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Distribution of Canada Lynx in Yellowstone National Park

Abstract

Little is known about Canada lynx in Yellowstone National Park, except that the species was present at the park's inception in 1872 and may have persisted to the present. The lack of basic information in the park and this species' listing as threatened in the contiguous U.S. by the Fish and Wildlife Service prompted our 2001–2004 survey of lynx presence and distribution. We traversed track detection transects during winter and used hair snares in summer to detect lynx in select habitats. Using DNA extracted from hair or fecal samples, we confirmed the presence of a female (unknown age), an adult female with a male kitten, and an adult male, each detected in a different year in the eastern portion of the park. Eight other unconfirmed lynx snow trails were also identified, including three from the central portion. Cumulatively, our detections represented at least three individuals, including two kittens born in different years. A male we identified in 2004 was detected 76 km south the following year in the Bridger-Teton National Forest, demonstrating that significant movement of lynx occurs within the Yellowstone Ecosystem. Reproduction that we and others documented, in addition to immigrants from peripheral populations, may contribute to lynx presence in the ecosystem.

Introduction

Little is known about the historic abundance and distribution of Canada lynx (*Lynx canadensis*) in Yellowstone National Park. The species was present during the late 1800s and early 1900s, but crude estimates of abundance varied, ranging from "limited" in number to "quite common" (Grinnell 1876, Blackburn 1879, Hofer 1887, Seton 1898, Skinner 1927, Bailey 1930). Lynx evidently persisted to the late 1900s: we found 34 references to lynx (tracks or direct observations) in archived ranger log books dated 1895–1926, including notes of six individuals killed in the park, and 73 sightings by park visitors or employees, 1887–2003 (Yellowstone National Park files). However, the reliability of these data is uncertain due to inaccurate field identification and inconsistent record keeping (Consolo-Murphy and Meager 1995). Bobcats (*Lynx rufus*) occur in the park and may be mistaken for lynx.

Detection surveys for rare carnivores occurred in the northern portion of the park from 1992 to 1998, but no lynx were detected (Gehman and Robinson 1997, 1998). The absence of a park-wide survey and the listing of this species as threatened in the contiguous U.S. underscored the need for baseline data (U.S. Fish and Wildlife Service 2000). Surveys refine knowledge of lynx distribution and help managers avoid or minimize adverse anthropogenic effects on the species (Ruediger et al. 2000). We documented lynx presence and distribution in the park from 2001–2004 by recovering hair and feces along snow trails in winter and by using hair snares in summer.

Study Area

Our survey occurred in select habitats that ranged from 2,100–3,110 m in elevation, within the 899,000-ha Yellowstone National Park located in northwestern Wyoming and adjacent portions of Idaho and Montana. The park is drained by the upper Yellowstone, Gallatin, Madison, Falls, Bechler, Snake, and North Fork Shoshone Rivers;

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and encompasses four mountain ranges and several wide plateaus. The climate is continental and characterized by long, cold winters and short, cool summers (Houston 1982). Mean monthly temperatures at Lake Yellowstone range from -12°C to 13°C, and average 1°C (Despain 1990). Total precipitation measured at sites representative of our surveys ranges from 52 cm at Lake Yellowstone to 81 cm at Snake River, with nearly 50% received as snowfall (Despain 1990; Western Regional Climate Center 2006). Approximately 79% of the park is forested and dominated by seral lodgepole pine (*Pinus contorta*) (Despain 1990). Other forest dominants include Engelmann spruce (*Picea engelmanni*), subalpine fir (*Abies lasiocarpa*), and Douglas-fir (*Pseudotsuga menziesii*). Non-forested areas include grassland and sagebrush steppe, wet meadows, alpine tundra, rock escarpments, and talus.

Methods

We focused our detection effort in habitats known to support lynx and their major prey, snowshoe hares (*Lepus americanus*), identified from pre-existing cover types mapped in the park and literature accounts (Despain 1990, Koehler and Brittell 1990, Mowat et al. 2000, Figure 1). We considered prime habitats to include conifer and deciduous forests with closed canopies, typically 40–300 yr of age, that were dominated by lodgepole

