Considerations on the Use of Remote Cameras to Detect Canada Lynx in Northern Maine

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Abstract - We used remote cameras to detect *Lynx canadensis* (Canada Lynx) in northern Maine during July–October 2005. A total of 1680 animal images was collected in 2512 camera-days of effort. Forty-five lynx detections were recorded, at a detection rate of 2 animals/100 camera-days of effort. Our analysis provides baseline detection rates for lynx in northern Maine and recommendations regarding survey design for other biologists. We suggest remote cameras are useful to survey lynx occurrence in an occupancy-estimation and -modeling framework, and in areas where snow-tracking surveys are not practical.

Few carnivore species are of greater concern in North America than *Lynx canadensis* Kerr (Canada Lynx; hereafter referred to as lynx), a US federally listed threatened species since 2000. Relatively little is known about its status and distribution in the northeastern US, where it was historically known from Maine to Pennsylvania (Hoving et al. 2003). The first studies of lynx ecology in the Northeast were initiated by the US Fish and Wildlife Service, the Maine Department of Inland Fisheries and Wildlife (MDIFW), and the University of Maine in 1999 (Vashon et al. 2005), and these provided management recommendations for lynx throughout its range. A primary goal of the Maine lynx studies was to develop effective survey techniques to document its status and distribution. However, because the lynx is secretive and occurs at low densities in remote and wild areas, survey protocol development has proven difficult.

There are no standard, uniformly effective methods to assess lynx occurrence and populations throughout its range (Aubry et al. 2000), and developing such a methodology is a high priority (USFWS 2005). Although hair snares have worked well for surveys of lynx in the Rocky Mountains (McDaniel et al. 2000), they have not proved successful in the Great Lakes states and the Northeast (Crowley et al. 2005). Snow tracking has been used to detect lynx occurrence throughout its range (Squires et al. 2004, Zielinski and Kucera 1995), but this has limitations, including logistical constraints due to snow conditions, high cost, and possible misidentification of tracks. Furthermore, snow tracking to monitor a species on a continental scale is problematic because of difficulties of achieving a similar sampling effort across locations (Squires et al. 2004). Researchers in Maine developed a lynx snow-tracking protocol in 2003 (Crowley et al. 2005). Although this technique was useful, winter logistics in remote areas of northern Maine were difficult, and the technique could only be used during January–March and only under ideal snow conditions. Hence, there is an interest in devising an alternative and effective technique to survey for lynx without the drawbacks of previously used methods.

Remote cameras are a relatively new technology and are increasingly used by wildlife researchers worldwide to detect carnivores (Harrison 2006, Heilbrun et al. 2003, Pierce et al. 1998, York et al. 2001). Such cameras function by an animal disrupting a motion- and heat-sensitive sensor, thereby photographing the animal at a specific location. The use of remote cameras is less invasive, less time consuming, and less costly than are other types of long-term observations of animals (Cutler and Swann 1999), and remote cameras are especially useful to record species that are secretive and that occur in landscapes that are difficult to access by humans. Assessments of the potential utility of remote cameras to assess lynx populations are in Crowley et al. (2005), Moen and Lindquist (2006), and Zielinski and Kucera (1995).

Our goal in this study was to utilize remote cameras to detect lynx presence in northern Maine and to provide recommendations for future surveys.

We surveyed lynx in one township (T11 R11 WELS; 46.61"N, 69.52"W) near Clayton Lake, Aroostook County, northwestern Maine; this township contained at least 6 marked lynx from an ongoing Maine Department of Inland Fisheries and Wildlife study (Vashon et al. 2005). Regenerating *Picea glauca* (Moench) Voss (White Spruce), *P. rubens* Sarg. (Red Spruce), and *Abies balsamea* (L.) P. Mill. (Balsam Fir) stands dominated the study area, and *P. mariana* (P. Mill.) (Black Spruce), *Larix laricina* (Du Roi) K. Koch (Tamarack), *Thuja occidentalis* L. (Northern White Cedar), *Acer saccharum* Marsh. (Sugar Maple), and *Betula* spp. (Birch) were present. Seasonal and permanent logging roads were common on the study area, and human density was limited. Topography was gentle to rolling with warm summers and cold winters.

