Canada Lynx in the Great Lakes Region

2004 Annual Report
to
USDA Forest Service
and
MN Cooperative Fish and Wildlife Research Unit

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Executive Summary

We summarize the second year of a project on the Canada lynx ecology in the Great Lakes region. The project is designed to address four major questions about this population of Canada lynx: distribution, habitat use, abundance, and persistence. In the first 21 months of this project we captured and deployed radiotelemetry collars on 17 adult Canada lynx. Each animal was located approximately weekly after being collared. Radiocollared females had kittens in 2004, and at least 2 of the kittens survived through Deceember, 2004 in each litter. Of the 17 Canada lynx collared, 2 died in 2003 and no animals died in 2004.

GPS collars have been deployed on 11 of the Canada lynx in this project. Over 3,000 locations will have been obtained from these collars when they are recovered. Animals wearing GPS collars were recaptured to download data from the collars. GPS collar locations will be fundamental to understanding movements and habitat use of Canada lynx. Ambient temperature and animal activity level is recorded by the collars indicating daily patterns in activity, and also shows how active an animal was when each GPS location was obtained.

In addition to the telemetry component of the project, we also conducted the second year of surveys for snowshoe hare, the major prey species of Canada lynx. Permanent pellet plots were established throughout the SNF for snowshoe hare. Plots were distributed based on stratified random, systematic, and selective site selection strategies. Many stratified random plots had few or no pellets. The highest pellet density over two years of pellet surveys occurred in young red pine and young upland black spruce cover types.

A prototype camera survey was finished in the area of Isabella, MN, and a snow-track survey for Canada lynx and other mesocarnivores was completed on the National Lynx Survey grid.

The project website (www.nrri.umn.edu/lynx) gets over 1,000 page requests per day. This website provides a history of the project, lists project goals and accomplishments, and includes links to press coverage of the project.

We begin the report with a brief chronological summary of the Canada Lynx ecology in the Great Lakes region project. The project has been supported by several agencies with some common deliverables and some deliverables that varied among agencies. To produce a cohesive, logically organized annual report, we describe the project in its entirety, and we indicate specific deliverables in Appendix 1. We first describe Canada lynx trapping and the deployment of radiotelemetry collars. The radiotelemetry program is very important because each of the major deliverables depends on telemetry data. Next, we address progress made on each of the major questions: 1) distribution, 2) habitat use, 3) abundance, and 4) persistence. Prey species surveys and other aspects of the project are also summarized.

We conclude each section with the current status and future plans for each topic. It is important to recognize that the project is less than two years old. A complete answer for some of the questions will require several years of data collection which was built into the project master plan. With the number of Canada lynx now radiocollared, and with expectations of more in the near future, there will be sufficient data for preliminary management recommendations in 2005.

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Introduction

The project to study Canada lynx in the Great Lakes region began even before the April 2000 listing of the Canada lynx as a threatened species under the U.S. Endangered Species Act (ESA). The ESA provides for the conservation and recovery of listed species, directing all federal agencies to utilize their resources to carry out programs for the conservation of listed species, and to consult with FWS to ensure that their actions do not jeopardize the continued existence of any listed species. Being listed as a threatened species status created a legal obligation to increase understanding of the ecology and natural history of the species throughout the conterminous U.S. range of lynx. Federal agencies, including the U.S. Forest Service (USFS), the U.S. Fish and Wildlife Service (USFWS), and the National Park Service (NPS), must follow provisions in the ESA, the National Forest Management Act (NFMA), and the National Environmental Policy Act (NEPA) while making management decisions that could impact Canada lynx. NFMA regulations mandate the USDA-Forest Service to maintain viable populations of all plant and animal species on each national forest.

Under NEPA the actions of all federal agencies are analyzed to fully disclose the expected impacts to the environment such that an informed decision can be made. Current analysis of the effects of proposed management actions in the Great Lakes region under NEPA may be based on insufficient information because most studies on the ecology of lynx have been conducted in the western U.S. and Canada. This information may not directly apply to the Great Lakes region which differs in climate, landscape, topography and vegetation. Additional information on the ecology of lynx in the western Great Lakes area gathered on this project will provide region-specific information and allow management and recovery efforts to address the Great Lakes portion of the U.S. lynx population with scientific data rather than assuming that extrapolation of data from other regions is sufficient.

Canada lynx populations in the lower 48 states were present as western Great Lakes, eastern, and western populations, respectively (McKelvey et al. 2000, Ruggiero et al. 2000). Historically, Minnesota had the highest numbers of lynx in the western Great Lakes population. Harvest data document the persistence of a lynx population in Minnesota through most of the 20th century (Henderson 1978, Loch and Lindquist, unpubl. manuscript). Yet relatively little is known about Canada lynx in Minnesota. The only estimates of home range size and demographic statistics on lynx in Minnesota are from a single field study (Mech 1980).

In the 22 months that have elapsed since obtaining regulatory approval for this project, 17 adult and 1 kitten Canada lynx have been captured and radiocollared. Understanding the factors affecting the apparent reappearance, current distribution, and long-term persistence of Canada lynx in the Great Lakes region requires a combination of basic and applied research. Information that will contribute most effectively to the recovery and conservation of lynx in the Great Lakes region include:

1. Determining distribution,
2. Determining habitat use and requirements,
3. Determining abundance, and
4. Monitoring the long-term persistence of the lynx population.

These needs could be subsumed under a more general heading of understanding the biology and ecology of Canada lynx in Minnesota and other states in the Great Lakes region. Work by the USFS, NRRI, and MN DNR has provided background information on distribution, a necessary precursor to determining abundance. Persistence of the Canada lynx population in this region can be addressed with genetic analyses and long-term monitoring. Habitat use is being determined with snow tracking, VHF telemetry, and GPS collar locations.

Literature Review

The Canada lynx is a medium-sized felid found in the boreal forests of Canada and the northern United States. Lynx populations increase and decrease with populations of the snowshoe hare (*Lepus americanus*) over an approximate 10-year period (Elton and Nicholson 1942, Keith 1963, Krebs et al. 2001). Throughout this predator-prey cycle, lynx populations lag 1-2 years behind hare populations (Brand et al. 1976, Poole 1994, Slough and Mowat 1996, O'Donoghue et al. 1997). Lynx occur at a density of less than 3 / 100 km^2 during periods of hare scarcity in northern Canada, but rebound to densities over 30 / 100 km^2 during peak hare years (Poole 1994, Slough and Mowat 1996).

Much of the past research on lynx has been conducted in Alaska and Canada. Information from Alaska and Canada provides a large amount of comparative literature that can be used to efficiently increase knowledge of lynx ecology in the contiguous 48 states. This is helpful because little was known about lynx ecology in the contiguous U.S. at the time of federal listing of the Canada lynx under the Endangered Species Act (Ruggiero et al. 2000). As late as 2000, there were only seven studies in the contiguous 48 states that focused on lynx ecology, and two of these had bobcats as the primary species of interest (Squires and Laurion 2000). Lynx populations in southern areas seem to have characteristics similar to lynx populations in northern areas during lows in the lynx-hare cycle (Koehler 1990), driven by the relatively low hare densities in both cases.

There are at least three ongoing studies of lynx in the contiguous U.S. outside of Minnesota that began just prior to lynx being listed as threatened under ESA. These studies are still in progress, and information is available as annual reports (Vashon et al. 2002, Vashon and Crowley 2003), publications in chapters and popular magazines (Squires and Laurion 2000, Todd 2003), and websites (e.g., http://wildlife.state.co.us/species_cons/lynx.asp). The study in Montana has resulted in over 50 lynx being radiocollared, with about 30 animals being maintained in recent years (Squires and Laurion 2000). The study area is in the mountainous region of northwestern Montana. The collection and genetic analysis of hair and scat samples for identification of individual lynx was pioneered during this study (ESchwartz et al. 2002), as was the development of the snow-tracking protocol for the National Lynx Survey (Squires 2002).

