Testing a remote camera protocol to detect animals in the Superior National Forest

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Summary

Automatic camera systems can detect the presence of free-ranging wildlife remotely when humans are not present to trigger the cameras. An automatic camera survey protocol was tested in the Superior National Forest near Isabella, Minnesota during winter 2004. Cameras were set out at 12 camera stations for up to 2 months. Wool soaked with a commercially available trapping lure was placed at each camera station. Fisher (*Martes pennanti*), marten (*Martes americana*), snowshoe hare (*Lepus americanus*), and red squirrel (*Tamiasciurus hudsonicus*) were all detected with this equipment. At least 34 animal images were recorded over 512 camera-days. Detection appeared to be species specific during this camera test with a scent-based lure: Canada lynx (*Lynx canadensis*), wolf (*Canis lupus*), coyote (*C. latrans*), and black bear (*Ursus americanus*) tracks were seen near the camera stations but these species were not observed in the pictures taken. There were many photographs taken without animals observed in them, although pictures that were taken documented the presence of several species. Pictures of lynx were taken when this camera equipment was set up on a food bait with known lynx visitation outside the survey area.

The Isabella area was selected because the National Lynx Detection Survey (NLDS) protocol (McDaniel *et al.*, 2000) had been conducted here from 1999 to 2001, and again in 2003. Snow tracking surveys that were conducted in the Isabella area in 2003 and 2004 identified species that would be likely candidates to be photographed. Canada lynx, a federally threatened species, were also located in the area (Moen et al. 2004). The Superior National Forest Lynx DNA reference collection shows lynx presence in the area for multiple years (USDA-FS Superior National Forest NRIS FAUNA database, 2006). We compared the ability of each technique to detect the presence of Canada lynx and other carnivores, and evaluated the potential for each technique to be used in detection and population estimation techniques. Lynx presence was not detected in our camera surveys nor with the NLDS hair snare technique. In contrast, snow-tracking surveys and track identification while checking camera stations identified lynx presence. Automatic camera systems can be used to identify animal species and provide photographic proof of species presence in an area during the winter.

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Introduction

Trees and shrubs reduce sightability of animal species that live in forested areas, and it is often necessary to interpret presence of a species based on tracks, scats, or other indirect evidence. Carnivores are even less likely to be seen than herbivores because of their lower population density. Yet the presence or absence of an animal species is a factor in many management decisions. Several methods can be used to detect presence, each with benefits and drawbacks. In a comparison of several techniques to detect presence of bobcats (*Lynx rufus*) in Arizona, tracking dogs found the most bobcats and was the most expensive technique (Harrison, 2006). Hair snares and scent stations were the cheapest detection method, but also detected the fewest animals. Automatic camera systems were intermediate in both cost and detection efficiency.

Automatic camera systems have been used in many studies (Cutler & Swann, 1999; Moruzzi *et al.*, 2002). Automatic camera systems are triggered by an animal passing in front of a sensor that detects movement, changes in ambient light, or a thermal differential. The remote camera approach provides photographic evidence of animal presence. It is easier to use and more cost-efficient than track plates, which require the interpretation of tracks left by an animal without other physical evidence (Foresman & Pearson, 1998). Track plates, or other track-based techniques such as snow-tracking, can be augmented with genetic analysis of hair, or scats. (McKelvey *et al.*, 2006). Urine is also a potential source of DNA for genetic analysis (Waits & Paetkau, 2005; Piggott & Taylor, 2003; Hedmark *et al.*, 2004).

A systematic and statistically sound method should be used when the desired goal is detecting carnivore presence (Zielinski & Kucera, 1995). Cameras are usually placed in the field for several weeks, with a food or scent-based attractant used to draw animals to the camera site. When species are rare or uncommon, as many carnivores are, the attractant increases the probability that individuals will be drawn to a camera site. If there are multiple images of the target species, and a species can be identified to individual based on pelt markings or antler conformation, it is possible to estimate population size based on a mark-recapture approach (Karanth & Nichols, 1998; Karanth, 1995).