During 24 July–18 October 2005, we placed and maintained 36 passive infrared-triggered remote cameras (Moultrie Feeders GameSpy 100 2.1 Megapixel Digital Camera) on logging roads throughout the 92.3-km^2 township at a density of one camera/section (259 ha). Our camera-stocking rate was higher than that of Crowley et al. (2005) and Moen and Lindquist (2006). We placed cameras as close to the center of each section as possible (given road constraints), on the side of logging roads, and perpendicular to the road to detect lynx traveling along the road. Each camera was attached 0.75 m off the ground to a sturdy tree and secured with a cable lock. About 4 m in front of the camera near the center of the road, a mixture of beaver castoreum, vaseline, and catnip was used as an olfactory attractant (McDaniel et al. 2000), and a compact disk (CD) was hung at the bait site and out of camera view as a shiny visual attractant. When a camera was triggered, one picture was taken every one minute the infrared beam was interrupted. Cameras were checked monthly (i.e., 3 times each during the study) to download images onto a laptop computer, replenish lures, and to change camera batteries. We calculated the total active camera-days of effort and per-species detection rates and used linear regression to model trends in lynx detection over the course of the study and to provide a predictive equation useful for assessing changes in lynx detection over longer time periods.

We recorded 2512 working camera-days out of 3024 possible camera-days; thus, the cameras functioned properly 83% of the time. We recorded more camera-days than were noted in most pertinent carnivore studies (Harrison 2006, Karanth and Nichols 1998, Soisalo and Cavalcanti 2006). We collected a total of 1680 animal images, and the total animal detection rate was 67 animals/100 camera-days (Table 1). Forty-five lynx images were taken (2 lynx/100 camera-days; Table 1). Most images (69%) were of

Table 1. Images of animals from a remote camera survey for *Lynx canadensis* (Canada Lynx) in northern Maine during 24 July–18 October 2005. Results are based on 36 infrared-triggered cameras placed afield for 2512 total working camera-days.

Species	Images	Proportion of all images	Images/camera-day[A]
Moose	1177	0.69	0.47
White-tailed Deer	112	0.07	0.04
Black Bear	87	0.05	0.03
Coyote	68	0.04	0.03
Snowshoe Hare	49	0.03	0.02
Canada Lynx	45	0.03	0.02
Other[B]	142	0.09	0.06
Total	1680	1.00	0.67

[A]Images/total working camera-days.
[B]For example, Rodentia, Passeriformes, Galliformes.

Alces alces L. (Moose) followed by *Odocoileus virginianus* Zimmermann (White-tailed Deer), *Ursus americanus* Pallas (Black Bear), *Canis latrans* Say (Coyote), and *Lepus americanus* Erxleben (Snowshoe Hare) (Table 1). The first lynx detection occurred on the third day of the 90-day study. The regression equation $y = 0.5606x + 1.0536$ (where x = study day and y = cumulative lynx detections) indicated that if the survey were extended to a 120-day period, a total of 68 lynx detections would be expected.

Remote camera studies for lynx are rare, and to our knowledge, no such results have been published in a peer-reviewed scientific journal. However, two unpublished reports have provided limited analyses of lynx detection rates using <550 camera-days/study. One of these, a prior remote-camera study on our northern Maine study area, produced three lynx detections in 300 camera-days (Crowley et al. 2005), and only 33% of radio-collared lynx present on the study area were detected. A Minnesota study reported no lynx detections in 512 camera-days, even though five radio-collared lynx were present on the study area and occasionally in proximity to cameras (Moen and Lindquist 2006). However, it was noted that a lynx hair-snare survey in the same region did not produce any lynx hair in this area either.

Our cameras were of a passive-infrared design, which record objects that interrupt an infrared sensor in a relatively wide area in front of the camera. Active infrared cameras are more expensive per unit, and an animal has to break a very narrow infrared beam emitted between the camera and a receiving unit. Thus, active infrared cameras are more likely to take close-up and broadside images. For lynx, this is useful to identify individual animals by pelage markings or color-coded radio-collars, as we were able to do with 15–20% of the lynx images obtained with passive-infrared cameras. These data could then be analyzed using capture-recapture or mark-recapture methods to estimate lynx abundance and density, rather than just presence or relative abundance (Heilbrun et al. 2003, 2006; Silver et al. 2004; Soisalo and Cavalcanti 2006). We suggest wildlife biologists use the active-infrared cameras to assess lynx abundance and density using capture-recapture methods.