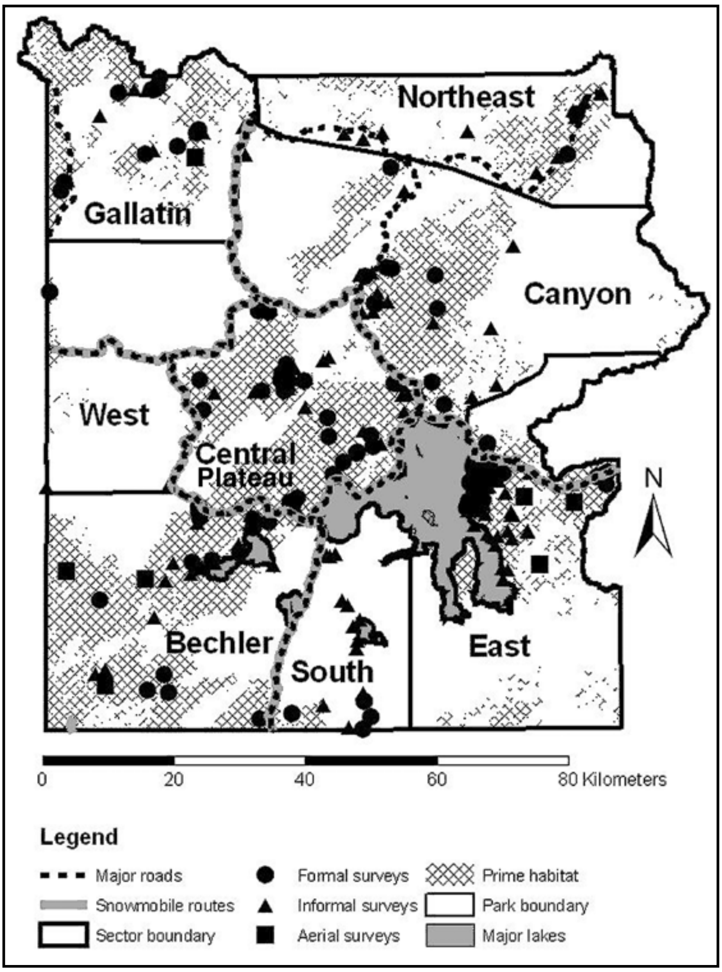

Figure 1. Prime habitat, sectors, and locations (transect midpoints) for Canada lynx detection surveys, Yellowstone National Park, Wyoming, 2001–2004. Some points and lines represent >1 survey in the same location.

pine, Engelmann spruce, subalpine fir, or aspen (*Populus tremuloides*) (Dolbeer and Clark 1975, Koehler et al. 1979, Wolfe et al. 1982, Koehler 1990, Malloy 2000). We did not survey early-successional (<20 yr of age) conifer forests, talus fields, open water, krummholtz, or grasslands, as these environments provided little cover above average winter snow-pack (approximately 90 cm) (Koehler et al. 1979, Wolfe et al. 1982, Mowat et al. 2000). We also did not survey the park's 1,000-km^2 northern winter range, where searches for cougar tracks, 1988 to 2004, revealed no lynx and obviated the need for additional surveys (Murphy 1998, Ruth et al. 2003). To evaluate the equitability of survey effort across the park, and to evaluate relationships between relative prey abundance and lynx detections, we identified geographic sectors of the park (Bechler, Canyon, Central Plateau, East, Gallatin, Northeast, South, West) based on elevation, soil type, and vegetation described by Despain (1990) (Figure 1).

During winter, we searched for lynx tracks along transect lines, traveling on skis in the back-country, on snowmobiles along park roads, in light airplanes, or in helicopters (Figure 1). For ski-based surveys, we subjectively chose starting points and transect routes through prime habitats based on their proximity to existing snowmobile or hiking trails, absence of topographic limitations such as escarpments, and the absence of avalanche hazards. We did not apportion transects equally across prime habitats because access to remote areas was limited by difficult, extended travel through deep (>1 m), un-crusted snow. We attempted to re-survey each route annually, but decreased effort where tracks of snowshoe hares were scant. Similarly, distances traveled per day varied, but increased during late winter when snow was crusted. In 2004, we limited survey effort mostly to the East sector to better assess lynx numbers.

