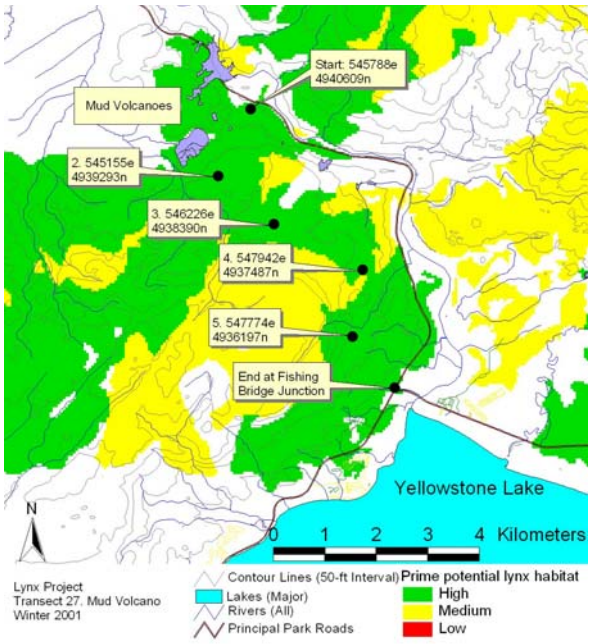
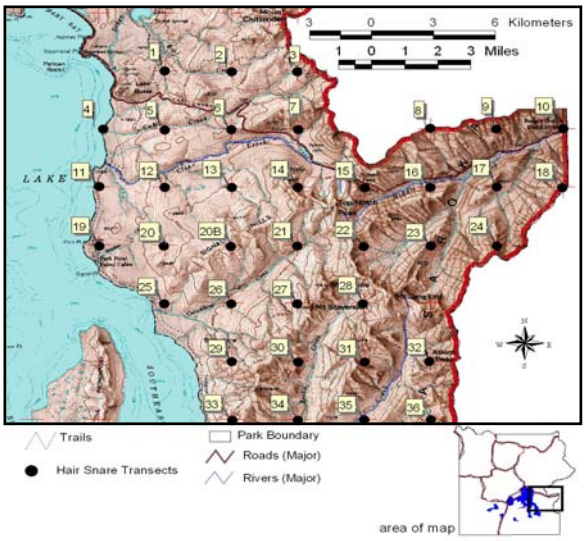
Final Report:

The Presence and Distribution of Canada lynx (*Lynx canadensis*) in Yellowstone National Park, Wyoming





by:

Kerry Murphy[a]
Tiffany Potter[b]
James Halfpenny[c]
Kerry Gunther[a]
Tildon Jones[a]
Peter Lundberg[d]

[a]Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190; kerry_murphy@nps.gov; kerry_gunther@nps.gov; tildon_jones@nps.gov; [b]Department of Forestry, University of Kentucky, Lexington, KY; tiffany.potter@uky.edu; [c]A Naturalist's World, P.O. Box 989, Gardiner, MT 59030; trackdoctor@tracknature.com; [d]Division of Science and Resources Management, Glacier National Park, West Glacier, MT, 59936; Peter_Lundberg@nps.gov.

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Introduction

Americans find the Canada lynx to be mysterious and valuable because of its secretiveness, life history association with snowshoe hares, and unique morphological adaptations. Like top carnivores such as gray wolves (*Canis lupus*), Canada lynx may also structure ecological communities through effects on herbivorous prey species (Eisenberg 1989). Due to its limited distribution in the continuous 48 states and specific association with boreal forests, deep snow, and snowshoe hares, the Canada lynx may be a sensitive indicator of adverse anthropogenic effects. In 2000, the Canada lynx was federally listed as a threatened species in the conterminous U.S., primarily because national forest plans lacked adequate regulatory mechanisms to protect the species (U.S. Fish and Wildlife Service 2000).

