National Interagency Canada Lynx Detection Survey in Minnesota, Wisconsin, and Michigan

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Summary

A variety of non-invasive techniques including hair snagging, snow-tracking, and remote cameras can be used to monitor mammalian carnivores. The National Interagency Canada Lynx Detection Survey (NLDS) was a survey designed to detect lynx with a hair-snagging protocol applied throughout the conterminous U.S. range of the lynx. Hare-snagging stations consisted of a scent lure, a carpet piece with nails to snag hair, and a pie tin to attract the cat's attention. We applied the NLDS protocol in the Superior and Chippewa National Forests in Minnesota, the Chequamegon and Nicolet National Forests in Wisconsin, and the Ottawa National Forest in Michigan. Mammalian species detected included black bears (*Ursus americanus*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), ungulates, and other canids. The NLDS did not detect lynx in the Great Lakes Geographic Area (GLGA) despite their likely presence on some of the Minnesota NLDS grids. We also opportunistically set up hair snagging stations in areas in Minnesota where we knew lynx were present to further test the efficacy of hair-snagging stations. We had limited success using hair snares to selectively sample for lynx despite placing snares in areas regularly used by lynx. We suspect the detection probability for lynx hair-snagging surveys in the GLGA may be low and other survey techniques may prove more useful, particularly for localized selective sampling for lynx presence.

Table of Contents

List of Figures

List of Tables

Introduction

Wildlife surveys can be broadly classified into those with selective sampling designs, where detection stations are placed in the areas most likely to detect the target species, and representative designs, where detection stations are placed randomly or stratified according to the frequency or availability of habitats. Most techniques used to detect mammalian carnivores can indicate presence with selective sampling designs but systematic and unbiased sampling designs, adequate sample sizes, and estimates of detection probability are required to obtain data concerning species presence and absence (MacKenzie 2005). Presence/absence data allow stronger inference from survey data, including estimates of distribution, habitat relationships, and population size (McKelvey et al. 1999). Absence is essentially impossible to prove unless the detection probability equals 1 (MacKenzie et al. 2002). Because this level of efficacy is rarely encountered, reliable information from presence/absence surveys requires estimating the detection probability of the survey technique (MacKenzie et al. 2002, MacKenzie 2005). Detection probability likely exhibits considerable variation in surveys conducted across large areas because of variations in the population density of the target species. Consequently, carnivore surveys using representative sampling designs across large areas are often required to confront trade-offs between survey efficacy and inference that often reflect both local and range-wide management issues (McKelvey et al. 1999).

Non-invasive techniques to detect mammalian carnivores include track surveys (Halfpenny et al. 1995, Squires et al. 2004), remote cameras (Karanth and Nichols 1998, Karanth et al. 2006), and molecular-based analyses using animal hair or scat (McKelvey et al. 1999, Weaver et al. 2005, McKelvey et al. 2006). Hair snagging has become a popular non-invasive technique because it provides genetic samples for individual-level identification and hair-snares are inexpensive, lightweight, require little maintenance, and can be used to survey large areas. Hair snagging has been used to detect several mammalian carnivores including black (*Ursus americanus*) and grizzly bears (*Ursus arctos horribilis*), Canada lynx (*Lynx canadensis*), Eurasian lynx (*Lynx lynx*), and ocelots (*Leopardus pardalis*) (Woods et al.1999, McDaniel et al. 2000, Weaver et al. 2005, Dixon et al. 2006, Schmidt and Kowalczyk 2006).

Felids are often monitored with hair snagging because they frequently communicate by head and neck rubbing (Wemmer and Scow 1977) and this behavior can be induced with olfactory stimuli, particularly catnip. Despite this behavioral advantage, the results of hair-

snagging protocols for felids are mixed. Canada lynx were detected on 45% of hair-snare transects in a high-density population in Yukon, Canada (McDaniel et al. 2000). However, hair snares were less effective (10%) than trained dogs (100%) and remote cameras (50%) for detecting bobcats in New Mexico (Harrison 2006). The detection of Eurasian lynx in a low-density population in Poland was more efficient when snares were attached to sites previously scent-marked by lynx (Schmidt and Kowalczyk 2006). Comprehensive sensitivity analyses examining the relationship between target species and snare density are generally lacking but a density of 1 snare every 25-50 ha has been suggested for relatively abundant ocelot populations (Weaver et al. 2005). If hair snares inherently have poor detection probabilities, require considerable knowledge about the movements and behavior of the target species, or must be deployed at large densities over large areas, the technique may be ineffective, particularly in locations where the target species is rare, wide-ranging, or poorly-studied.