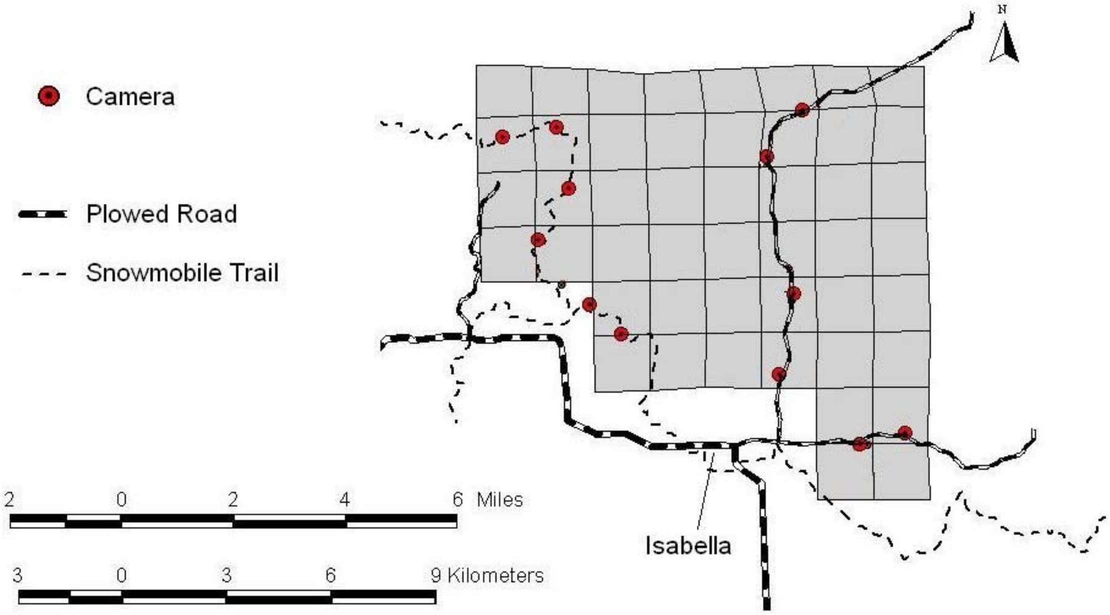
It is especially desirable to document presence and obtain population sizes of rare species. We placed the remote cameras in areas where radiocollared lynx would be in the vicinity of the camera stations (Burdett *et al.*, 2007; Moen *et al.*, 2006). We could detect how close lynx wearing GPS radiocollars were to cameras when locations were obtained. We also overlaid the camera grid onto an area that had been previously surveyed with the National Lynx Detection Survey (NLDS) hair snare plots (Burdett *et al.*, 2006). In this report we summarize camera detection events, camera performance, and efficiency of using the remote camera approach in northeastern Minnesota.

Methods

We conducted the camera survey in the winter of 2004. Cameras were deployed from 2/19/2004 to 4/23/2004 on 6 sites along a plowed Superior National Forest road, and from 3/1/2004 to 4/1/2004 on 6 sites along a designated snowmobile trail (Fig. 1). The survey area was located near Isabella in Lake County, Minnesota (Figure 1), on the northern edge of an area in which 5 radiocollared lynx were present. Plots were randomly placed within sections that were accessible in late winter. This protocol was based on a previously established protocol survey design (Zelinski and Kucera 1995), with 2 camera stations set up within each 4-mi^2 sample unit. Remote 35mm camera systems were placed to survey 6 sampling units.

Unlike the food bait used in the established protocol (Zelinski and Kucera 1995), we used a tuft of sheep (*Ovis aries*) wool scented with a commercial trapper's lure (Gusto, Minnesota Trapline Products, Pennock, MN) wired to a tree trunk to draw an animal into the detection area. Camera station locations were selected to overlap areas of previous NLDS stations and snow tracking survey routes.

Figure 1. Location of camera survey area north of Isabella, Minnesota. Camera stations were placed near plowed roads or near snowmobile trails.