We use methods similar to those used in Montana and Maine to obtain basic information that we can then compare directly to results from the Montana and Maine studies of lynx, although portions of our study differ because of differences in technology and management focus. Both Minnesota and Maine have southern boreal forest vegetation with many of the same tree species. Both areas are managed in part for timber harvest, although Maine forests are mainly privately owned, while most of Minnesota study area is public land. Conditions encountered by lynx in Maine probably provide the most direct comparison to conditions encountered by lynx in Minnesota.

A large part of the current project is based on VHF and GPS telemetry, which makes it possible to determine habitat use and requirements of Canada lynx. Telemetry work also provides basic ecological information on distribution, abundance, residency, movement patterns, reproduction, and survival of lynx. Telemetry locations are augmented by snow tracking to provide insights into characteristics of habitats that lynx are using for movement and foraging. Tissue, scat, and hair samples collected from captured lynx and while snow tracking will provide baseline data for the question of persistence of the Canada lynx population in Minnesota.

Capture, Handling, and Radiocollaring of Canada Lynx

Trapping Method*s*

The protocol that we employ draws from protocols that have been used to capture and process over 75 Canada lynx on the Maine and Montana lynx research projects (Squires and Laurion 2000, Vashon et al. 2002). We only used box traps to capture lynx in 2004. We have found it possible to capture lynx in both winter and summer in box traps. Traps were checked within 24 hours of being set. Records of trap setup and effort at each trap location were maintained.

Lynx were anaesthetized by injection with a pole-syringe while the animal was in the box trap. Drug dosage followed standard protocol (Kreeger et al. 2002), and allowed a 30-40 minute handling time. During processing, a hood or towel was placed over the head to protect the eyes. The rectal temperature of anesthetized lynx was periodically monitored throughout the handling process. We began monitoring pulse rate and respiration in fall 2004. Anesthetized lynx were kept warm in cold weather with heat reflective blankets, chemical hand warmers, and/or sleeping bags throughout handling. Antibiotics were injected intramuscularly prior to release.

Data collected on captured animals included sex, estimated age, body mass, and morphological measurements. Lynx were ear tagged (Standard Rototags, NASCO, Inc. catalog# C15920N) if they were too small to fit with radiocollars. A skin plug was collected from the ear if animals were ear-tagged. In 2004 the use of ear tags was discontinued except on animals with drop-off collars. Genetic material was collected from blood samples placed on Whatman filter cards, and a few hairs were collected as a reserve genetic material. The animal was fitted with either a VHF collar (Vashon et al. 2002) or a GPS radiotelemetry collar before release.

Non-target species were also trapped in 2004 (Table 1), although incidental catch was reduced compared to 2003 because we only used box traps Non-target species that were incidentally trapped in 2004 included fisher (*Martes pennanti*), marten (*Martes americana*), snowshoe hare (*Lepus americanus*), black bear (*Ursus americanus*) and domestic dog (*Canis familiaris*). Most of these species have also been incidentally trapped in the Maine project (Vashon et al. 2002). We also placed radiocollars on 2 bobcats (*Lynx rufus*) that were trapped.

Trap Locations and Captures

In this project we had at least 2,066 trap nights in 164 different days of trapping in 2004 (Table 2). Canada lynx were caught throughout the year. The trapping effort can be divided into three separate phases: (1) from January to April before kittens are born; (2) from July to November when there was no snow on the ground; and (3) December when there was snow on the ground. Snow is important because it allows us to search for tracks and set traps based on lynx locations.

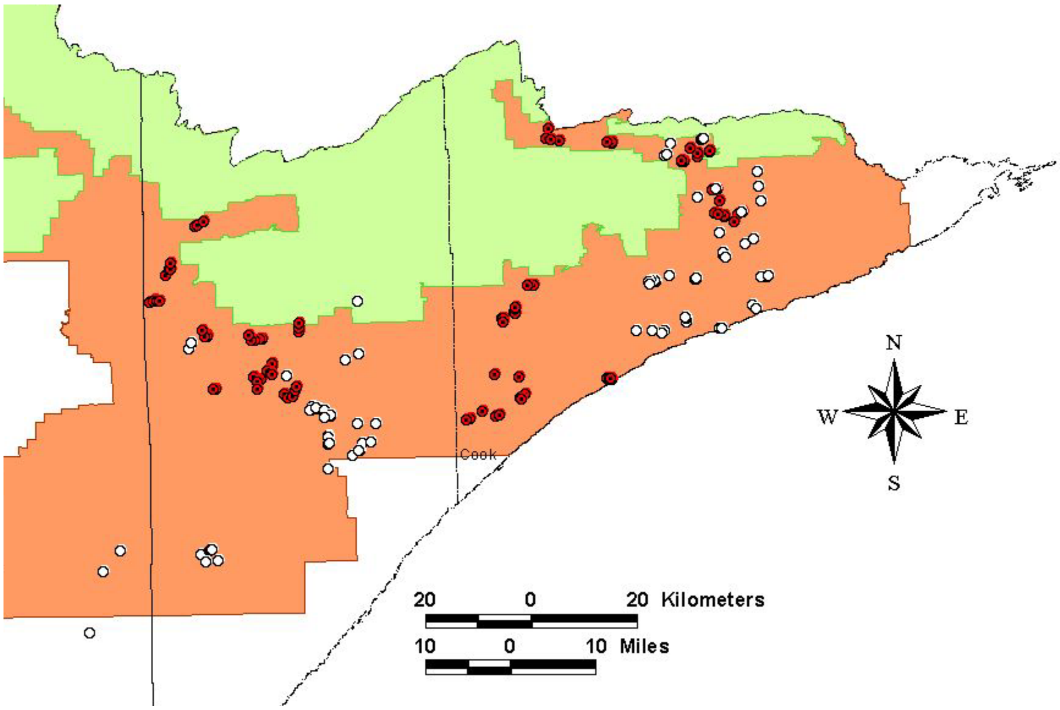
Table 1. Trapping effort in and near Superior National Forest in 2004 from January 1 to December 31, 2004. Effort is broken down into three periods based on the type of trapping and the basis for trap locations, with counts representing minimum numbers for days trapped and trap nights. Direct comparison to 2003 trapping effort is not valid because of different methods.

	January to April	July to November	December	Total
Days trapped	91	52	21	164
Trap nights	1,756	226	84	2,066
Traps / day	19	4	4	13
Lynx processed	12	7	2	21
Lynx released w/o processing	6	1	2	9
Other species	37	2	1	39
Lynx / 100 Trap nights	1.0	3.5	3.5	

The winter trapping season that begun in January 2004 continued until early April 2004 and 9 animals were radiocollared. Some animals were retrapped and their GPS collar was replaced, for a total of 12 captures (with processings during this time period). One other male lynx (L10) was snared by a trapper and became a study animal as well. Traps were placed in the general areas of Isabella, Ely, Tofte, and Grand Marais (Fig. 1). Trapping in the first winter period resulted in about 1 lynx capture per 98 trap nights including all recaptures, or 1 lynx capture per 146 trap nights if all recaptures that were released without processing are excluded.

Summer/fall trapping began in July 2004 when L13's collar dropped off earlier than expected. From July until November 2004, with no snow cover on the ground, we trapped 2 new animals and retrapped and replaced collars on 5 others (L2, L6, L7, L12, L13). Trapping effort was focused on the Isabella, Bassett, Babbit, and Brimson areas. Trapping in the snow-free period resulted in about 1 lynx capture per 28 trap nights including all recaptures, or 1 lynx capture per 32 trap nights if all recaptures that were released without processing are excluded.

Figure 1. Locations of Canada lynx traps in and near Superior National Forest in 2003 and 2004. Trap locations in 2003 are shown with a solid symbol, locations in 2004 are shown with a white symbol. Brown areas indicate Superior National Forest, and green areas are the Boundary Waters Canoe Area and Wilderness.



The last phase of trapping in 2004 began when snow was on the ground in December. In one month one new lynx was trapped, and we recaptured one additional animal. Trapping was focused on the Isabella, Ely, and Bassett areas in December. Traps were deployed where there was evidence of Canada lynx using an area from tracks in the snow, resulting in an increased efficiency compared to 2003. Trapping in December resulted in about 1 lynx capture per 29 trap nights including all recaptures, or 1 lynx capture per 57 trap nights if all recaptures that were released without processing are excluded.