Surveys were classed as "formal" or "informal." Formal surveys were conducted ≥12 hr post snowfall, to allow time for tracks to accumulate. Records included rare carnivore locations (Universal Transverse Mercator locations), counts of snowshoe hare and red squirrel (alternate prey *Tamiasciurus hudsonicus*; Staples 1995, Apps 2000) tracks, cover types, and snow-tracking conditions. Counts only included tracks ≤24 hr old. We did not calculate tracks (all ages) per km-day, across several prior days, because the timing of snowfalls was often difficult to estimate. Formal track data for each transect were used to index the relative winter abundance of snowshoe hares and red squirrels for each sector. Informal surveys were conducted immediately after or during a snowfall when the 12-hr rule precluded a formal survey, or when we prioritized survey distance over collection of detailed information. Informal data were principally survey length and path, and records of rare carnivore detections. Snowmobile-based surveys occurred only on major park roads, except those plowed for use by automobiles. Informal surveys in aircraft occurred ≥24 hr post snowfall, typically in areas too remote or hazardous to visit on skis. Transects consisted of straight flight lines crossing prime habitats at approximately 3.2-km intervals, with start points, end points, and survey times identified subjectively based on vegetation coverage and lighting conditions. When feasible, pilots landed helicopters and we examined carnivore tracks.

We collected hair and feces found along snow trails and at bed sites of suspected lynx for DNA-based assessment of species, sex, and individual (Carnivore Conservation Genetics Laboratory, Missoula, Montana; Mills et al. 2000; Pilgrim et al. 2005). We also documented tracks using measurements, plaster casts, or photographs (Murie 1974, Halfpenny et al. 1995). Lynx tracks were rated as "definite" if the species' identity was verified by DNA tests and gait and print patterns were consistently clear and supportive of presence; "probable" when no useable DNA was retrieved, but gaits and prints were consistently clear and supportive; and "possible" when no DNA was recovered, gaits and prints were generally supportive, but consistently unclear. Feces used for food-habits analysis were frozen after collection, then re-hydrated for 24 hr and washed in a #20 sieve with 0.850 mm openings. Hairs were identified based on their internal medulla and external scale patterns (Moore et al. 1974) using a microscope (400x and 1000x) and reference collections of hairs, bones, claws, and teeth.

During the summer and early fall, 2001–2003, we used two approaches to detect lynx using hair snares (Figure 2). First, we deployed transects on a single 23 km x 23 km grid (529 km^2) located in the East sector, following the National Lynx Detection Protocol (McKelvey et al. 1999). We also deployed transects ad hoc in nine other areas of the park during two summers following the National