Rates of carnivore detection vary considerably due to differences in remote camera survey design and species ecology, and generally ranged from 0 images/100 camera-days of effort for *Puma concolor* L. (Mountain Lion; Long et al. 2003) to 16/100 camera-days for *Panthera onca* L.(Jaguar; Soisalo and Cavalcanti 2006). Remote camera detection rates for *Lynx rufus* Schreber (Bobcat), which is occasionally sympatric with lynx in northern Maine, have been reported at 4 images/100 camera-days (Harrison 2006) and 7 images/100 camera-days (Heilbrun et al. 2006). Our detection rate of 2 lynx/100 camera-days was somewhat lower than the average detection rate for carnivores, but nonetheless represents the first estimate for lynx using remote cameras for a large-scale (>2500 camera-days) effort.

Snow-track surveys (McKelvey et al. 2006, Squires et al. 2004, Zielinski and Kucera 1995) and hair snares (McDaniel et al. 2000) have proven useful to monitor lynx populations and to identify individual animals, but have higher labor and equipment costs. Intuitively, snow-track surveys should be highly useful as a tool to survey lynx, as tracks in snow can be identified easily, and there is no need to attract animals to a specific location as is necessary for hair snares and remote camera surveys. McKelvey et al. (2006) extracted DNA from hair and scat samples collected along lynx tracks in snow to confirm track identification and to document individual lynx.

To our knowledge, the only comparison among snow-tracking, remote cameras, and hair snares to survey lynx was conducted by Crowley et al. (2005). They found that snow-track surveys by snowmobile were the most efficient technique in northern Maine. Snow-track surveys required about one personnel-hour of effort to detect one lynx, while remote cameras and hair snares required 70 and 165 personnel-hours, respectively. However, snow-track surveys require perfect tracking conditions and an immediate response to suitable snowfall events. Deep snow can also limit biologist access to survey areas. We suggest that remote cameras should not replace snow-track surveys for lynx, but when adequate snowfall is problematic, or biologists are limited in number or ability to respond immediately to field conditions, remote cameras may be a useful alternative.

We also provide some insight on the design of remote camera surveys for lynx. Placement of remote cameras along forest roads was appropriate and logistically necessary. High logging-road density (>1 km of road/km^2) is typical in the best Maine lynx habitat, and is characteristic of an intensively logged landscape. Cameras on roads likely also increased the total number of pictures of moose than would be expected with cameras placed randomly on the landscape. Most roads were overgrown and received no human use until hunting seasons (August–October). Although we had expected increased remote camera vandalism given their placement on roads, we had no such problems, and none of our cameras was stolen.

Our beaver castoreum and catnip oil lure, suggested by McDaniel et al. (2000), worked well for lynx, and we suggest that other surveyors use it. However, black bear was attracted by the lure and disturbed some cameras, sometimes affected the field of view, infrequently removed cameras from trees, and destroyed one camera. Bear interference was greatest in August and greatly diminished in September and October. Rarely, moose nudged cameras and changed the field of view.

In general, performance of the relatively inexpensive Moultrie GameSpy digital camera ($150/unit in 2005) was satisfactory. We recorded >2000 blank images, likely caused by waving branches, arthropods (i.e., spiders building webs over the camera sensor), or animals at the edge of camera sensor range. Blank images are relatively common and expected when using remote cameras (Moen and Lindquist 2006). Regardless, our inexpensive cameras were useful to monitor several wildlife species in summer in northern Maine. Downloaded images from digital cameras provide immediate information on wildlife in the field, identify camera set-up problems, facilitate adjustments to improve efficacy, and eliminate the cost of using film.

Looking ahead, current research on remote cameras to survey lynx in northern Minnesota (R. Moen, University of Minnesota Duluth, Natural Resources Research Institute, pers. comm.) and incorporation of remote camera surveys within an occupancy-modeling framework (MacKenzie et al. 2003, 2006; Moore and Swihart 2005) will undoubtedly shed more light on the utility of remote cameras to survey lynx.

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Literature Cited

Aubry, K.B., L.F. Ruggiero, J.R. Squires, K.S. McKelvey, G.M. Koehler, S.W. Buskirk, and C.J. Krebs. 2000. Conservation of lynx in the United States: A systematic approach to closing critical knowledge gaps. Pp. 455–470, *In* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (Eds.). Ecology and Conservation of Lynx in the Contiguous United States. University Press of Colorado, Boulder, CO. 474 pp.

Crowley, S.M., C.R. McLaughlin, A.D. Vashon, J.H. Vashon, W.J. Jakubas, J.F. Organ, and G.J. Matula, Jr. 2005. A comparison of survey techniques to detect Canada Lynx (*Lynx canadensis*) in northern Maine. Unpublished report. Maine Department of Inland Fisheries and Wildlife, Bangor, ME.