There have been 9 male and 9 female Canada lynx fitted with radiotelemetry collars on the project through 2004. One male and 1 female bobcat have also been captured through 2004. Captures in 2004 were either new captures, recaptures to download GPS collar data, or recaptures to place GPS collars on animals that had previously worn a VHF collar (Table 2). Trapping effort may appear lower because of a reduction in trap nights compared to 2003 (Table 1), but the main reason for this is increased effort in the pre-trapping phase to increase efficiency.

Table 2. A brief description of each processing of Canada lynx in 2004. Each lynx is referred to in the report by the ID indicated here. Additional details on each animal, including those radiocollared in 2003, are on the project web site (www.nrri.umn.edu/lynx).

ID	Date	Sex	Description
L09	Jan 09	F	Captured near Devils Track Lake by Grand Marais, MN. This 14 pound female was fitted with a Telemetry Solutions GPS radiotelemetry collar and released.
L10	Jan 13	M	Caught in a trapper's snare in Normanna Township, about 15 miles north of Duluth, MN. This 23 pound male was held overnight at the Lake Superior Zoo and released the next day fitted with a Telemetry Solutions GPS radiotelemetry collar.
L02	Jan 26	M	Recaptured and his VHF collar replaced with a Telemetry Solutions collar.
L11	Feb 12	F	Captured northeast of Isabella, MN on February 12, 2004. This 17 pound female was fitted with a ATS VHF radiotelemetry collar and released.
L06	Feb 13	M	Recaptured and the data was downloaded from his Lotek GPS collar, and then he was released with a new Lotek GPS collar.
L02	Feb 14	M	Recaptured because technicians had identified a possible flaw in collar radio signal. The collar was removed and replaced with a Lotek GPS collar.
L12	Feb 24	M	Captured west of Isabella, MN around Birch Lake Reservoir. This 26 pound male was fitted with a Lotek GPS radiotelemetry collar and released.
L04	Mar 04	M	Recaptured and his VHF collar replaced with a Telemetry Solutions GPS collar
L07	Mar 23	F	Recaptured to download the GSP data in the collar and then released with a VHF collar
L13	Mar 25	F	Captured south of Brimson, MN. This 23 pound female was fitted with a GPS radiotelemetry collar and released.
L14	Mar 29	F	Captured near Isabella, MN. A 23 pound female, she was fitted with a GPS collar and released
L15	Mar 31	M	Captured near Grand Marais, MN. A 27 pound male, he was fitted with a VHF collar and released.
L02	Apr 06	M	Recaptured and data from his Lotek GPS collar was downloaded and the same collar was then placed on him.
L13	Jul 03	F	Recaptured because her Telemetry Solutions GPS collar had dropped off. She was fitted with a VHF collar and released.
L06	Aug 03	M	Recaptured and his Lotek GPS collar was replaced with a VHF collar.
L12	Sep 30	M	Recaptured and his Lotek GPS collar was replaced with a VHF collar.
L24	Oct 02	F	Captured south of Harris Lake, about 500 yards from where L12 was captured on September 30, 2004. L24, a 19 pound female, was fitted with a Lotek GPS radiotelemetry collar and released.
L02	Nov 25	M	Recaptured and data from his Lotek GPS collar was downloaded and a new GPS collar was placed on him.
L07	Nov 29	F	Recaptured and her VHF collar was replaced with a Lotek GPS collar
L16	Nov 29	F	A kitten of L07, was captured and outfitted with a kitten-size GPS collar.
L25	Dec 08	M	Captured near Bassett and outfitted with a VHF collar.
L14	Dec 09	F	Recaptured and her Lotek GPS collar was replaced with a VHF collar.
B01	Mar 26	F	Captured near Grand Marais, MN. A 13 pound female, she was fitted with a VHF collar and released. She was legally trapped in January 2005.
B02	Mar 29	M	Captured near Brimson, MN. A 14.5 pound male, he was fitted with a VHF collar and released.

Den Site Visits and Kittens

This was the first year of the project in which we were able to monitor females during the denning season. Only 2 males were collared in the spring of 2003, the first year of this project. Based on the experience on other lynx projects in Montana and Maine, a localization of positions would indicate that a female had denned. Parturition was expected in early May. The ideal time to visit a den is about 4-5 weeks after parturition if one wants to mark each kitten with an ear tag. We attempted to visit each den when kittens were about five weeks old, weigh kittens, take morphological measurements, obtain a blood sample, and ear tag each kitten for later identification. Three of the 4 females (L7, L13, and L14) that weighed more than 20 pounds on capture localized and produced kittens. The other female that weighed more than 20 pounds, and females that were lighter than 20 pounds on capture did not appear to localize, and thus we suspect did not have kittens.

L7's den was visited on June 8, 2004 (Fig. 2). We found 3 kittens in her den. Neither L13 or L14 had localized to the extent that L7 did in early May; thus we initially thought that either litters were unsuccessful or possibly that the females were going to give birth later in May. L13 had indications of localizing by mid-June, and we visited the den on June 23, 2004 and found 5 kittens. Finally, L14's den was located after two attempts in which she moved off of the den before we could find it. Kittens were not handled at L14's den, but we did have observation of at least 2 and possibly 3 kittens on July 3, 2004. Dens of each female were visited in late summer or early fall and vegetation measurements made.

After dens were visited we checked to determine if the female moved the kittens to a second den. L7 moved her kittens about 150 m to a second den shortly after the den visit. L13 did not move her kittens, nor did L14 appear to move, although kittens were not handled at that den. Sightings reports indicated that all 5 kittens of L13 survived into September 26, 2004, and that at least 3 of the 5 kittens were still with L13 in December, 2004 and February 2005. L7 was seen with 2 kittens on October 24 and November 12, 2004. One of the kittens was radiocollared on November 30, 2004 (Fig. 2), that same day a second kitten was photographed. Finally, L14 also appeared to be successful in bringing kittens through the summer, she was observed with 2 kittens on September 16, 2004. She also appeared to have kittens with her in December, 2004, although by February 2005 kittens were no longer traveling consistently with her and there had been no visual contact.

Figure 2. Images of kittens and den sites from the 2004 denning season. (a) L7 den site on June 7, 2004 (b) kittens of L13 on June 23, 2004, (c) den of L14 in October, 2004 and (d) ear tag of kitten of L7 on November 30, 2004. Additional images of the kittens and den sites are available on the project website (www.nrri.umn.edu/lynx).

Future Plans

The third winter trapping season is ongoing. Areas near Isabella, Brimson, Babbit, Bassett, and Ely, MN are currently being trapped, with plans to move into areas near Tofte and Grand Marais in the near future. We will try to keep the 6 Lotek GPS collars and 2 Telemetry Solutions GPS collars deployed this winter. Emphasis this winter will be on trapping kittens from last year, obtaining new animals, and retrapping previously collared animals for collar replacement. Dens will be visited in early June to document reproduction and obtain genetic samples from kittens.

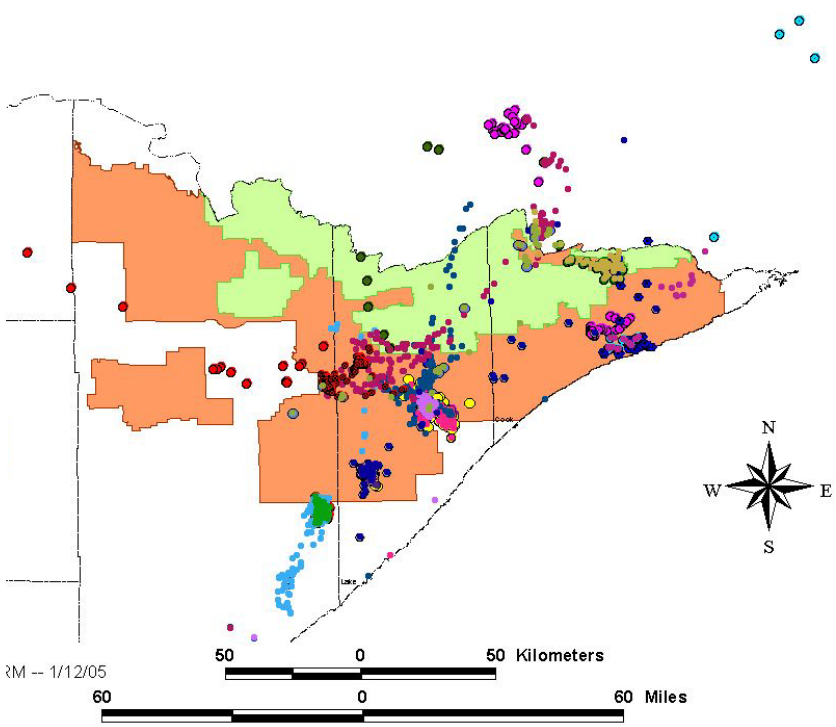
Location and Distribution

Telemetry locations were used to determine the location and distribution of Canada lynx wearing VHF telemetry collars and GPS collars. Locations of lynx were also obtained from snow-tracking and reports of sightings by USFS personnel and the general public and reported separately.