Camera systems. We used 3 different models of camera systems in this project due to availability. We used 2 models from Foresite Industries, the 35A and the RTV. Both the 35A and the RTV models are dual sensor camera systems, which means that the camera is triggered by a microwave motion sensor or passive infrared heat sensor. The third camera model we used was made by Non-Typical Engineering. The DeerFinder (DF) system we used is no longer made and parts may not be available. The DF system also uses a dual sensor system to trigger the camera. Each camera was set up to take 1 picture per trigger event, with a delay of 1 minute between events.

Cameras were set up within 20 m of snowmobile trails or plowed roads, but were not visible from the road or snowmobile trail. Placement on roads or trails would have resulted in images of cars and snowmobiles. Placement off the roads or trails meant that we created a path in the snow to the camera station. Each site consisted of a camera system and a scent lure. The scent lure was wired to a tree trunk approximately 45 cm off the snowpack. The camera system's detection window was centered between the lure and the snowpack. We removed or bent back vegetation that could blow in the wind and trigger the camera detector system. Clearing the area also improved the quality of the picture. Sites were visited weekly to check the number of camera events and operation of the systems. Film and/or batteries were replaced as necessary and scent lure was re-applied.

Because the remote camera survey along the snowmobile trail (Fig. 1) was ended before the camera survey along the road, and because we had not acquired pictures of lynx at the lure-based camera stations, we tested the camera system with a food bait, which had been successful in the past (Moen *et al.*, 2006). Legs of road-killed deer were used as the bait, and we placed the camera system in an area which lynx tracks had been observed. This test with a food-based lure was done 30 km west of the automatic camera survey.

Results

Cameras were deployed for 512 camera-days. Seventeen rolls of film were developed resulting in 34 unique animal events (Table 1). Detections were made at 8 of the 12 camera stations in 5 of the 6 sampling units. Mammal species detected included both carnivores and herbivores. Some images of carnivores indicated interest in the scent. In other images the carnivores were either passing through the area or responding to the lure (Fig. 2). Marten (*Martes americana*) and fisher (*Martes pennanti*) were detected 8 times in the 34 images. Most marten sightings were during daylight (Table 1).

Red squirrels (*Tamiasciurus hudsonicus*) and snowshoe hares (*Lepus americanus*) were seen most frequently in the images, with herbivores being detected about 3 times more frequently than carnivores. Some herbivores may not have been attracted to a trapper’s lure; a white-tailed deer (*Odocoileus virginianus*) appeared to be incidental and passing though the detector field of view. In another case, a snowshoe hare sniffed at the lure (Fig. 2). All events detected were of mammals except for one image of a turkey vulture (*Cathartes aura*). Most sightings of snowshoe hare were at night, while most pictures of red squirrels were during the day (Table 1).

Table 1. Number and type of events detected at camera stations. A total of 12 camera sites were used. We categorized images by whether they were taken in darkness (flash photograph) or during daylight (natural light). False events were events in which an animal was not seen in the photograph.

Type of Event	Sites	Night	Day	Total
Fisher	2	1	1	2
Marten	4	1	5	6
Red squirrel	3	0	4	4
Snowshoe hare	4	20	0	20
White-tailed deer	1	0	1	1
Turkey vulture	1	0	1	1
Total Animal	8	22	12	34
False	8	80	89	149

There were 7 occurrences of the film being entirely used up prior to the camera check. Based on the date/time imprint on the last photo of the roll and the date/time of the subsequent camera check, there were 26 days of non-survey, 19 of those days at one site at which an apparently malfunctioning camera was replaced, and also where the 24-exposure film was occasionally fully exposed before the end of a weekly sampling period. Thus, while cameras were actually deployed for 538 days, there were only 512 camera-days in which the cameras were functioning.

Figure 2. Example images of herbivores and carnivores taken with automatic cameras. The marten appears to be sniffing the scent-soaked wool, while the fisher is smelling the ground underneath the lure. The snowshoe hare appears to be attracted to the scent lure, while the deer is passing through and appears to be ignoring the lure.