The NLDS was a genetically-based representative survey initiated in 1999 to detect Canada lynx across the species' conterminous U.S. range (McKelvey et al. 1999). The NLDS was a hair-snagging protocol that collected a hair sample from lynx by eliciting a rubbing response to catnip placed on snares. This protocol was selected by an interagency team because it was designed to meet agency goals, was cost effective, and would likely detect Canada lynx when present in sufficient numbers (McKelvey et al. 1999, McDaniel et al. 2000). The nation-wide scope of the NLDS required an inexpensive, low-maintenance survey technique that ensured representative sampling, efficacy, and reliability (McKelvey et al. 1999). Flexibility associated with the representative sampling design of the survey was also required because of its broad scale.

We summarize the results of the NLDS grids we surveyed in the national forests in the Great Lakes Geographic Area (GLGA). The intent of the NLDS in this region was to determine if lynx were currently found in areas with past records of lynx presence. The Hiawatha National Forest and Voyaguers National Park chose to do their own surveys, and their results are not included in this report. We particularly scrutinize results from Minnesota because it is the state with the most consistent historical record of lynx presence in the GLGA and a telemetry project initiated in 2003 radiocollared lynx near 2 of the 4 NLDS grids in Minnesota. We also tested the NLDS hair snagging technique by opportunistically setting up hair snagging stations in areas

where we knew lynx were present. Finally, we evaluate hair snagging relative to other non-invasive survey methods including remote cameras and snow tracking.

Methods

NLDS. Personnel from the Natural Resources Research Institute (NRRI) of the University of Minnesota Duluth and the Superior National Forest, Duluth, MN conducted the NLDS from 1999-2002 in the national forests of Minnesota, Wisconsin and the Ottawa National Forest in Michigan (Table 1, Fig. 1). The NLDS was conducted during summer or fall in most of the United States but we conducted the NLDS during both summer-fall and winter because of concerns about limited summer access to lowland areas on some grids (Table 1). All grids were run for three years, the duration mandated in the NLDS protocol. The Superior 1 grid was conducted for a 4th year in 2003 after lynx were radiocollared in this area (Moen et al. 2003).

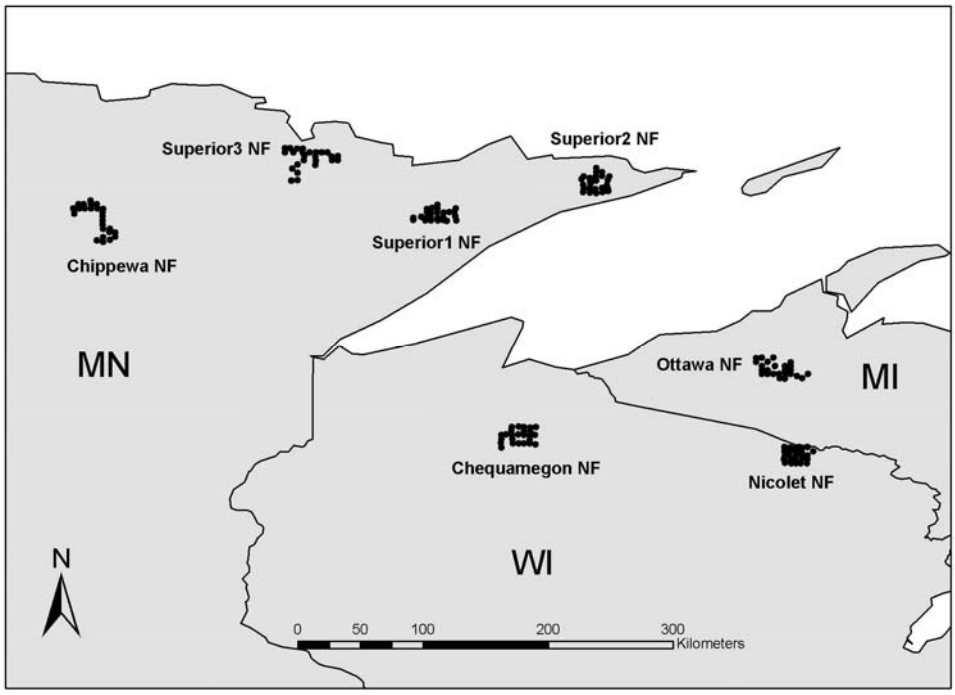
Table 1. Name, location, survey year and season for 6 NLDS grids conducted on national forests within the Eastern Region of the USDA – Forest Service in Great Lakes Geographic Area.