Radiotelemetry and GPS collar Locations

We used aerial telemetry and ground-based telemetry to obtain animal locations. Almost all of the aerial locations were obtained by Dr. Michael Nelson (USGS, wolf-deer project out of Ely). Locations were determined with a GPS unit on board the plane after the animal was located. Ground-based telemetry was done by project crew members. It was logistically very difficult to obtain locations simultaneously with two observers (Squires and Laurion 2000), but we did use as short an interval as possible between triangulation locations. Ground-based telemetry locations were calculated with LOAS v. 2.10 (Ecological Software Solutions, www.ecostats.com).

Figure 3. VHF and GPS telemetry locations of lynx captured in this study as of 12/31/04. Each animal is color coded with a different symbol. Many locations are on top of each other at this map scale. Brown areas indicate Superior National Forest, and the green area is the Boundary Waters Canoe Area and Wilderness.



Captured lynx were located from the northeastern tip of Minnesota west to Little Fork, MN (Fig. 3). The southernmost location is from an animal that was not in range of telemetry searches for over a month in the fall. We also do not know how far into Canada some of these animals may have gone because it is cost-prohibitive to fly into Canada regularly. Thus, the movements shown represent minimum distances over which radiocollared animals have ranged.

In the 2003 annual report we included pictures and maps of each lynx that had been captured (Moen et al. 2003). Because of the number of animals that have been captured, and because of the availability and high use of the website, we have not included the information on individual animals in this report. General locations of individual animals are available on the project website (www.nrri.umn.edu/lynx). More than half of the Canada lynx that have been collared have worn GPS collars for at least some of the time (Table 3).

Table 3. The number of telemetry locations and status of each Canada lynx or bobcat that has been radiocollared.

Animal	VHF	GPS	Status
Lynx			
L01	33		Dead, legally trapped in Ontario
L02	136	415	Wearing Lotek GPS collar
L03	13		Dead of unknown cause in Minnesota
L04	38	0	Telemetry Solutions collar dropped off and not recovered
L05	70		Wearing Lotek GPS collar
L06	59	591	Wearing ATS VHF collar
L07	68	281	Wearing Lotek GPS collar
L08	58		Wearing ATS VHF collar
L09	27	0	Telemetry Solutions collar dropped off and not recovered
L10	15	476	Telemetry Solutions collar dropped off, collar recovered, but animal not retrapped (possible that L25 is L10, genetic tests underway to confirm).
L11	39		Wearing ATS VHF collar
L12	19	312	Wearing ATS VHF collar
L13	32	152	Wearing ATS VHF collar
L14	45	398	Wearing Lotek GPS collar
L15	24		Wearing ATS VHF collar
L16	11		Wearing ATS VHF collar
L24	7	260	Dead, about January 30, 2005. Cause of death possibly due to predation by fisher. Was wearing Lotek GPS collar
L25	9		Wearing ATS VHF collar
Bobcats			
B01	30		Dead, harvested in January 2005 in Minnesota by trapper.
B02	22		Wearing ATS VHF collar

Male and Female Home Range Sizes

Male lynx tend to range more widely than female (Fig. 4 and 5). Females with kittens tended to have an even smaller area of use (Fig. 4). The home ranges of adult females with kittens tended to be smallest, while males had the largest home ranges (Table 4). One female (L11) was an exception, she had a small number of locations in two widely separated areas and was also located during transition between the two areas (need to include the area units in the table and here in the text).

Figure 4. Locations of 4 female lynx (each female coded with a different symbol color). Females with green, pink, and blue symbols all had kittens in the summer of 2004, although locations are from 1.5 to 6 months prior to parturition. The female indicated by a red symbol may not have had kittens this year, her body mass at capture was < 20 pounds.

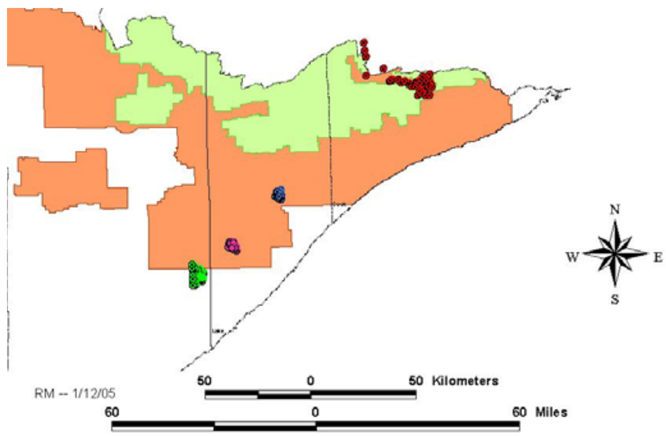


Figure 5. Locations of 5 male lynx (each animal coded with a different symbol color). All of these males had at least 1 longer-distance movement. The duration of the movement varied from a week to several months.

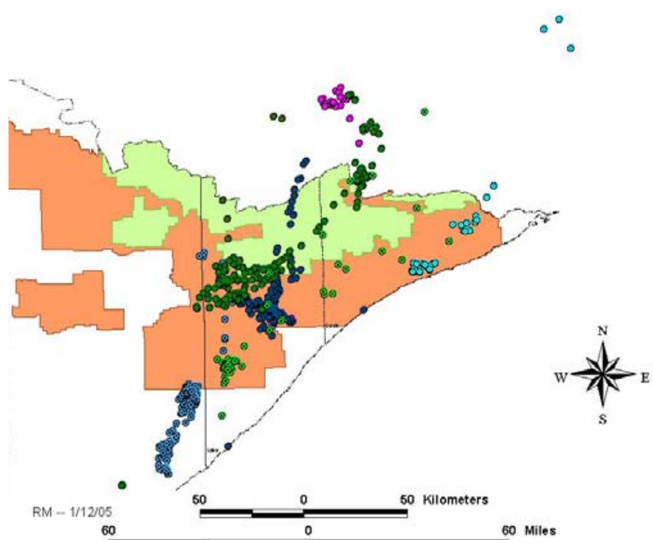


Table 4. The size of home ranges for radiocollared lynx. Home range sizes were calculated with Home Range Extension for ArcView (Rodgers and Carr 2001). Areas shown are 50% and 95% kernel home ranges for animals using either VHF or GPS. Home range in this table is based on at least 15 locations. Home range sizes are a minimum size, in some cases based on periods of less than one year. Calculations are preliminary and should not be cited without permission.