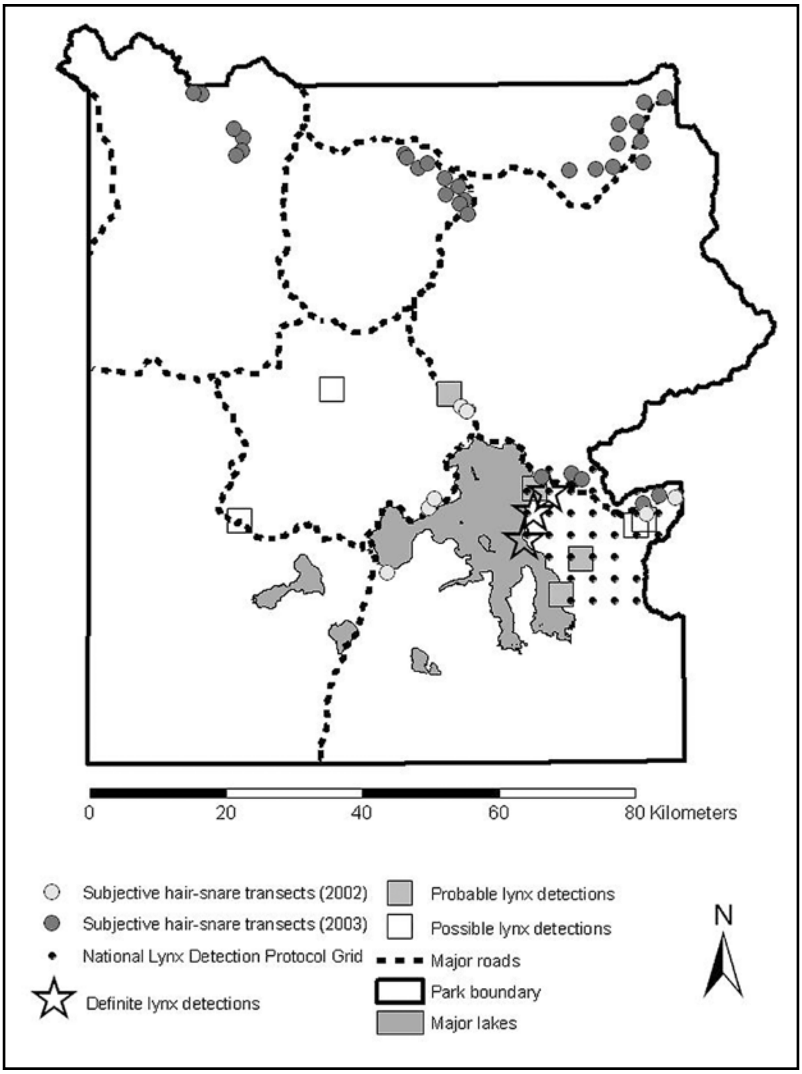

Figure 2. Locations of National Lynx Detection Protocol and subjectively-placed hair snare transects, and lynx detections; Yellowstone National Park, Wyoming, 2001–2004.

Protocol for snare and attractor materials, but deviated from systematic spacing by subjectively choosing the transect site, number and spacing, and period (two weeks) of deployment.

Results

During four winters and across eight sectors, we completed 103 formal snow tracking surveys ranging from 1 to 23 km in length, totaling 570 km; and 148 informal surveys, ranging from 0.4 to 30 km in length, totaling 1,143 km (Table 1). Per sector, ski-based detection effort varied from three total formal and informal surveys, traversing 20 km (West), to 90 surveys totaling 531 km (East). We encountered snowshoe hare tracks more frequently in the East sector (mean = 10 tracks per km) than all others (range of means = 0–5 per km; Table 1). The East sector (mean 8 per km) tied for 2nd highest frequency of red squirrel tracks. We completed 41 snowmobile-based surveys (total 749 km; range 2–63 km) on park roads in or on the boundary of seven sectors, including some reaches that did not bisect prime habitat. Seven aircraft-based surveys

TABLE 1. Distribution of formal and informal Canada lynx detection surveys, Yellowstone National Park, 2001-2004.

	Formal						Informal	
		Total	Snowshoe Hare		Red Squirrel			Total
Sector	No.	Distance	Mean[1]	(*s; range*)[1]	Mean[1]	(*s; range*)[1]	No.	Distance (km)
Bechler	15	74	1	(2; 0–7)	6	(7; 0–22)	18	170
Canyon	10	69	3	(3; 0–9)	5	(4; 1–14)	16	136
Central Plateau	28	150	2	(2; 0–8)	6	(4; 0–15)	21	164
East	32	163	10	(9; 0–32)	8	(8; 1–32)	58	368
Gallatin	11	62	5	(7; 0–24)	3	(2; 0–7)	8	78
Northeast	2	14	1	(1; 0–2)	27	(34; 3–51)	11	67
South	4	33	1	(2; 0–4)	2	(2; 0–4)	14	145
West	1	5	0	–	8	–	2	15
Total	103	570					148	1,143

[1]Index values for individual surveys calculated as tracks per km of transect. Mean = mean index value for sector; (*s; range*) = sample standard deviation; range.

were completed in three sectors, totaling 693 km (range 40–183 km).

During summers 2001–2004, we deployed 21–35 hair snare transects (105–175 stations) per year on the east side of Yellowstone Lake following the National Protocol. We collected 336 total samples, visually rejected 139 samples as not from lynx, analyzed 197 using DNA techniques or hair scale patterns, and identified 108 to species. We also deployed from 1–10 transects ad hoc at four locations in 2002 and six in 2003, collected 174 total samples, analyzed 166, and identified 77 to species.

We confirmed lynx presence with DNA at three locations, all in the East sector (Figure 2): a female in summer 2001 (National Protocol, female DNA from hair); an adult female (probable) accompanied by a male kitten (male DNA from hair) in winter 2003; and an adult male (male DNA from feces) in winter 2004. We were unable to determine if the female detected using a hair snare in 2001 was the female found with the kitten in 2003. Similarly, we could not determine if the males detected in 2003 (kitten) and 2004 (adult) were the same individual, but the lynx identified in 2004 was detected (Carnivore Conservation Genetics Laboratory) the following winter 76 km south in the Bridger-Teton National Forest using genotypes obtained from hair and fecal samples (Berg et al. 2005). We made four probable detections, including a female accompanied by one kitten in the East sector in 2004, and found four possible tracks, including two observed at different locations from a helicopter. The definite and probable detections occurred in mature lodgepole pine or Engelmann spruce forests with understories dominated by young confer, and averaged 2,426 m in elevation (s = 98; range 2,360–2,615 m). Lynx snow trails also crossed meadows up to 75 m wide. The lynx feces that yielded DNA, as above, contained snowshoe hare bones, claws, or hair.