Very little is known about the distribution of Canada lynx and its ecological requirements in the park. The species historically occupied the area, but appears to have been uncommon relative to similarly sized forest carnivores such as red fox (*Vulpes vulpes*) (Grinnell 1876, Blackburn 1879, Schullery and Whittlesey 1992, Consolo-Murphy and Meagher 1995, Halfpenny et al. 1999). Seton (1898), who distinguished between Canada lynx and bobcat, noted that Canada lynx were "somewhat common in the woods," and that Superintendent George S. Anderson believed they were "quite common." Bailey (1930) stated that Canada lynx "were said to be common and generally distributed throughout the timbered region." Skinner (1927) said "probably this cat has always existed in limited numbers in the Park, where it frequents the forests of the plateau region. I believe there are about ten individuals present and that the number has not changed materially for years."

The Yellowstone National Park files contain records of 73 direct or indirect (tracks) observations of Canada lynx made by park visitors or employees from 1887–2003. The distribution of sightings suggests a park-wide distribution for the species historically, but as expected, sightings were concentrated along roads where visitor activity was greatest. Park sighting records contain considerable bias and inaccuracy due to variability among observers and other factors (Consolo-Murphy and Meager 1995). In addition, we found 34 new references to Canada lynx observations (tracks or direct observations) in ranger log books (Yellowstone National Park archives) dating 1895–1926, including at least six individuals killed in the park. This new information suggests that historically, Canada lynx were not necessarily rare.

Recent listing as a threatened species and lack of comprehensive survey data in the park underscored the need for basic information on Canada lynx. Inventory data are essential to avoid adverse effects of park management activities such as road reconstruction and to support joint conservation planning efforts among federal and state agencies. In response to the dearth of information, we initiated a park-wide survey with the objective of documenting Canada lynx presence and distribution in the park from 2001–2004.

Methods

Prime habitat and park sectors —We focused snow tracking and hair-snare detection surveys in prime habitats (PHs) for Canada lynx. PHs were identified based on their potential to support snowshoe hares, the primary prey of Canada lynx, using cover types described for Yellowstone National Park (Mattson and Despain 1985) (Table 1; Figure 1). Cover types were included or excluded as PH based on Quinn and Parker (1987), Sullivan and Sullivan (1988), Major (1989),

Koehler (1990), Koehler and Brittell (1990), Murray et al. (1994), Staples (1995), Poole et al. (1996), and Mowat et al. (2000). PHs typically included spruce-fir (*Abies lasiocarpa, Picea engelmannii*), and lodgepole pine (*Pinus contorta*) stands in climax, late, middle, or pigmy (wind-blown and snow-free) stages; aspen (*Populus tremuloides*) stands; and willow (*Salix sp*.) shrub fields in riparian zones. Lodgepole pine stands in early successional stages, typically less than 180 cm in height that emerged from sites burned between 1977 and the present, were eliminated as PH because snow pack typically reduced horizontal and vertical cover available to prey and predators (Sullivan and Sullivan 1988, Koehler 1990). We also eliminated 1) the northern winter range in Yellowstone National Park because it was extensively surveyed for felids from 1988–2004 by Murphy (1998) and T. Ruth (pers. comm.) during cougar (*Puma concolor*) population studies, and 2) open habitats such as talus fields, open water, krummholtz, and grasslands (Mowat et al. 2000). Once PHs were identified, we further subjectively classed PH as high, middle, or low quality based on our practical knowledge of park vegetation structure and the literature above. We also identified geographic sectors of the park based on their characteristic range of elevation, soils, and over story vegetation (Figure 2; Despain 1990).

Ski-based snow tracking surveys—We documented Canada lynx while skiing on transect lines in search of tracks, bed sites, hairs, and scats. The starting locations of 33 snow-tracking surveys in PH were based on their accessibility to snowmobiles or ski trails and the absence of avalanche hazards (Figures 3 and 4). We did not attempt to apportion survey efforts equally because coverage, accessibility, and rating (high, medium, low) of PH varied greatly across sectors.