Cutler, T.L., and D.E. Swann. 1999. Using remote photography in wildlife ecology: A review. Wildlife Society Bulletin 27:571–581.

Harrison, R.L. 2006. A comparison of survey methods for detecting bobcats. Wildlife Society Bulletin 34:548–552.

Heilbrun, R.D., N.J. Silvy, M.E. Tewes, and M.J. Peterson. 2003. Using automatically triggered cameras to individually identify Bobcats. Wildlife Society Bulletin 31:748–755.

Heilbrun, R.D., N.J. Silvy, M.J. Peterson, and M.E. Tewes. 2006. Estimating Bobcat abundance using automatically triggered cameras. Wildlife Society Bulletin 34:69–73.

Hoving, C.L., R.A. Joseph, and W.B. Krohn. 2003. Recent and historical distributions of Canada Lynx in Maine and the Northeast. Northeastern Naturalist 10:363–382.

Karanth, U.K., and J.D. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79:2852–2862.

Long, E.S., D.M. Fecske, R.A. Sweitzer, J.A. Jenks, B.M. Pierce, and V.C. Bleich. 2003. Efficacy of photographic scent stations to detect Mountain Lions. Western North American Naturalist 63:529–532.

McDaniel, G.W., K.S. McKelvey, J.R. Squires, and L.F. Ruggiero. 2000. Efficacy of lures and hair snares to detect lynx. Wildlife Society Bulletin 28:119–123.

McKelvey, K.S., J. VonKienast, K.B. Aubry, G.M. Koehler, B.T. Maletzke, J.R. Squires, E.L. Lindquist, S. Loch, and M.K. Schwartz. 2006. DNA analysis of hair and scat collected along snow tracks to document the presence of Canada Lynx. Wildlife Society Bulletin 34:451–455.

MacKenzie, D.I., J.D. Nichols, J.E. Hines, M.G. Knutson, and A.B. Franklin. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84:2200–2207.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. Elsevier Academic Press, Burlington, MA. 343 pp.

Moen, R., and E.L. Lindquist. 2006. Testing a remote camera protocol to detect animals in the Superior National Forest. University of Minnesota Natural Resources Research Institute Technical Report No. NRRI/TR–2006–28, Duluth, MN.

Moore, J.E., and R.K. Swihart. 2005. Modeling patch occupancy by forest rodents: Incorporating detectability and spatial autocorrelation with hierarchically structured data. Journal of Wildlife Management 69:933–949.

Pierce, B.M., V.C. Bleich, C.B. Chetkiewicz, and J.D. Wehausen. 1998. Timing of feeding bouts of Mountain Lions. Journal of Mammalogy 79:222–226.

Silver, S.C., L.E.T. Ostro, L.K. Marsh, L. Maffei, A.J. Noss, M.J. Kelly, R.B. Wallace, H. Gomez, and G.A. Crespo. 2004. The use of camera traps for estimating Jaguar (*Panthera onca*) abundance and density using capture/recapture analysis. Oryx 38:148–154.

Soisalo, M.K., and S.M.C. Cavalcanti. 2006. Estimating the density of a Jaguar population in the Brazilian Pantanal using camera-traps and capture-recapture sampling in combination with GPS radio-telemetry. Biological Conservation 129:487–496.

Squires, J.R., K.S. McKelvey, and L.F. Ruggiero. 2004. A snow-tracking protocol used to delineate local lynx, *Lynx canadensis*, distributions. Canadian Field-Naturalist 118:583–589.

US Fish and Wildlife Service (USFWS). 2005. Recovery outline for the contiguous United States distinct population segment of the Canada Lynx. Unpublished report. US Fish and Wildlife Service, Region 6, Denver, CO.

Vashon, J.H., A.L. Meehan, W.J. Jakubas, J.F. Organ, A.D. Vashon, C.R. McLaughlin, and G.J. Matula, Jr. 2005. Primary diurnal home range and habitat use by Canada Lynx (*Lynx canadensis*) in northern Maine. Unpublished report. Maine Department of Inland Fisheries and Wildlife, Bangor, ME.

York, E.C., T.L. Moruzzi, T.K. Fuller, J.F. Organ, R.M. Sauvajot, and R.M. DeGraaf. 2001. Description and evaluation of a remote camera and triggering system to monitor carnivores. Wildlife Society Bulletin 29:1228–1237.

Zielinski, W.J., and T.E. Kucera (Eds.) 1995. American Marten, Fisher, Lynx, and Wolverine: Survey methods for their detection. USDA Forest Service General Technical Report PSW-GTR-157, Albany, CA.

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