		50% GPS	95% GPS	50% VHF	95% VHF
L07	Female	5	28	1	11
L08	Female			44	283
L13	Female	1	19	1	6
L14	Female	9	35	2	21
L24	Female			76	489
L02	Male	23	144	11	126
L05	Male			360	1,489
L06	Male	86	343	11	76
L10	Male	50	295	43	208
L12	Male	504	3,067		

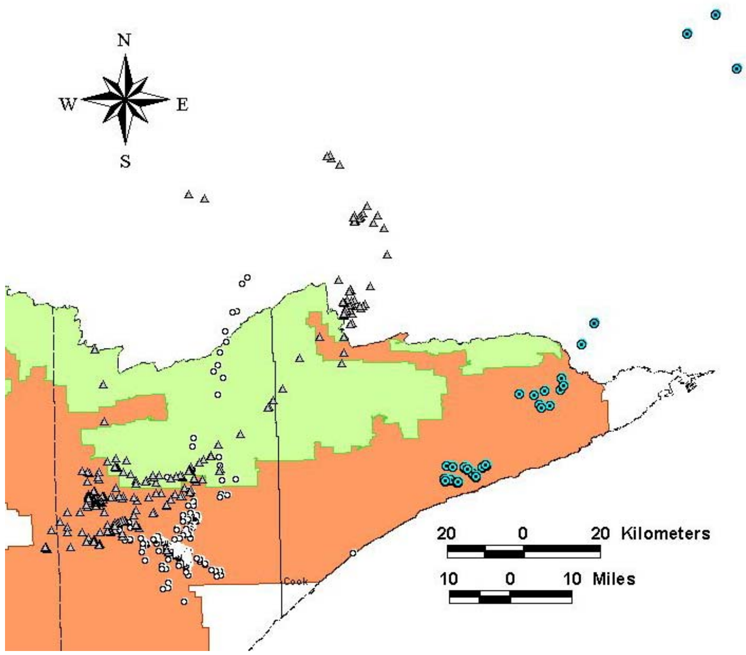
Long Movements By Males

Adult males tended to make long-distance movement on the order of 40 to 80 km (Fig. 6). Movements could be for a longer duration (e.g., months in the case of L12 and L15), or much shorter (e.g., days in the case of L06). All but one of the males has been located in Ontario at least once.

Future Plans

We will continue with deployment of collars, but can also begin analysis of home ranges. With relocations of the animals that are currently collared and new animals that will be collared through the rest of the winter it will be possible to make biologically-based management recommendations in the near future. We will also be changing the duty cycle of these collars to increase collar life.

Figure 6. Long movements of adult male lynx. The map shows movements by L12 (Hollow triangle) and L15 (Solid circle with dot) over about three months, and a 150 km movement by L6 (Hollow circle) over six days that was recorded on his GPS collar.



Habitat Use

We now have almost 3,000 GPS telemetry locations and about 700 VHF telemetry locations from which to infer habitat use. Estimating habitat use will be a two-stage procedure in which we will first calculate home range sizes and areas to indicate where 95% of locations were obtained, and then the concentration or core area from which 50% of locations were obtained (Fig. 7, 8). The second step will be to compare composition of each of these different locations, and compare habitat composition in the areas adjacent to areas where locations were obtained for each lynx. For example, in the winter L7 appeared to spend more time in the aspen-birch cover type than in what was identified as brush in 1995 satellite imagery (Table 5).

Figure 7. Fifty percent and 95% kernel home ranges for radiocollared Canada lynx. Note differences in size, with smallest home ranges being used by females with kittens. Larger home ranges are used by females without kittens or smaller males.

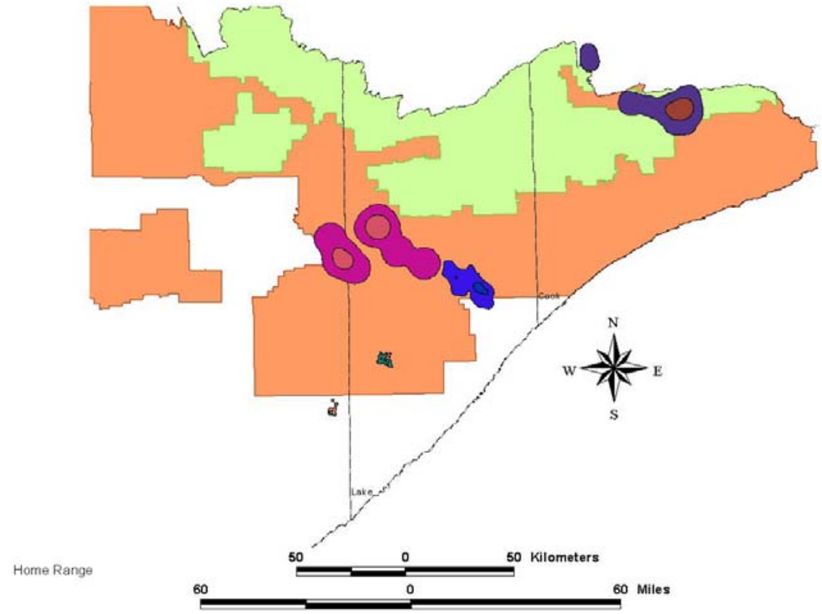


Figure 8. Fifty percent and 95% kernel home ranges for larger male radiocollared Canada lynx. Note differences in size compared to females and smaller males (Fig. 8).

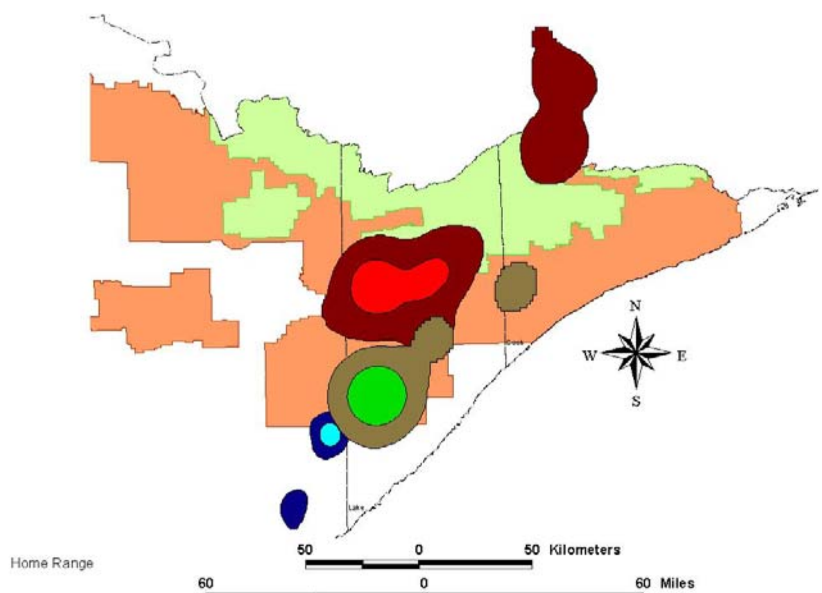


Table 5. Proportional utilization of different cover types by Canada lynx L07 from December 2003 to March 2004. The satellite imagery and cover type definitions are from 1995 (Wolter et al. 1995, Wolter and White 2002) and the animal locations were taken with a Lotek GPS collar. We will also be comparing proportions of cover types in adjacent areas that L07 did not use, in this case it appears that the aspen-birch cover type is utilized out of proportion to its availability.

Cover type	50% GPS	95% GPS
Acid bog	7	6
Aspen-birch	55	40
Brush	11	18
Conifer	19	21
Grass / Bare	1	6
Hardwood	5	4

Future Plans

Recovery of GPS collars will provide excellent resolution on habitat use on a fine temporal and spatial scale, with three or four locations being obtained per day from each collared animal throughout the year. This will enable us to provide initial habitat models incorporating features such as GIS based landscape-scale features, vegetation measures, prey abundance, carnivores, and human disturbances such as road and trail density based on lynx locations and habitat characteristics collected while snow tracking. Chris Burdett will be developing dissertation papers and developing models of resource utilization functions that address habitat use in a predictive manner.

Abundance

At this point we are still able to consider abundance from the perspective of the minimum number of individuals that have been identified. Since 2002, over 50 individual lynx have been identified in Minnesota from DNA analysis. This is not all of the Canada lynx in Minnesota, however. There are some animals that we attempted to radiocollar but to date have failed to trap. There are also other lynx that we have heard about which are likely not our collared animals, either because pictures were taken of the animal, or reports from individuals that saw the animal. There are still other animals that go unreported until we make personal contact in local areas. For example, on a recent visit to the Sawbill trail to check traps, we were told that there were at least 2 Canada lynx present in the area over the past summer near the residence—we knew nothing about these animals until that day. As another example, a Canada lynx was seen at a lodge on the Gunflint trail several times throughout the summer of 2004. We only heard about these sightings in October 2004 when the lodge owner contacted us to ask whether Canada lynx have ever attacked humans.