More pictures were taken at camera stations near roads than on the snowmobile trail (Table 2). The increase in pictures was due to herbivores, more pictures were taken of both red squirrel and snowshoe hare. There were also more false trigger events at the road camera stations than on the snowmobile trail camera stations (Table 3), although this was due in part to camera type. An animal was seen in about 40% of the pictures.

Table 2. Detections per 100 camera-days of photo events on the Snowmobile trail stations or the Road stations. The number of false detections is affected by camera type (see Table 3).

Event Type	Road	Snowmobile
Fisher	0.6	0.0
Marten	1.1	1.1
Red squirrel	0.6	1.1
Snowshoe hare	4.5	2.2
Deer	0.0	0.5
Turkey vulture	0.3	0.0
Total Animal	7.1	4.8
False	44.6	6.5

False detections (photographs without animals) occurred more frequently than photographs with animals. The cause of false detections is unknown, although there are multiple possible causes: an animal could move out of the picture frame prior to the photo being taken, wind could blow vegetation enough to cause a trigger event, a small animal might not be visible in the picture, the camera could malfunction, or some other unknown cause. Camera type seemed to affect whether false events were triggered. The RTV camera had the most false events, while the 35A did not have any false events. Even though the RTV camera had the most false events, it still had about as many animal detections per camera day as the other camera types (Table 3).

Table 3. Effect of camera type on detections. Units are detections per 100 camera days. The number of false detections are a function of camera type.

Camera Type	Camera-Days	Animals/ 100 CD	False / 100 CD
35A	211	7	0
DF	135	7	11
RTV	192	5	80

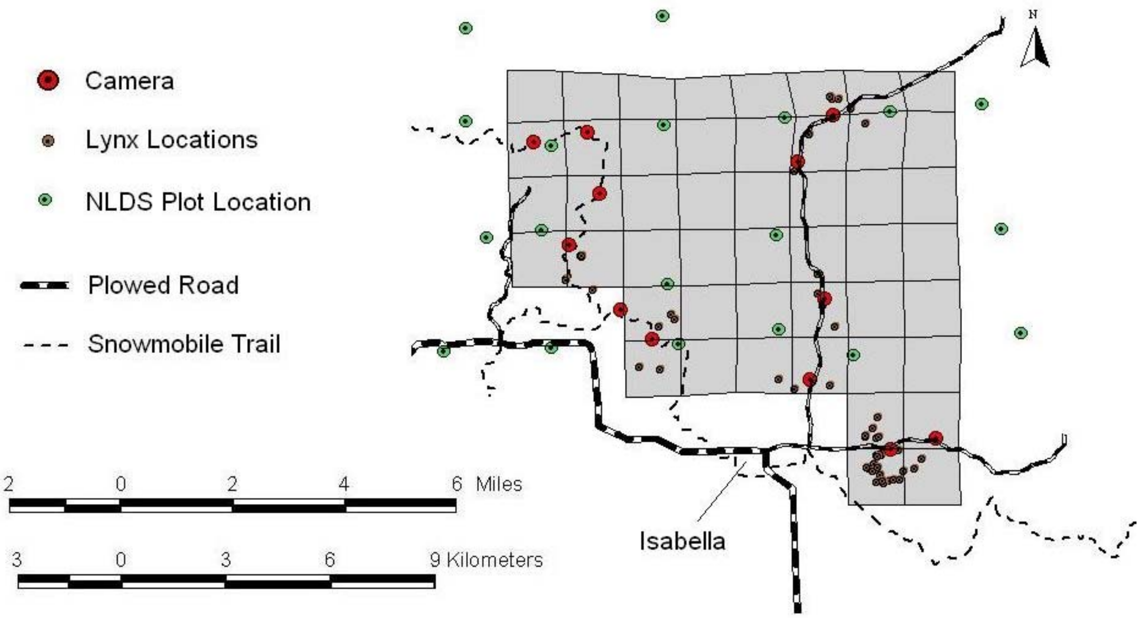
Animal Species Not Photographed. Tracks of lynx, wolf and black bear were seen near camera stations during camera station checks, but these species were not seen in any photographs. One possibility is that these species did not cross the detection window. Another possibility is that cameras malfunctioned when these species crossed the detection window. At least 12 times tracks of fisher, marten, snowshoe hare, red squirrel or coyote were seen within the expected detection area of the camera systems yet no photos were taken (Table 4). An additional 3 times there were tracks within the detection area and a picture was taken, but photos did not show any visible animal. This would happen if the animal left the field of view of the camera before the picture was taken.

