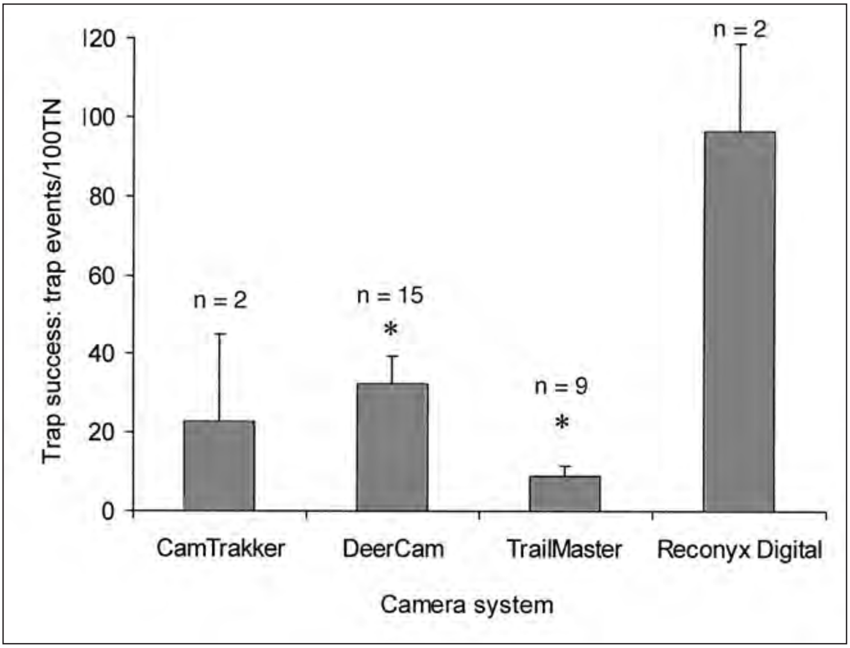

Figure 4. Average trap success (+ SE) among camera types. Stars indicate a significant difference between camera types. CamTrakker and Reconyx were not analyzed statistically due to small sample sizes.

10, bobcat at 8, and coyote at 5 of the 16 trap sites. While there was slightly more deciduous forest at the sites where raccoon, black bear, and coyote were present, none of these relationships was significant for any buffer radius surrounding traps. Bobcat, however, avoided coniferous areas, and was present in areas with significantly less coniferous than deciduous forest for buffer sizes of 750 m (means = 8.40 vs. 19.34%, respectively; t = 2.15; p = 0.048), 500 m (means = 10.61 vs, 21.79%, respectively; t = 2.14, p = 0.069), and in areas with marginally significantly less coniferous for the 250-m (means = 9.10 vs. 22.10%, respectively; t = 2.14; p = 0.153) buffer radius (Fig 6).

There were no relationships between trap success of carnivores and distance to the main access road, except for bobcat, which showed a positive relationship between trap success and distance from the road (Fig. 7).

Hikers/hunters were photographed at nine of the camera sites, and trap success at sites varied widely, from 5.56/100 TN (station 12) to 436.36/100 TN (station 14) for the heavily used hiking trails. There was no relationship between extent of human foot traffic and trap success for any of the carnivores.

There were no significant relationships between white-tailed deer trap success and carnivore trap success. Gray squirrel occurred at eight sites, and we found a significant (but weak) positive relationship between gray squirrel trap success and coyote trap success (n = 16; p = 0.0391; y = 0.1849x + 0.4761; r^2 = 0.2882). The only relationship between carnivore-carnivore trap success was a marginally significant, positive relationship between black bear and bobcat (n = 16; p = 0.0867; y = 0.4159x + 0.6814; r^2 = 0.1951).

Discussion

Our study demonstrated that remote cameras can be used to survey multiple carnivores simultaneously with a non-baited, systematic, camera