Pilot Camera Survey

We tested automatic remote cameras to detect the presence of lynx, with the ultimate goal of using these cameras in a mark-recapture methodology to estimate population size of lynx. Remote camera systems can detect the presence of free-ranging wildlife automatically. The test was conducted near Isabella in the Superior National Forest in winter 2004. The Isabella area was selected because the National Lynx Detection Survey protocol (McDaniel et al. 2000). had been conducted here in 2002, 2003, and again in 2004. In addition, snow tracking surveys were conducted in the same area in both 2003 and 2004. Thus, it was possible to directly compare the ability of each technique to detect the presence of Canada lynx and other carnivores in the Isabella area. Remote 35mm camera systems were placed to survey six sampling units. Six systems were set up along plowed forest roads for 65 days. Another six systems were set up along a designated snowmobile trail for 31 days. Seventeen rolls of film were developed (not all rolls were fully exposed) resulting in 33 images of animals. These included fisher (*Martes pennanti*), marten (*M. americana*), white-tailed deer (*Odocoileus virginianus*) snowshoe hare (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), and a turkey vulture (*Cathartes aura*). Detections were made at 8 of the 12 camera stations, in five of the six sampling units. Canada lynx were not detected with the system that was used in this test. It is possible that other conditions, such as using a different attractant, or increased sampling effort, could have resulted in images of Canada lynx being obtained.

Future Plans

We will continue scat collection and trapping program to document the presence of individuals in the population. In addition, we will maintain the sightings hotline and follow up on leads. We will continue testing the use of cameras to help determine abundance of lynx.

Persistence

Persistence in the context of this project is the ability of the Canada lynx population present in Minnesota to persist through a complete lynx-hare cycle. Data collected in the first few years of this project will help determine whether the population does persist at low densities during the low in the lynx-hare cycle. Demographic data from collared animals will allow us to predict survival and fecundity of the Canada lynx population and build initial population models. Continuous observations of lynx would support the concept of persistence, but only the genetic data will make it possible to confirm persistence of Canada lynx in the Great Lakes region.

The question of persistence is important because it is unknown whether lynx remain at low population densities during lows in the lynx-hare cycle. It is possible that lynx are sometimes extirpated from Minnesota during the lows in the lynx-hare cycle and then recolonize from Canada. Even 25 years ago the appearance of lynx in Minnesota during highs in the lynx-hare cycle was hypothesized to result from dispersal of lynx native to Canada (Mech 1973). Genetic evidence suggests that at least some of this dispersal results in gene flow between widely separated lynx populations (Schwartz et al. 2002). The dispersal hypothesis does not require that lynx be extirpated from Minnesota during lows in the lynx-hare cycle.

Persistence of the lynx population can be determined over a multi-year period. However, we should be able to use information from genetic analysis of hair, scat, blood, and tissue samples and survival of collared individuals to provide an initial estimate of persistence. An existing collection of genetic samples collected under the auspices of Superior National Forest can be used as a starting point (Loch and Lindquist, unpubl. manuscript). NRRI project personnel will ship over 20 Canada lynx tissue, scat and hair samples collected in 2004 for analysis, and other scat, hair, and tissue samples will be sent to the Carnivore Genetics Laboratory by SNF personnel. In the short-term, at least, there appears to be the potential for persistence. Reproduction has been documented in this population, and through 2004 there had been no natural mortality of lynx documented. Mortality that did occur appeared to be caused by humans in all cases.

Future Plans

We will continue to collect scat, hair, and tissue samples for genetic analysis. By the end of this year we should have enough genetic samples analyzed when the historic data samples are included so that we can at the very least develop a genetic picture of the existing Canada lynx population in the SNF, including parent-offspring relationships.

Website, Public Involvement, and Canada Lynx Sightings

The lynx project website at www.nrri.umn.edu/lynx, continues to generate positive support for the project, and serve as a conduit of information for interested professionals and the general public. It is one of the most visited websites on the NRRI server, receiving over 1,000 page requests per day in 2004. Lynx sightings are still being reported to the NRRI toll-free "hotline" (800-234-0054) or to an email address established because it would be easy for members of the public to remember (lynx@nrri.umn.edu). Some of the sightings included pictures that have been included on the project website (www.nrri.umn.edu/lynx).

The SNF and NRRI continued to jointly issue press releases on the lynx project in 2004. In addition, several other sightings of Canada lynx were reported by USFS personnel—in some cases USFS personnel had seen the animal themselves, in other cases the sighting had been reported by the public. Some of the sightings reports were used as locations to set up scent stations and traps for Canada lynx, and three of the sightings ultimately resulted in the capture and radiocollaring of a study animal. Sightings that have been reported to NRRI address will be forwarded to the Minnesota D.N.R. sightings database (link on www.nrri.umn.edu/lynx).

One new feature of the Lynx project website is that we tried an experiment on using it as a fund-raising mechanism. At the end of the 2004 an anonymous donor made $1,000 available if we could match the $1,000 with contributions from others. We added a live link to the home page and in only 8 days were able to meet the match. We have kept the fund-raising link active on the web page.

Future Plans

We will continue to receive lynx sightings at the lynx "hotline" and on the lynx email address. These sightings will be used to continue building the Canada lynx sightings database, and may also be used to help determine where and when to put trapping effort.

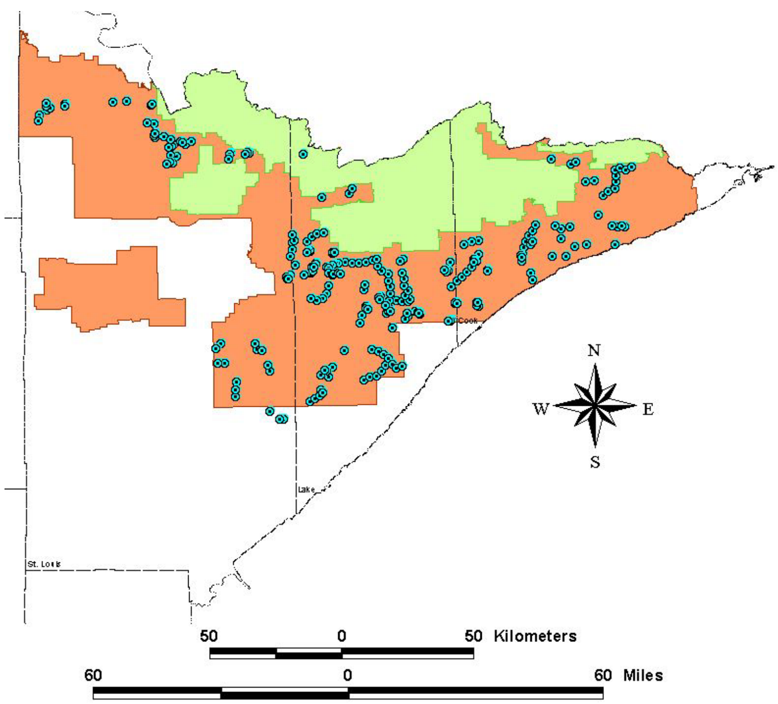
Prey Species Surveys

The primary prey of Canada lynx in this geographic region is snowshoe hare (Aubry et al. 2000). Nick McCann, a MS student at the University of Minnesota Duluth will be calibrating pellet counts with actual snowshoe hare density for his project. Grouse, other small mammals and carrion seem to be less important components of the lynx diet (Aubry et al. 2000), although while snow tracking project personnel have found at least one kill of ruffed grouse (*Bonasa umbellus*). We continue to conduct surveys for snowshoe hare to develop an index for estimating prey availability. Data collected on prey species abundance will be analyzed independently of lynx data, and will also be a part of Canada lynx habitat analyses.

Hare Pellet Survey

Hare fecal pellet transects consist of five 1 m^2 circular plots placed at 20 m intervals (McKelvey et al. 2002, Murray et al. 2002). Plots were permanently marked with a reinforcing bar (rebar) stake at 3/8" diameter and revisited each May-June for the duration of the project. All fecal pellets within the plot boundary were counted and removed. 50% of the pellets found directly on the plot boundary were counted (McKelvey et al. 2002). Vegetation obscuring pellets was moved but pellets deeply incorporated into the organic layer of the forest floor were not counted.