Table 4. Animals in the vicinity of camera stations based on track counts, and species that visited the lure site but did not trigger camera, based on tracks present during the weekly maintenance check. The presence of tracks was noted during each maintenance check, regardless of tracking conditions (e.g., fresh snowfall would have obliterated existing tracks), thus these are conservative estimates of animals in the vicinity of camera stations.

	Tracks in vicinity		Tracks at Scent station	
Species	Road	Snowmobile	Road	Snowmobile
Coyote	5	3	1	0
Wolf	1	3	0	0
Canada lynx	1	0	0	0
Marten	7	3	0	1
Fisher	4	4	2	2
Mink	1	0	0	0
Black bear	1	0	0	0
Snowshoe hare	13	7	1	1
Red squirrel	12	8	3	0
Deer	1	9	0	1
Total	46	37	7	5

Lynx presence near camera stations. GPS radiocollar locations indicated that lynx were present within 1 km of the active camera stations at least 16 times (Fig. 3). The closest GPS location of a lynx was 188 m from an active camera station. This camera survey was set up within a plot network for the National Lynx Detection Survey Protocol, operated in both summer and winter (Fig. 3), which did not produce any lynx hair (Burdett *et al.*, 2006).

Figure 3. Location of camera survey area north of Isabella, Minnesota. Camera stations were placed near plowed roads or near snowmobile trails. Lynx locations within 7 days of the camera deployment and within 1 km of a camera station are indicated. Also in the background is part of the grid of NLDS plot locations in the Isabella area.



Comparison to Other Remote Camera Projects. Enough remote camera projects have been published to generate some expectations of the range of number of pictures to be obtained. Each project in Table 5 reported the frequency with which pictures were obtained from remote camera stations. There are factors which affect the number that are study-specific, however. For example, camera locations were selected based on GPS collar locations of jaguars (Soisalo & Cavalcanti, 2006), resulting in the highest capture rate of these studies. Trails known to be traditionally used by the target species were selected in some of these studies (Heilbrun *et al.*, 2006; Karanth & Nichols, 1998). The type of attractant, and whether or not an attractant was used, also varied among studies. While the results from this project in Minnesota were among the lowest with respect to animal events per 100 camera-days, there were several other projects with similar picture frequencies. The other camera trap project from a northern latitude was conducted during snow-free seasons (Moruzzi *et al.*, 2002), but had an efficiency similar to what we obtained during the winter (Table 5).

Table 5. Comparison of camera trap efficiency in Minnesota compared to camera trap efficiency in other published studies. Camera-Days is the number of days multiplied by the number of camera stations that were active, Pics is the number of pictures taken, Pictures/100 Camera-Days (Pics/100 C-D) standardizes the comparison across experiments. Camera-days, Pictures, or Pictures / 100 Camera-Days were calculated from data in the original paper.

Carnivores	Camera-Days	Pics	Pics/100 C-D	Author
Tiger [a]	803	59	7	Karanth & Nichols, 1998
Tiger	552	47	9	Karanth & Nichols, 1998
Tiger	936	60	6	Karanth & Nichols, 1998
Tiger	788	21	3	Karanth & Nichols, 1998
Tiger	387	31	8	Karanth, 1995
Tiger			1[b]	Carbone *et al.*, 2001
Bobcat	948	65	7	Heilbrun *et al.*, 2006
Bobcat	140	5	4	Harrison, 2006
Jaguar [a]	960	157	16	Soisalo & Cavalcanti, 2006
Jaguar	960	131	14	Soisalo & Cavalcanti, 2006
Ocelot [a]	450	29	6	Trolle & Kery, 2003
Ocelot	3040	168	6	Di Bitetti *et al.*, 2006
Ocelot	1968	20	1	Haines *et al.*, 2006
Ocelot	1375	23	2	Silver *et al.*, 2004
Canada lynx	2512	45	2	Nielsen pers. comm. 2006 [c]
Mountain lion [a]	1121	0	0	Long *et al.*, 2003
Carnivora	1130	30	3	Azlan & Lading, 2006
Carnivora	5985	178	3	Moruzzi *et al.*, 2002
Carnivora	512	8	2	This study