National Forest	Grid	Location	Years	Season
Superior 1	40	Isabella, MN	1999-2003	Summer-Fall
Superior 2	43	Grand Marais, MN	1999 - 2001	Winter
Superior 3	66	Cook, MN	2000-2002	Winter[a]
Chippewa	44	Wirt, MN	1999-2001	Winter
Chequamegon	39	Clam Lake, WI	1999-2001	Summer-Fall[b]
Nicolet	38	Eagle River, WI	1999-2001	Summer-Fall
Ottawa	35	Kenton, MI	1999-2001	Summer-Fall

[a] Surveyed in summer-fall during last year (2002) of survey.

[b] Surveyed in winter during first year (1999) of survey.

Figure 1. Location of 6 NLDS grids surveyed by NRRI in the GLGA, 1999-2002.



The NLDS was designed to use the same experimental protocol throughout the range of lynx in the U.S. (McKelvey et al. 1999). All GLGA grids met the NLDS protocol of a survey grid of 25 transects placed approximately 2 miles apart. The Superior 1 grid exceeded the criteria, it was expanded to 30 transects in 2003 to incorporate a portion of the home range of 1 radiocollared male lynx. Each transect contained five detection stations placed at 100 m intervals along a predetermined random bearing. The 25 transects in a survey grid were initially placed in a 5 x 5 grid but, consistent with the NLDS protocol (McKelvey et al. 1999), habitat discontinuities, habitat quality considerations, and limited road access required frequent changes to the idealized 5 x 5 grid shape (Fig. 1).

Individual stations in each grid (n=125) consisted of a hair snare baited with a liquid lure (active ingredients included beaver castoreum and catnip oil) and catnip, an aluminum pie pan

for a visual lure, and a scent pad baited with the liquid lure (McDaniel et al. 2000) (Fig. 2). Stations were checked and rebaited after two weeks and rechecked and removed after one month. Snares where hair was present were removed from the field in plastic bags and processed at field camps. All genetic analyses of collected hair samples were performed at the Carnivore Genetics Laboratory in Missoula, MT that is operated cooperatively by the University of Montana and USDA-FS Rocky Mountain Research Station. Beginning in 2000 we kept all samples in locked boxes until they were delivered to NRRI for shipment to the Carnivore Genetics lab.

Figure 2. Hair snare baited with liquid lure and catnip (A), scent pad baited with liquid lure (B), and pie tin (C) at a NLDS station.

A B C

Non-Random Hair Snagging outside of NLDS protocol within the Superior National Forest. We also conducted 4 experiments where individual hair-snare stations were selectively placed in areas of known lynx presence. These stations were visited at about 2 week intervals similar to the NLDS protocol. Hairs were collected according to the NLDS protocol and sent in for genetic analysis when necessary.

- Experiment 1 consisted of 10 stations placed north of Tofte, MN in an area being regularly used by 3 lynx during March 2002. Stations were placed near lynx tracks, scent marks, and locations where lynx had either bedded or killed a snowshoe hare.

- Experiment 2 consisted of 3 stations placed near recent lynx tracks southeast of Isabella, MN in March 2002. Multiple lynx were radiocollared in this area from March 2003 through 2006
- Experiment 3 consisted of 6 stations placed near Isabella, MN in September 2002. These stations were associated with several lynx sightings that had occurred in the previous month. These stations were placed in areas appearing to be suitable lynx habitat but were not associated with actual lynx sign.
- Experiment 4 consisted of 6 stations placed within the home ranges of at least 4 lynx wearing GPS collars near Isabella, MN in August 2005. We had prior knowledge of the movements and activity areas of 3 of these lynx from telemetry data, trapping efforts, and a snow tracking habitat study conducted during previous winters. We placed hair snare stations and remote cameras in 6 areas used by lynx based on telemetry locations, often where the lynx had been previously trapped. We monitored these stations for approximately 2 months.