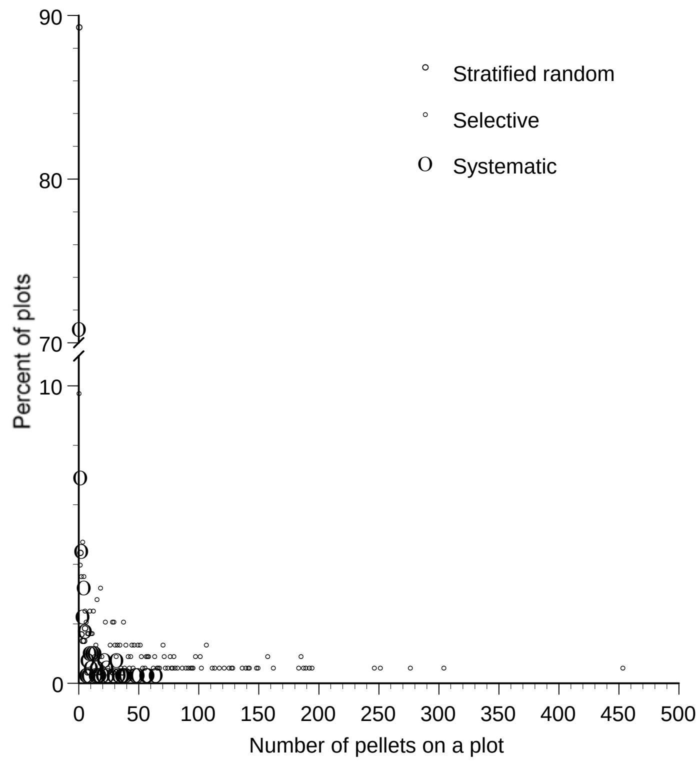
Figure 9. Hare pellet survey plots established in the SNF on existing plots that are surveyed every spring. Brown areas indicate Superior National Forest, and green area is the Boundary Waters Canoe Area Wilderness.



Snowhoe hare pellet plots were placed throughout the SNF. Over 180 permanent transects were established in the spring of 2003 following the methods described above. An additional 54 transects were established in the spring of 2004. Hare pellet plots were randomly placed in habitats according to availability as part of an existing plot network (Hanowski and Niemi 1995), systematically placed in known lynx home ranges, or selectively placed in habitats with a high snowshoe hare density. This plot placement provided a broad overview of hare density in SNF, a basis for comparison to hare density in areas where Canada lynx had an established home range, and also a basis for comparison in an area that had high hare density based on human observations.

Hare presence is patchy in SNF when considered on the random availability of habitats. About 90% of hare survey pellet plots did not have hare pellets (Fig. 10). While negative information, this is useful because it suggests there are cover types that are not likely to be used by Canada lynx, and also because it identifies cover types where Canada lynx are more likely to be present based on prey density. The hare pellet survey results were of increased value in the second year of the surveys because we will not have the bias inherent in the presence of multiple years of pellets. Hare pellet plots are cleared every year that they are run (McKelvey et al. 2002).

Figure 10. Hare pellet survey results from random, systematic, and stratified plot placement. Key points in interpretation of this figure are that the points in the upper left represent plots that did not have hare pellets. These plots were selected according to habitat availability, and would not be the focus of continuing hare survey work in future years. The points in the lower right represent the cover types in which hare density is high, and which will be identified on GIS and remote-sensing data layers and searched for in other areas of SNF.



Snowshoe hare pellet density can also be examined based on cover type and stand age. The highest hare pellet counts were found in cover types that were defined as red pine pole and saw timber, jack pine saw timber, and upland black spruce regeneration (Table 6). The pellet plots will be repeated this spring, and we will determine whether hare densities are consistently highest in these cover types. Pellet counts were highest in younger red pine and black spruce stands in both years, and there were a few unexplained shifts that we will be monitoring in 2005. For example, the Aspen-

White spruce and Jack Pine cover types had higher numbers of pellets in 2003, and then no pellets in 2004.

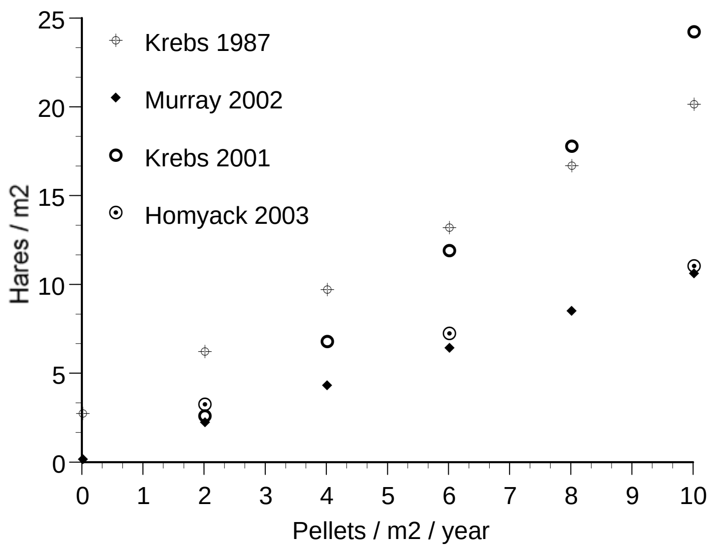
Table 6. Snowshoe hare pellet densities per plot index. The number of plots and density of snowshoe hare pellets in each of the cover types in the randomly-located plots that were stratified on the basis of habitat availability. The top 25% of pellet counts are indicated by bolded text.

Cover type	Stand Age	n	2003 Pellets / m^2	2004 Pellets / m^2
Aspen/white spruce	pole	5	**1.00**	0.00
Bigtooth aspen	saw	5	0.00	0.00
Black spruce	pole	20	0.10	0.00
	saw	5	0.00	0.00
Cedar	pole	5	0.00	0.00
	saw	20	0.70	0.00
Fir/aspen/PB	regeneration	20	0.45	0.05
	pole	45	0.33	0.08
	saw	30	**1.13**	**0.50**
Jack pine	regeneration	30	**0.63**	**0.42**
	pole	20	0.30	0.15
	saw	10	**3.40**	0.00
Maple/beech	saw	5	0.00	
Mixed swamp conifer	pole	15	0.00	0.29
	saw	10	0.00	0.00
Open		5	0.00	0.00
Paper birch	pole	25	0.20	0.04
	saw	5	**0.20**	**1.00**
Quaking aspen	regeneration	85	**0.98**	**0.84**
	pole	30	0.07	0.07
	saw	45	0.49	0.00
Red pine	regeneration	9	**0.78**	**0.63**
	pole	5	**6.00**	**6.00**
	saw	35	**2.80**	**0.43**
Sugar maple	pole	10	0.00	0.00
	saw	5	0.00	0.00
Upland black spruce	regeneration	5	**7.40**	**9.80**
	pole	5	0.00	**0.40**
White pine	pole	10	0.80	**1.10**

Relationship Between Pellet Density and Snowshoe Hare Population Density

Correlations between snowshoe hare fecal pellet density and estimated hare density have been demonstrated in the Yukon (Krebs et al. 1987, Krebs et al. 2001), Idaho (Murray et al. 2002), and Maine (Litvaitis et al. 1985). Although Krebs et al. (2001) admonish land-managers against assuming that this relationship is consistent among different regions, and published studies may support this (Fig. 12), there is a reasonable expectation that such a relationship exists in northern Minnesota. To identify any such relationship, we cleared pellets from plots at 10 sites in October and November of 2004 and will conduct a mark-recapture effort in March and April of 2005. Sites that were selected fell within or near known Canada lynx use-areas that were identified by radio-locations from collared lynx.

Figure 10. Relationship between pellet density and snowshoe hare population density in published literature. Ongoing work will determine where the SNF snowshoe hare population regression line would fit.