Surveys were classed as "formal" or "informal," based on the timing of recent snowfall and type of data that were collected. Formal data included records of rare carnivore tracks left by Canada lynx or wolverine (*Gulo gulo*), tracks of their prey (e.g., snowshoe hares), cover types, and snow tracking conditions encountered along transect segments. Formal surveys were conducted at least 12 hours after a snowfall, but only tracks left within the last 24 hours of the survey were tallied. The 12-hour rule provided for at least some tracks to accumulate following the last snowfall. The 24-hour rule ensured that counts would be limited to a short, standardized time period. Informal surveys were conducted when the 12-hour rule precluded a formal survey or when we prioritized transect distance over detailed survey data. Informal data were principally survey length and location and records of rare carnivore detections. Trained backcountry rangers conducting other activities, and who lacked the time to conduct a formal survey, frequently conducted informal surveys. In 2004, we conducted only informal surveys to maximize search efforts in the East sector of the park, where we previously detected Canada lynx.

Snowmobile-based snow tracking surveys—To increase snow tracking effort, we also used snowmobiles to conduct formal and informal surveys along groomed park roads, a technique used in Montana to monitor Canada lynx populations (B. Giddings, pers. com.).

Air-based snow tracking surveys—We also surveyed remote PHs for Canada lynx tracks using airplanes (*Piper Supercub*) and helicopters (*Bell Jet Ranger, 206B*), a technique used to monitor populations in Alaska (Golden 1993, Stephenson 1986). Flights occurred at least 24 hours after a new snowfall, typically in areas too remote or hazardous to visit on skis. Transects consisted of straight flight lines crossing PH at approximately 2-mile intervals, with start and end points and times for surveys chosen subjectively by observers in the field based on vegetation coverage and lighting conditions. Aircrews consisted of a pilot and one

experienced observer. When feasible, we landed in helicopters to examine and document tracks of rare carnivores. We were not permitted to land airplanes.

Documenting carnivore sign and food habits—Catalog information such as Universal Transverse Mercator (UTM) location, time, habitat characteristics, and weather and snow conditions were recorded where rare carnivore sign was encountered. We documented tracks of rare carnivores using measurements, plaster casts, and/or photographs. We also collected hairs along tracks and from bed sites and stored them in vials with a desiccant for DNA-based identification following Mills et al. (2000) at the Carnivore Conservation Genetics Laboratory, University of Montana, Missoula. The reliability of rare carnivore tracks were rated as "definite" if the species' identity was verified by DNA tests and all gait patterns and print measurements were supportive of Canada lynx presence; "probable" when nearly all gaits and prints were supportive, but some aspects of tracks were non-interpretable and/or non-supportive (no useable DNA); and "possible" when most interpretable evidence suggested Canada lynx presence, but details of prints or gait patterns were consistently unclear (no DNA).

We collected scats when following definite Canada lynx tracks. Scats were frozen after collection, then re-hydrated for 24 hours and cold-washed in a #20 Sieve with .850mm screen openings. Internal medulla and external scale patterns were identified using a microscope (400x and 1000x) following Moore et al (1974); reference collections of hairs, bones, claws, teeth were used.

Track identification training—Project personnel and other YNP staff participating in snow tracking surveys received six hours of classroom and field instruction annually on the identification and documentation of Canada lynx sign and data collection procedures. During December or January each year, we received sign identification training at a Canada lynx study site in northwest Montana managed by the U.S. Forest Service, Rocky Mountain Research Station.

Camera-based detection of forest carnivores— During winter 2002, we deployed camera stations (*Trailmaster 1500 and 35-1,* Trailmaster Infrared Monitors, Division Goodson & Assoc., Inc., Lenexa, KS; *Camtrakker,* Camtrakker, Inc., 1050 Industrial Dr., Watkinsville, GA) at subjectively-chosen sites in the East sector, principally the Bear, Cub, and Clear Creek drainages, to detect rare carnivores and to evaluate their potential for broader use. Stations contained hair-snares (see-below), a visual attractor (pie plates), scent lures (beaver castorium, propylene glycol, and glycerine), and electronic predator (bird song) calls. Cameras were triggered when animals interrupted an infrared beam near ground level. We re-checked the stations at 2–4 week intervals to collect hairs from the hair-snares, to collect and replace film in cameras, and to look for rare carnivore tracks.