Results

We did not detect lynx on any of the NLDS grids but detected several other mammals, including bobcats (Table 2, Appendix 1). Black bears were consistently detected at grids conducted during the fall (Table 3) and regularly destroyed hair-snare stations. Bobcats were detected in both summer and winter surveys (Table 3). Wolves (*Canis lupus*) or domestic dogs (*Canis familiaris*), coyotes, and unidentified ungulate species were also detected on multiple grids. The presence of human and domestic cat hairs was probably from unintentional contamination during sample processing. Field notes recorded on NLDS data sheets suggest that the majority of the samples classified as ‘other’ were from mustelids, including fishers (*Martes pennanti*) and American martens (*Martes martes*). Winter climate did not seem to have a large effect on the ability of DNA to detect species from our samples (78% success in summer/fall, 65% success in winter).

Table 2. Species results from NLDS grids conducted by NRRI, 1999-2002. Genetic analysis was done at the Carnivore Genetics Laboratory in Missoula, MT.

Location	Quality DNA?	Black Bear	Bobcat	Wolf/ Dog	Ungulate	Coyote	Dom. Cat	Human	Other
Chequamegon	65%	9	4	1	1	0	0	0	2
Chippewa	61%	2	6	3	0	0	0	0	6
Nicolet	77%	60	0	1	0	4	2	0	5
Ottawa	81%	51	2	0	1	2	1	2	10
Superior1	67%	19	1	1	2	2	0	0	8
Superior2	83%	2	1	1	0	2	0	0	14
Superior3	34%	5	0	1	0	0	1	0	3

Table 3. Number of individual species detections (hits)/100 days per NLDS grid in GLGA, 1999-2003. Domestic cat and human were excluded because they are presumed result of contamination. Black bear and bobcat evaluated seasonally to compare effect of season on detection rate with a hair-snagging protocol.

Species	Hits/100 Days
Black Bear	22.4
Summer	*36.9*
Winter	*1.5*
Bobcat	2.1
Summer	*1.8*
Winter	*2.6*
Wolf/Dog	1.2
Ungulate	0.6
Coyote	1.5
Other	7.3
All species	35.2
Carnivore (inc. bear) species	27.3

We detected 1 lynx during our experiments with non-random placement of hair snare stations. This consisted of a single hair found on a snare that snow tracks indicated a lynx had visited during experiment 1 north of Tofte, MN. However, this snare was installed on a day when technicians had removed several hundred lynx hairs from snow beds so it is also possible that the hair came from a glove. Tracks or telemetry locations placed lynx within 100 m of stations used

in non-random surveys 1, 2 and 4. One lynx wearing a GPS collar programmed to collect 2 locations per day had a home range overlapping non-random survey 4 and its mean distance to a hair snare/camera station was 5.1 ± 4.3 (SD) km^2 during the 2 months of this survey (Fig.3). Several lynx wearing GPS collars were located near the Superior 1 grid and the cameras deployed in experiment 3 (Fig. 4).

Figure 3. Distribution of GPS collar locations of male lynx L28 relative to 5 of the 6 non-random hair snare/camera stations deployed in August and September 2005. The GPS collar of lynx 28 was programmed to collect 2 locations/day although actual acquisition rate was lower.