Snow Tracking

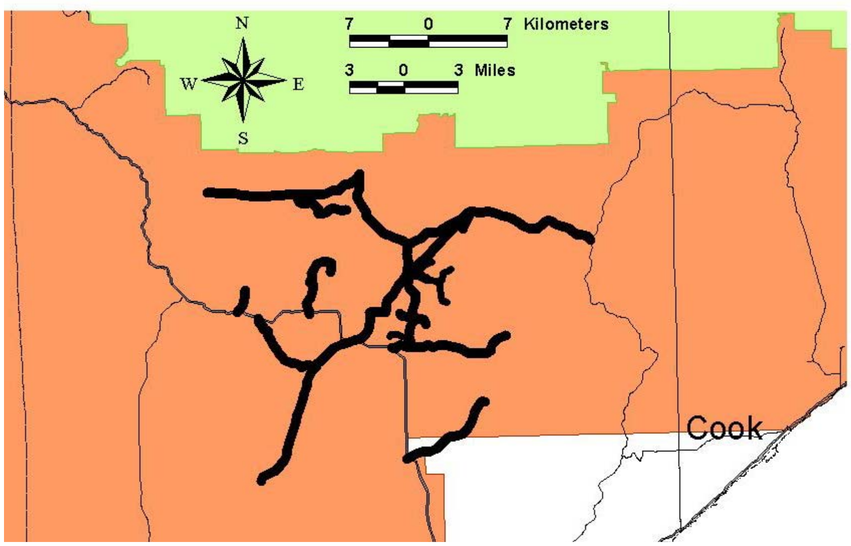
Snow Track Surveys

Snow track surveys are being completed in the Isabella area where 4 Canada lynx are radiocollared to index relative density of carnivores and prey. Track surveys were conducted with a modification of the track survey protocol being used in Montana (Squires 2002). The track survey is done by either snowmobile or vehicle on plowed roads within a couple days of fresh snowfall when tracks are visible and distinct. In 2004 122 km of vehicle (46 km) and snowmobile (76 km) routes were surveyed at a vehicle speed of < 20 km/hr from March 9 to March 30. UTM coordinates of all tracks were recorded with a handheld GPS unit. The most common carnivore track encountered was marten (*Martes america*), with lynx tracks also being found on the survey routes (Table 7). Tracks of both snowshoe hare and red squirrel were far more abundant than tracks of any carnivore (Table 7). Survey routes may need to be modified each year due to timber harvest operations. Changes in how roads are plowed may also determine whether surveys are done by vehicle or by snowmobile. The complete snow tracking report will be available on the project website.

Table 7. Track counts along 122 km of snow track surveys. The track counts were made either from snowmobile or from a vehicle.

Mesocarnivores	Track Count	Tracks / km
Marten	114	0.93
Red fox/Coyote	56	0.46
Fisher	41	0.34
Weasel	11	0.09
Wolf	12	0.10
Lynx	6	0.05
Otter	2	0.02
Mustelid spp.	1	0.01
Prey species		
Snowshoe hare	671	5.50
Red squirrel	669	5.48
Grouse spp.	3	0.02

Figure 11. Snow track survey routes followed from March 9 to March 30 in 2004. Snow track surveys were centered on Isabella, Minnesota.



Snow Tracking Individual Animals

GPS telemetry locations and VHF telemetry locations are typically made at intervals of hours to days. These point locations indicate where an animal was, but provide no information on the path it took to get from one location to another. Even within a six hour interval there may be multiple beds, resting, walking, and hunting behaviors. Movements related to hunting behavior are of particular importance because Canada lynx obtain most of their food by hunting. Habitat specific movement patterns would not be identified with GPS or VHF telemetry locations, but may indicate the selection of cover types for hunting or bedding, as well as how Canada lynx respond to apparent changes in prey density. Therefore, it is critical to obtain some measure of lynx response to prey availability in relation to habitat type. Following Canada lynx trails in the snow provides a movement path. Prey density can be indexed by recording every path that crosses a lynx trail. These two data sets provide a means to monitor lynx response to changing prey densities in relation to cover type, because lynx trail, prey tracks, and cover type are spatially related. We will test whether there are differences in cover type and prey density by comparing actual lynx trails to random movement paths generated from previously collected lynx trails. Snow tracking in 2004 provided the basis for the development of this protocol (Table 8), in which we obtained track logs, including kill sites, for several lynx.

Table 8. Summary of individual movement paths followed in winter 2004. These tracks were followed within days of fresh snowfall and GPS track logs were obtained to show the cover types each lynx was moving through.

Lynx	Distance (km)b	Kills	Kills/km
L02	6.6	1	0.15
L04	1.1	0	0.00
L05	2.5	2	0.80
L06	1.9	1	0.53
L07	4.3	3	0.70
L08	0.7	0	0.00
L09	3.9	1	0.26
L10	2.3	1	0.43
L11	0.2	0	0.00
Unk.	X	3	X
Total	23.5	12	0.38

We will continue backtracking Canada lynx in the 2004 winter. The backtracking is following a specific protocol that will allow identification of hunting sites, bed sites, and other aspects of Canada lynx behavior. We will also be repeating a modified version of the snow tracking protocol (Squires 2002) in the Isabella area this year. The snow tracking protocol will be augmented with a test of a remote camera survey in the same area that we have radiocollared Canada lynx, and in which we are conducting the snow tracking survey. The remote camera survey, in combination with genetic analyses, may make it possible to provide independent estimates of Canada lynx densities in this area.

In addition, this would be a protocol that could be applied to other parts of the SNF, and other geographic areas as well.

Projects and Cooperative Studies

In addition to informal cooperation with other lynx projects, we have begun more formal collaboration with three other collaborators. Dr. Pat Zollner, with the North Central Research Station at Rhinelander, Wisconsin, is working on very fine-scale movement patterns of the GPS collared animals. Kerry Fanson, a Ph.D. student out of Purdue University, is studying the utility of fecal hormone analysis. We also tested the activity counters in the Lotek GPS collars on captive lynx at the Wildlife Science Center in Forest Lake, Minnesota (www.wildlifesciencecenter.org).

Acknowledgements

We would also like to thank the many individuals who have reported sightings or helped the project in other ways. In addition, some individuals have contributed greatly to this research project. Project management assistance was provided by Ed Lindquist and Steve Mighton with the Forest Service. Dr. Michael Nelson, of the USGS BRD, has obtained almost all of the aerial locations while locating moose, deer, and wolves for other studies. Dr. Pat Zollner with North Central Research Station of the U.S. Forest Service helped by providing GPS collars. David Danielsen has done much of the GIS analyses for the project. Steve Loch worked for the project as a temporary employee, and also put in many hours as a Forest Service volunteer. Hard work by students, interns, volunteers, and technicians have helped bring this project to its current level.

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Appendix 1. Deliverables Listing

The funding agreement between FWS Coop Unit and NRRI required an annual report in which progress made on identified topics was reviewed. Progress made is in this annual report. Other deliverables were met by actions during the first year of the project but are not listed here. For example, the purchase of a freezer in 2003 and the use of project personnel and NRRI facilities for use as a temporary storage facility for lynx carcasses and/or body parts was called for in the agreement between the Fish and Wildlife Service and the University.

A second funding agreement between the USFS and NRRI required an annual report in which progress made on identified topics was reviewed. There was some overlap between the deliverables for Agreement 1 and Agreement 2.

1.1	Location and distribution	Reviewed in annual report in the Radiocollaring section (p. 4) and also in the Location and Distribution section (p. 10). Portions also covered in the Lynx Sightings section (p. 18).
1.2	Persistence	Reviewed in annual report in the Persistence section (p. 17).
1.3	Habitat use	Reviewed in annual report in the Habitat Use section (p. 14).
1.4	Prey species surveys	Reviewed in annual report in the Prey Species Surveys section (p. 19).
2.1	Capture and radiocollaring of lynx	Reviewed in annual report in the Capture and Radiocollaring of lynx section (p. 4).
2.2 2.3	Locations and suitable lynx habitat Development of lynx sampling framework	Reviewed in annual report in the Location and Distribution section (p. 10). Portions also covered in the Lynx Sightings section (p. 18) and the Snow Tracking section (p. 23).