From snow trails, hair snares, and tracks found in summer, we detected nearly all small, medium, and large carnivores that occur in the park, including wolverines (*Gulo gulo*) in three sectors. We did not confirm the presence of fisher (*Martes pennanti*).

Discussion

Our cumulative detections from 2001–2004 represented at least three individuals: a female (2001; DNA), a male kitten (2003; DNA), and a different kitten of unknown sex (2004; probable track), all that could partially or completely account for our other definite, probable, and possible detections. Coupled with historic sightings records and ranger notes on lynx deaths, our findings suggest that lynx occur in the park today, and may have persisted from the park's inception. However, lynx are apparently limited to the East Sector where we also recorded the highest and second-highest indices of snowshoe hare and red squirrel abundance, respectively, and possibly to the Central Plateau sector. With some exceptions, lynx select habitats similarly to snowshoe hares (Mowat et al. 2000). The East sector is dominated by andesitic soils that exceed other park soils in moisture-holding capacity and nutrients, and better support subalpine fir and Engelmann spruce forests with thick understory vegetation desired by snowshoe hares (Wolfe et al. 1982, Despain 1990). Although the extensive boreal forests that characterize snowshoe hare habitat in the Canadian Rockies and Alaska extend southward into the U.S., they are fragmented and disjunct in the U.S. Rocky Mountains (Koehler and Aubry 1994, Agee 2000). In Yellowstone Park, wet boreal (subalpine) forests are limited to sites that exceed 2,100 m in elevation and have adequate soil moisture, nutrients, and shade (Despain 1990). Habitat limitations for snowshoe hares are particularly evident in the central and southwestern portions of the park where well-drained, nutrient-poor rhyolitic soils predominate (Despain 1990). In the mature lodgepole pine forests in these regions, sparse regeneration of young conifer and woody debris typically provides meager cover in the forest understory. Nonetheless, lynx may have occurred outside the East and Central Plateau sectors as well, as our survey techniques undoubtedly did not detect individuals with certainty, particularly where survey effort was low.

Habitat conditions for snowshoe hares may improve in the park in response to crown and surface-level fires that burned 245,000 forested ha, 28% of the park, in 1988 (Franke 2000). Habitat use by hares is positively correlated with horizontal cover at 1–3 m in height (Hodges 2000). Secondary forest succession following stand-replacing fires typically includes dense stands of small-diameter trees with high levels of horizontal cover (Agee 2000). Lodgepole pine repopulated select Yellowstone burn sites up to 1.9 x 10^6 seedlings per ha (Anderson et al. 2004). Coarse woody debris at ground level and snags, additional cover for snowshoe hares, accumulated to 180 metric tons per ha (Tinker and Knight 2004). Although some 15–80 year-old stands (Agee 2000) in the park will likely support snowshoe hares, stocking rates for lodgepole pine are highly variable (Turner et al. 1997, Anderson et al. 2004), and many burn sites may lack sufficient horizontal cover (Buskirk et al. 2000).

The presence of lynx kittens in the park suggests at least one adult was resident (Brainerd 1985, Koehler 1990, Squires and Laurion 2000). Reproduction that we and Squires and Laurion (2000) documented may contribute to lynx persistence in the Yellowstone Ecosystem, in addition to ingress from peripheral populations in Northwest Montana or Colorado. Our anecdotal observation of the adult male first detected in the park in 2004, and 76 km distant the following winter, is consistent with findings of other workers who documented long distance movements of lynx (Mech 1977, Brainerd 1985, Slough and Mowat 1996, Mowat et al. 2000, Squires and Oakleaf 2005). Whether our observation represented a southerly dispersal of a subadult from a natal range, an extended movement within a large home range, or an extra-territorial exploration is unknown. Regardless, movements of this magnitude may improve population size and decrease extinction risks by enhancing habitat occupancy and contact between prospective breeders, particularly in the Yellowstone Ecosystem where patchy subalpine forests may result in wide spacing between lynx (Shaffer 1981, Gilpin and Soulé 1986, Agee 2000, Squires and Oakleaf 2005, this study).

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