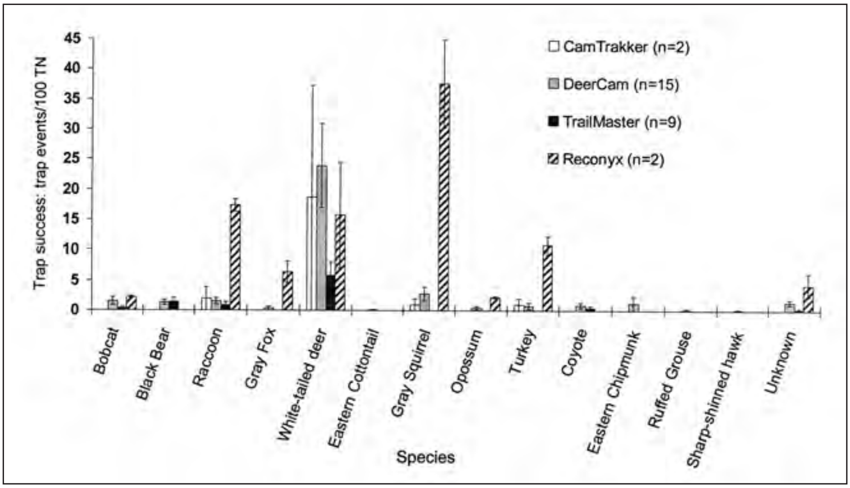

Figure 5. Trap success of species captured separated by camera type. Note that due to small sample size for Camtrakker and Reconyx, a particular animal may not have passed in front of those two cameras, rather than represent a true trap success of zero.

site set-up. We photographed 13 species: 10 mammals, five of which were carnivores, and three birds. With the exception of the ubiquitous white-tailed

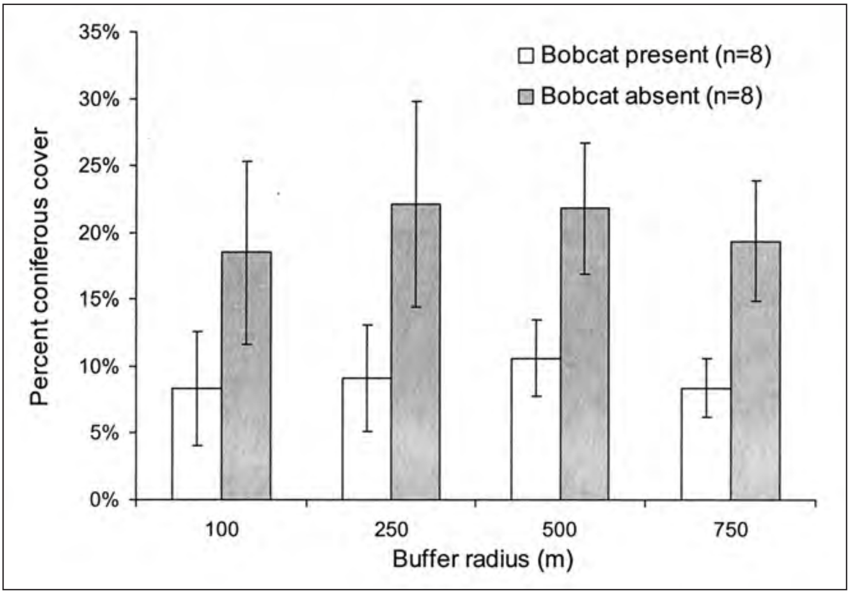

Figure 6. Bobcat presence as correlated with the percent coniferous cover among different sized buffers. Bobcat did not occur in areas with a high percentage of coniferous forest for buffer radii of 250 m, 500 m, and 750 m.

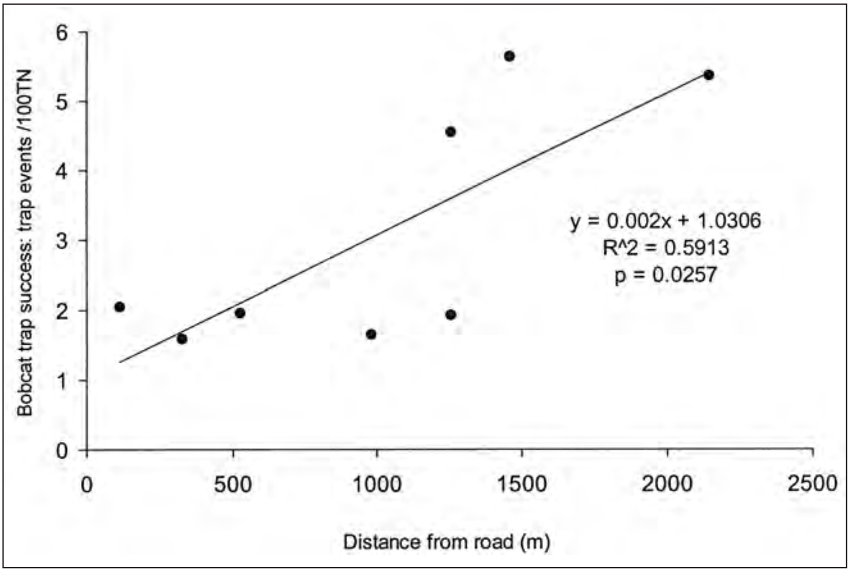

Figure 7. Bobcat trap success as it related to distance from the road. Across the eight camera stations where bobcat was present, trap success increased with distance from the main access road.