[a] Tiger: *Panthera tigris*, Jaguar: *P. onca*, Ocelot: *Leopardus pardalis*, and Mountain lion: *Felis concolor*
[b] The mean of several studies
[c] Clay Nielsen, Southern Illinois University-Carbondale, 12/12/2006

Many of the studies in Table 5 were focused on a single species in areas where the target species was expected to be captured. If pictures of other species had been reported, the frequency of events would probably have been much higher. For several remote camera projects in which all species are reported, the frequency of pictures being taken can increase by 5 to 10 times (Table 6). Typically, herbivores are more frequently photographed than carnivores, in this study there were 7 pictures of herbivores for every carnivore.

Table 6. Comparison of camera trap efficiency in Minnesota compared to camera trap efficiency in other published studies for all mammal species. Camera-Days is the number of days multiplied by the number of camera stations that were active, Pics is the number of pictures taken, Pics/100 C-D standardizes the comparison across experiments.

All species	Camera-Days	Pics	Pics/100 C-D	Author
Brazil	1035		21	Silveira *et al.*, 2003
Florida	7700	5511	72	Roberts *et al.*, 2006
Florida	-	-	31	Main & Richardson, 2002
Borneo	1127	225	19	Azlan & Lading, 2006
Malaysia	1443	787	55	Azlan & Sharma, 2003
Malaysia	5972	2121	36	Azad, 2006
Minnesota	538	35	7	This study

Food-based attractant results (outside our camera survey area). When we deployed the DF camera system with a deer leg for a bait in an area where lynx tracks had been observed, there were 19 pictures of lynx and 1 false event on 2 films (Fig. 3). One of the problems associated with a food-based attractant is that an animal may stay in an area for a longer time; essentially the survey method is modifying the animal's behavior. For a detection type camera survey project this is acceptable, but for a mark-recapture camera survey project behavior modification would not be acceptable.

Figure 4. Images of a Canada lynx taken at a food-based attractant 30 km west of the lure-based attractant camera survey.

Discussion

Detection rates for camera surveys were lower or slightly lower in this project in northern Minnesota than for other remote camera surveys conducted in tropical areas. However, the detection rate did approach the low end of results reported elsewhere, which indicates that the technique can be successfully used in Minnesota, even in winter. One generalization is that many of the other remote camera surveys had 2 to 10 times as many camera-days as we used in this pilot project. Surprisingly, the number of mammal species identified in this project at 500 camera-days was as large as the number of mammal species found in a Malaysian camera project at 500 camera-days (Azad, 2006). Another factor that could have affected the frequency of pictures is that the Minnesota project was done in winter. Animals are able to move more freely in summer when there is no snow, and it is possible that picture frequency would increase.

One difference in the Minnesota project was that the number of false events (pictures without animals) was about 150% of the number of animal pictures. Few studies report the number of false events, one project that did indicated that the number of false events was 23% of the number of animal events. Most of the false events recorded in the project were from the RTV camera model. However, this camera also was most efficient at recording animal events. False events can vary by camera model, and testing of the cameras before deployment is recommended (Swann *et al.*, 2004). The camera models we used, which are no longer being manufactured and are based on older technology, might be a worst-case scenario with respect to false events. It is likely that the frequency of false events would decrease with currently available cameras, we do not see the high ratio of false events:animal events in cameras we are currently using (R. Moen, pers. obs.).