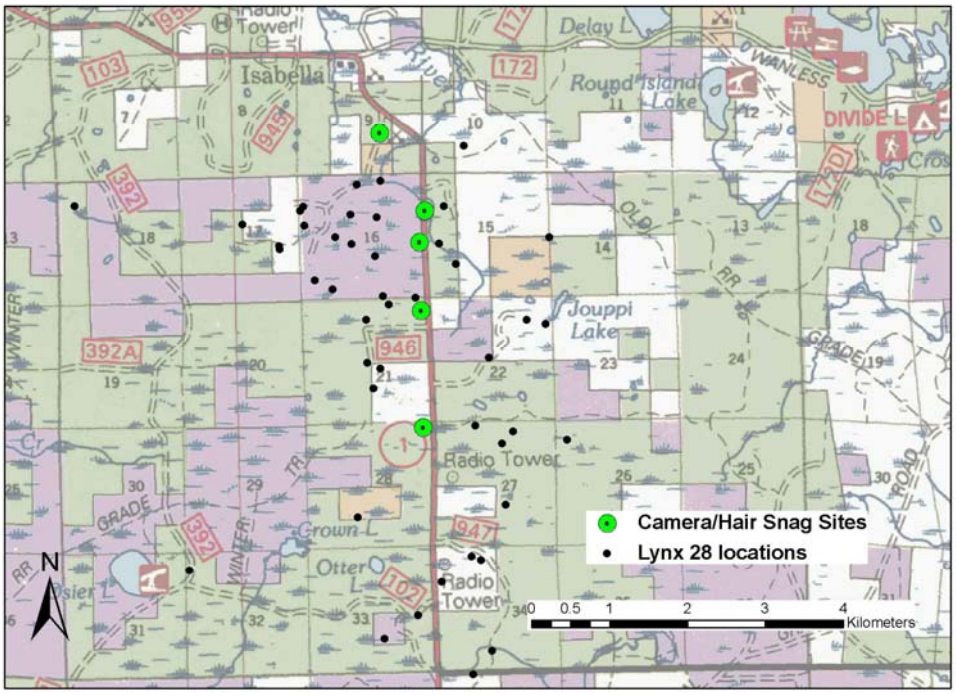
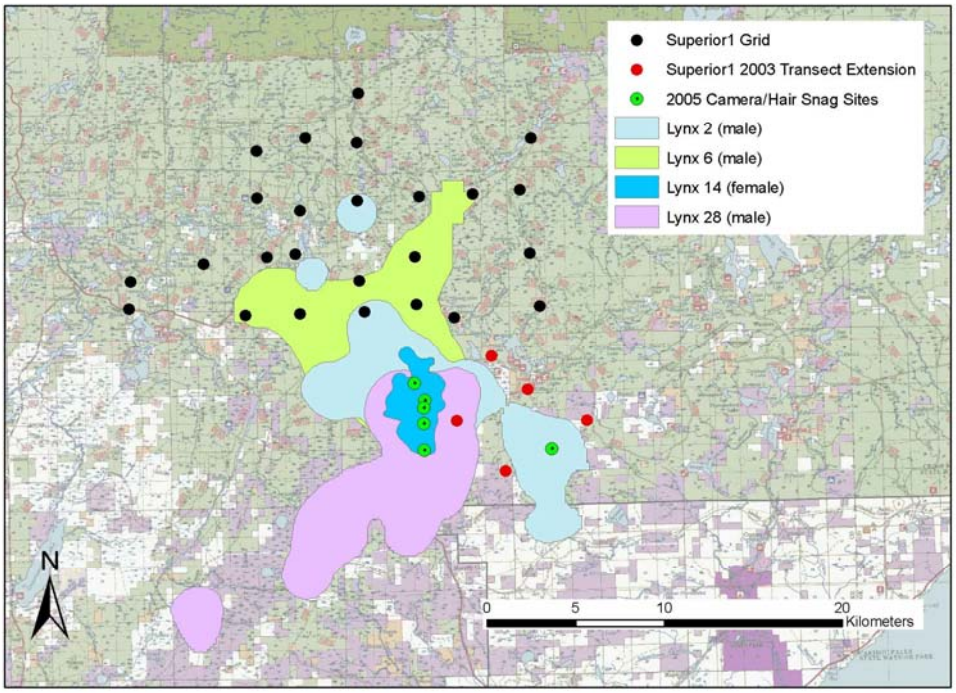


Figure 4. Distribution of lynx home ranges relative to Superior 1 NLDS grid and August/September 2005 non-random hair snare/camera survey (i.e., experiment 4).



In addition to evaluating NLDS results on a per grid basis (Table 3), we also determined detection rate for individual snare stations to enable comparisons with other survey methods. The detection rate per snare across the GLGA was 0.03 hits per 100 snare-days. The detection rate per station for any animal on the Superior1 grid was lower for the NLDS than remote cameras (Moen et al. 2006) (Table 4). These results should be considered relative to the typical higher cost associated with camera stations.