deer, trap success for the other 12 species was lower than 6.5/100 TN, and for 10 of these species, it was below 2.0/100 TN. While this trap success may seem low, it is similar to that reported in other remote camera studies in the US and abroad (Cuellar et al. 2006, Gompper et al. 2006, Kelly 2003, Moruzzi et al. 2002, Séquin et al. 2003) and underscores the need to use a large number of cameras and camera trap days of effort for carnivore studies.

Other studies have indicated that an effort of approximately 1000 trap nights is needed to be certain that an animal is truly absent from a site (Carbone et al. 2001). We approached this number at 891 trap nights and captured all mid-sized to large mammals believed to be present, with the exception of red fox, indicating either a true absence of it or a need for more effort. Future surveys at this site should add one to two additional trapping stations to increase trap nights above 1000 per survey, and consider changing camera locations or trapping season.

Our study also showed that camera systems vary in their capability to capture animals. This calls into question the use of different camera systems for a single survey, due to the difficulties in distinguishing true variation in trap success among animals versus among cameras. Since we paired different brands opposite each other at each site, we believe that our study did not suffer from camera bias. But our study also shows that different studies may require different camera systems, depending on the species studied and the questions asked. Therefore, our discussion below may be specific to the goals of this study—to obtain information on multiple carnivore species across the study site and to evaluate trap success among camera types.

DeerCam significantly outperformed TrailMaster. Additionally, we found it more difficult to set up and to program TrailMaster's active beam system, leading to more user error. This system also had the most malfunctions consisting of false triggering until all film was exposed. Also, if not set low enough to the ground, small animals can move beneath the active infrared beam and not be detected, as previously noted in laboratory studies (Swann et al. 2004). TrailMaster also suffered more damage from animals, particularly from chewing of exposed wiring. Further work is needed to statistically test Camtrakker against DeerCam, but CamTrakker also experienced more user error than DeerCam and was more difficult to trouble-shoot in the field. Unlike the Swann et al. (2004) lab tests, we did not find CamTrakker to have particularly high detection rates, and CamTrakker seemed to be the most unreliable under field conditions, especially with high humidity and rainfall, with the most malfunctions that consisted of no triggering. While sample sizes were low for CamTrakker, our results are consistent with past CamTrakker experience in other field projects (M.J. Kelly, unpubl. data; Thompson et al., in review). Of the film cameras, DeerCam was the easiest to use and to trouble-shoot, experienced the fewest malfunctions, and was the most inexpensive.

Although sample sizes were small, the Reconyx digital performed remarkably better than all of the film cameras. The Reconyx appeared to be more heat and motion sensitive and to have a wider infrared beam, allowing it to record smaller animals. While not presented in this paper, we also photographed mice repeatedly with Reconyx. Because we programmed this system to take three photographs with each triggering, we captured groups of raccoon, gray fox, and turkey, and increased our trap success for such species. Of all the camera systems trialed, only Reconyx had zero malfunctions in this study. This feature, and its capability to store hundreds of photographs, make it particularly attractive for future remote camera studies. Unlike other digital remote camera systems (Thompson et al., in press), Reconyx has no delay between detection of an animal and camera firing. However, image quality of Reconyx is not as high as in the film cameras, making identification of individuals by natural markings more difficult, especially for more subtly marked species such as bobcat. Furthermore, the price of Reconyx (≈$500–1000 per unit) is high.

While our GIS consisted of relatively simple, clearly defined habitat layers, our results confirm the utility of combining remote camera survey techniques with species-specific habitat-use patterns. Other studies have shown that coyote prefers edge sites around agricultural or disturbed open areas, while black bear prefers interior areas away from development and agricultural land (Moruzzi et al. 2002). We did not find this relationship for coyote and bear, but our study site consisted almost entirely of forestland, with only few small, open areas present. To gain more information on habitat use, future surveys should include more habitat types.