Another difference that is relevant when comparing studies is the type of attractant used and the protocol used to select survey sites. If the goal is to obtain pictures of carnivores, it may be more suitable to use some sort of food-type attractant (Zielinski & Kucera, 1995). The scent attractant we used was skunk-based, which would tend to be most attractive to mustelids such as marten and fisher that were photographed in this project. Even when a food bait is used, all carnivore species at a site may not be drawn in. Mountain lions did not visit camera sites with food as an attractant in South Dakota (Long *et al.*, 2003), even though it was known based on radiotelemetry locations that mountain lions were present. Similarly, we have had deer legs set out that were not visited by lynx that we knew were present in the area (R. Moen, pers. obs.).

Site selection and length of time camera stations are deployed are also important considerations. For many of the remote camera studies with higher camera success, site selection was based on prior knowledge of animal movement paths, or based on locations through which animals were forced to move due to vegetation density. For example, trails and paths cut in dense brush increased the rate at which bobcats were seen in a Texas study (Heilbrun *et al.*, 2006), and GPS collar locations were used to identify places to put cameras in Belize (Soisalo & Cavalcanti, 2006). When 36 cameras were placed on generally older logging roads and trails, lynx were detected when a beaver castoreum/catnip scent lure, 45 pictures of lynx were taken from August to October (Clay Nielsen, Southern Illinois University, pers. comm.). In contrast, in the Minnesota project sites were located adjacent to man-made travelways (road or snowmobile trail) and were set off of the travelway by up to 20 m, which would probably reduce the number of pictures taken.

Species-specific behaviors must also be considered in camera placement and interpretation of picture events. One reason camera mark-recapture studies have been successful with tigers is that tigers traditionally use specific paths (Karanth & Nichols, 1998). On the other hand, coyotes, especially alpha male coyotes, avoided having their picture taken (Sequin *et al.*, 2003). Most of the predator species for which the camera trap has been successful are members of Felidae. We have also obtained pictures of mustelids in camera trips, both in this pilot project and in other camera deployments. However, we have rarely taken pictures of canids (coyotes, foxes, or wolves) with these remote camera systems. A dirt hole set during the snow-free season did not lead to more pictures of canids than a cubby set in a camera experiment in Vermont (Moruzzi *et al.*, 2002), although sample size was small.

We believe that the use of a skunk-based lure is not the best method to detect lynx presence in an area with automatic cameras. First, results of this project in which tracks of lynx were seen in the vicinity of the scent-based attractant indicate that lynx were not drawn to this lure. This is not surprising, as the lure is designed for mustelids. One possibility might be to try combinations of lures to determine if more than one lure could draw in more species, or to use other tools such as a visual attractant (McDaniel *et al.*, 2000). A combination of a skunk-based lure, a catnip/castor oil lure, and a visual attractant were used simultaneously in Vermont (Moruzzi *et al.*, 2002).

However, a more compelling reason why a skunk-based lure would not be as attractive to lynx is the number of pictures that we have obtained while using a food-based attractant. In numerous camera deployments we have obtained over 100 pictures of lynx that were attracted to and fed on the leg of a road-killed deer. Remote cameras have also been used to photograph lynx in Washington (McKelvey *et al.*, 2000).

The National Lynx Detection Protocol did not result in lynx presence being detected, even when variations in season and trap placement were tried in an effort to obtain lynx hair from hair snares (Burdett *et al.*, 2006). In contrast, other methods have been used to detect the presence of lynx, either concurrently with a camera survey protocol or on their own. Track surveys have consistently identified lynx as being present in Isabella when they were known to be present based on the telemetry experiment.

Combining techniques for the detection of a target species would probably be the most successful method of all. Even though this project was camera-based, there were several additional species that were identified based on presence of tracks in the area. Interpreting species from tracks is possible, but may perhaps be questioned more than identifying species from a picture. Thus, an additional refinement would be to identify species from tracks and then confirm with genetic analysis of scats, urine, or hair (McKelvey *et al.*, 2006). It is likely that with a combination of camera surveys, tracking, and visual observations that much additional information could be gained about animals in the Superior National Forest.

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