Table 4. Comparative detection rates for hair snares and remote cameras. Detection rates are for all animals on remote camera survey and the NLDS Superior 1 grid. Also included is a coarse estimate of the detection rate of lynx using selective hair-snare sampling in areas of known lynx presence.

Survey type	Detection rate/100 station days
Remote Cameras	6.0
NLDS	0.2
Hair snares (lynx only)	0.1

Discussion

The NLDS detected several carnivore species in the GLGA but seemed particularly effective for black bears. More black bear samples were collected (n = 148) than all other species combined (n = 90) despite conducting 43% of our annual grids during winter. Our results corroborate studies advocating hair snagging for black bear research (Woods et al. 1999, Triant et al. 2004, Dixon et al. 2006). The NLDS results from the GLGA could potentially be used to examine genotypic differences among regional bear populations. In particular, black bear samples collected from the Ottawa National Forest in MI and the Nicolet National Forest in WI, areas separated by about 100 km, could be examined with population-assignment analyses (Dixon et al. 2006). From the perspective of a felid survey, bears are problematic because they frequently destroyed the hair-snare stations and may reduce the ability to detect other species.

The NLDS also detected bobcats on 5 of the 7 grids we surveyed, including 3 of the 4 Minnesota grids. We believe the NLDS provided an adequate detection rate for bobcats in the GLGA. We obtained multiple bobcat detections on the Chippewa grid in north-central Minnesota, the region of the state traditionally supporting the largest bobcat harvests (Dexter 2005). Inadequate snow conditions prevented the Chippewa grid from being placed in its preferred location during the 1st year. The grid was relocated during the 2nd year to coincide with areas of greater conifer cover and multiple bobcats were detected. Bobcats have a wider prey base than lynx but still frequently exhibit preferences for coniferous forest (Lovallo and Anderson 1996, Chamberlain et al. 2003). It is possible that our experience with the Chippewa

grid reflects the importance of having prior knowledge of the target species distribution when using a hair-snagging protocol.

We did not detect lynx in the GLGA. This was unexpected because the NLDS successfully detected bobcats in the GLGA and has successfully detected lynx elsewhere (J.Claar, pers. comm, Kevin McKelvey, pers. comm., McDaniel et al. 2000). Possible reasons for this lack of success in the GLGA include the unlikely presence of lynx on some survey grids (e.g., those in WI and MI), the disjunct distribution of patches supporting abundant snowshoe hare populations in the region and locally, the lack of prior knowledge about lynx distribution in Minnesota when planning the placement of NLDS grids, and factors associated with eliciting a rubbing response. We acknowledge the speculative nature of our suggestions but suspect they may still help interpret and improve hair-snagging surveys.

The lack of detections on the Wisconsin and Michigan grids may be due to the absence of lynx. Historic lynx records in Wisconsin and Michigan largely coincide with large region-wide lynx irruptions in the mid-20th century (Mech 1973, Thiel 1987, Beyer et al. 2001). The United States Fish and Wildlife Service (USFWS) subsequently concluded that lynx present in these areas probably represent nomadic or dispersing animals rather than resident populations (USFWS 2003).

However, lynx were present in Minnesota during the NLDS. Lynx radiocollared near the Superior 1 grid during the telemetry project begun in 2003 have territories and have reproduced in this area (Moen et al. 2003, Moen et al. 2004, Moen et al. 2005a, Burdett et al. 2007) (Fig. 3). Five lynx have also been radiocollared to the north and south of the Superior 2 grid northwest of Grand Marais, MN but their home-range overlap with the Superior 2 grid is less than that near the Superior 1 grid. Lynx sightings have been common throughout much of northern Minnesota during and after the NLDS so lynx may have been present on other Minnesota NLDS grids too. In addition to our surveys, a NLDS grid was conducted for 2 of the prescribed 3 years in Voyageurs National Park in Minnesota and also failed to collect lynx hair although a putative lynx track was found near a hair snare and lynx have been confirmed present in the area (Route et al. 2007).