Bobcat in our study showed preference for deciduous rather than coniferous forest at buffer sizes of 500- to 750-m radii (0.79- to 1.77-km^2 area) surrounding each camera trap location. Habitat selection by carnivores does occur at several spatial scales (Brown and Litvaitis 1995), but to our knowledge, this study is the first report to show habitat selection for bobcat at such a fine spatial scale. Other studies have focused on larger landscapes using, for example, 3.3-km buffer radii (34-km^2 area) surrounding bobcat locations (Litvaitis et al. 2006), home-range size (8.6–60 km^2) (Chamberlain et al. 2003, Lovallo and Anderson 1996), or core areas (1.4–3.0 km^2) (Chamberlain et al. 2003) in comparison to entire habitat in the surrounding study sites.

Studies in New Hampshire suggest that bobcats prefer early successional habitats that support cottontail (Litvaitis et al. 2006), but our study site did not contain much of this habitat for comparison. In Mississippi, bobcats, especially males, selected mature pine stands with extensive herbaceous cover (Chamberlain et al. 2003), while in eastern Maine, they preferred hardwood understories, and in western Maine, softwood understories (Litvaitis et al. 1986). Bobcats also occur in dense chaparral-type vegetation in Texas (Heilbrun et al. 2006), and clearly exhibit flexibility across the species' range.

Bobcats avoided the main access road, indicating greater sensitivity to vehicle disturbance than the other species. This pattern is consistent with previous research showing that bobcats occur in areas with fewer roads (Litvaitis et al. 2006, Lovallo and Anderson 1996), and that bobcat, especially female, movement is influenced by disturbance from hunters (Chamberlain et al. 1999). The main access road in our study area was frequently driven by hunters, and this increased with the onset of the hunting season in the middle of our survey. However, it appears that bobcats do not respond similarly to all types of disturbance, since human foot traffic did not influence bobcat trap success across the study site.

Heilbrun et al. (2006) had high bobcat detection rates in their similar-sized study area (31.5 km^2) in Texas, and could identify individual bobcats by their distinct coat patterns and estimate density through mark-recapture. Their high detection rate did correspond to high bobcat density (48 per 100 km^2). While we could identify some individual bobcats, we did not have enough photographs with which to conduct mark-recapture analysis and can only compare our trap success to Heilbrun et al. (2006). It should be noted, however, detection rate (i.e., trap success) may be related to local abundance of target species, but those indices are controversial (Anderson 2001, 2003; Engeman 2003) because few studies have calibrated photographic detection rates to independent assessments of abundance. Photographic detection rates have been calibrated for *Panthera tigris* L. (tiger), but even this remains controversial (Carbone et al. 2001, 2002; Jennelle et al. 2002). However, other studies have demonstrated that photographic capture frequency correlates with abundance of target animals (O'Brien et al. 2003).

Our trap success for bobcat (1.46/100 TN) was much lower than that of Heilbrun et al. (2006) in the central Texas coastal plain (6.86/100 TN), potentially indicating a much lower population density at our study size. However, our trap success was higher than found by Moruzzi et al. (2002) in Vermont (<1.0/100 TN), who did not photograph enough bobcat to examine habitat preference. Interestingly, we had higher trap success for bobcat than coyote, while Moruzzi et al. (2002) found the opposite. This may indicate that bobcats have not yet been reduced in number by competition with expanding coyote populations as suspected in Vermont (Moruzzi et al. 2002), Maine (Litvaitis and Harrison 1989), and New Hampshire (Litvaitis et al. 2006). We did not find evidence of avoidance of coyotes by bobcats in this study, but if coyote range is expanding and competitively excludes bobcats, and if abundance is correlated with detection rate (i.e., trap success), continued surveys in this area should reveal a decrease in bobcat trap success and an increase in coyote trap success through time.

This study highlights the potential of remote camera monitoring over a large area, on multiple species, and in conjunction with a GIS. The use of remote photography can decrease survey time and effort, especially for rare, elusive, or territorial species, and can reduce adverse effects that may be caused by more invasive methods, such as physical capture (Heilbrun et al. 2006). For individually identifiable specimens of species such as bobcat (and potentially coyote; Séquin 2001), larger sample sizes can be obtained with camera traps than in studies with physical capture, and these remote captures can be used to obtain robust estimates of abundance and density. For other species, photographic detection rates can be analyzed in conjunction with their temporal pattern (e.g., by conducting repeated surveys in the same locations over time) to calculate more accurate estimates of relative abundance and proportion of area occupied (MacKenzie and Royle 2005, MacKenzie et al. 2003, Royle and Nichols 2003). While we plan to increase our effort and continue to monitor on a yearly basis, we encourage replication of this technique over different areas and over time to build the data sets necessary for comparative analyses and for occupancy estimates.

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