The NLDS may have failed to detect lynx because the representative sampling design of the NLDS may be incompatible with lynx movements and use of space in Minnesota. Lynx in Minnesota often localize in specific areas regardless of whether they are consistently present in

these areas or not. Breeding female lynx inhabit home ranges < 20 km^2 whereas non-breeding females and males have larger home ranges up to 500 km^2 (Mech 1980, Burdett et al. 2007). In addition, resident lynx in Minnesota often cluster their movements in intensively used core areas supporting abundant prey (Burdett et al. 2007). Snowshoe hare populations in our region have shown diminished population cycles in recent decades, possibly due to the fragmented nature of high quality snowshoe hare habitat (Keith et al. 1993). It could be inherently difficult to detect lynx with a representative sampling design such as the NLDS given the broad but localized movements of lynx in Minnesota. In addition, forested landscapes in Minnesota are very heterogenous and lack the coarse-scale topographic gradient associated with forest types preferred by lynx in the western U.S. Despite latitude in balancing the competing goals of detection and inference (McKelvey et al. 1999), the representative sampling design of the NLDS may have resulted in a poor probability of detection given the heterogeneity of northern Minnesota forests and corresponding behavioral response of lynx.

We placed our NLDS grids in areas with historical records of lynx presence. Unfortunately, information on the current distribution of lynx was unavailable prior to the start of the NLDS in 1999. Lynx are consistently associated with 20-50 year old regenerating forests (Koeher 1990, Mowat and Slough 2003, Hoving et al. 2004). The shifting mosaic of this age-class in Minnesota likely modifies fine-scale lynx distribution through time and makes ideal placement of the grid difficult when current lynx distribution is unknown. Within the lynx telemetry study area in Minnesota our grid locations generally coincided with lynx territories and movements detected during the subsequent telemetry study. However, overlap was not exact and modifying the placement of grids to better overlap lynx territories may have improved the success of the NLDS in the GLGA similar to Eurasian lynx in Poland (Schmidt and Kowalczyk 2006). The lack of distinct altitudinal associations with preferred lynx habitat types in the GLGA also complicates broad-scale decisions about grid placement.

Additional explanations for the lack of lynx detections could be associated with eliciting the rubbing response. An inherent disadvantage of hair snagging censuses for felids is the need to induce behavior (i.e., rubbing) to obtain a detection, a problem not associated with scat collection or remote photography (Harrison 2006). Also, catnip response in felids is apparently controlled by an autosomal dominant gene (Todd 1962) that could be poorly represented in some regions.

Our opportunistic experiments with selective sampling suggest that the probability of detecting felids with hair snares may be low. Similar results were found for bobcats in New Mexico (Harrison 2006). However, additional experiments over larger areas using snare densities similar to those used in the NLDS would be required to obtain a valid test of hair-snagging as a selective sampling method for lynx in the GLGA. In particular, a comprehensive evaluation of hair-snagging efficacy will require carefully designed studies investigating the sensitivity of the technique to differences in the densities of the target species and hair snares. The NLDS placed stations at a minimum density of 1 snare/75 ha using systematic placement of each 5-station transect along a grid designed for representative sampling. Selective hair snagging surveys conducted in a relatively high density ocelot population suggested a density of 1 station every 25-50 ha was needed to be effective (Weaver et al. 2005). A station density of 1/25 ha would require about 373 stations to selectively survey a similar area as the NLDS. A need for high snare densities may reduce the logistic advantages of hair snagging.

We have also used other non-invasive techniques to detect and monitor lynx in Minnesota. A randomized remote-camera study did not detect lynx near the Superior 1 grid but lynx are routinely photographed in both Minnesota and Maine when cameras are selectively placed and food is used as bait (Moen et al 2005a, Moen et al. 2006, Clay Nielsen, pers. comm.). Remote-camera surveys do not provide the ability to identify individual lynx because lynx lack the unique markings of other felids (Karanth et al. 1998, Karanth et al. 2006) and a genetic sample is not obtained. However, we have consistently been able to identify individual lynx with genetic analyses of hair or scat samples collected during snow-tracking (Squires et al. 2004, Moen et al. 2005b, McKelvey et al. 2006). Snow-tracking surveys using randomized or adaptive-cluster sampling designs would offer an efficient survey technique within the structure of a representative sampling design that provides additional inference to the target species population than selective sampling.

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