Hair-snare surveys— to detect Canada lynx presence, we used two approaches for locating and spacing transects with hair-snares. First, we deployed transects on a single 14 mile x 14 mile grid (196 mi^2) located on the east side of Yellowstone Lake, following guidelines in the National Lynx Detection Protocol (NLDP) (McKelvey et al. 1999). Transects were spaced at 2-mile intervals and consisted of five stations spaced at 100-m intervals. Stations contained a hair-snare nailed to a tree 46 cm above ground, with visual (aluminum pie plates) and scent lure (as above) attractors hung from nearby tree limbs. Hair snares consisted of a 2" by 2"

piece of carpet containing nails inset to snag and hold animal hairs (e.g., those of cheek-rubbing Canada lynx) and the scent lure above. Stations were deployed, checked twice at 2-week intervals for visits by animals, and then removed from the field. Hairs were collected from the hair-snare, the tree supporting or trees growing near the snare, or from the ground, then stored in a vial with desiccant for subsequent identification based on cuticle patterns of hair follicles (Moore et al. 1974) or DNA-based techniques. The grid was deployed from early summer to early fall, 2001–2003. Because some of the transects occurred in extremely remote areas and could not be maintained simultaneously, we stratified transects by watershed and sub-sampled the grid at different times each summer. Logistical constraints or area closures due to wildfires precluded access to some transects during summers 2001 and 2003.

Second, we deployed "subjective" transects during two summers in six other areas of the park following NLDP guidelines for snare and attractor materials, but deviating with respect to the number and spacing between transects and stations. The number of transects varied from 1 to 10 per survey rather than the 25 minimum (NLDP); stations varied from 2 to 11 per transect. Transect and station sites were chosen subjectively based on vegetation, topography, and logistical constraints and were often deployed for only two weeks.

Canada lynx sightings and follow-up investigations of tracks—We developed and distributed an information poster to YNP ranger offices, visitor centers, and warming (winter) huts prompting staff and visitors to report sightings of Canada lynx or their tracks. We investigated these reports by reviewing sighting records, interviewing reporting persons, and where possible, visiting locations where tracks were found and documenting the tracks ourselves.

Results

Ski-based snow tracking effort—During four winter seasons, we completed 103 formal snow tracking surveys ranging from 1–23 km in length, totaling 563 km; and 136 informal surveys ranging from 0.4–90 km in length, totaling 1,051 km (Table 2, Appendix 1). Surveys were widely distributed throughout PH and occurred under un-crusted snow conditions that consistently revealed animal tracks (Figures 5–8; Table 3). Combining formal and informal data, surveys totaled 1,614 km over four winters. As the study progressed, we decreased snow tracking effort in the west-central and southwest portion of the park after encountering little snowshoe hare sign, but increased effort on the east side of Yellowstone Lake, attempting to re-verify Canada lynx first detected during winter 2001. During 2004, we focused nearly all winter effort in this latter area, attempting to document Canada lynx numbers and their sex and age characteristics.

Snowmobile-based snow tracking effort—From 2001–2003, we completed 41 snowmobile-based surveys totaling 749 km (Table 4), mostly under favorable snow tracking conditions. No snowmobile-based effort occurred during 2004 when survey efforts were focused in remote habitats on the east side of Yellowstone Lake.

Aircraft-based snow tracking effort—We completed four snow tracking surveys in airplanes and two in helicopters, totaling 693 km (range 40–183 km) (Table 5). Three aerial surveys occurred in the Bechler sector (Figure 9). This area was difficult to access on foot, but use of aircraft was

advantageous because conifers, primarily lodgepole pine, were widely spaced and because deep snow pack covered much of the forest understory, conditions that enhanced the sightability and identification of tracks. Three surveys also occurred in the East sector, again to improve information on the Canada lynx individuals which were discovered there earlier in the study.

Camera-based detection effort—During winter 2002, we deployed 7 camera stations for 170 total camera nights along trails and roads in the Bear, Cub, and Clear Creek drainages in the East sector (Table 6). Cold temperatures (<-20 ^{o}F) during January and February frequently rendered cameras inoperable. However, we detected coyotes at a single camera station on 4 separate occasions.

Hair-snare-based detection effort—We annually deployed and revisited 21–35 hair-snare transects (105–175 stations) on the east side of Yellowstone Lake following the NLDP (Figure 10, Table 7, Appendix 2), collecting 336 total samples, analyzing 197, and identifying 108 to species. We also deployed from 1–10 transects at six "subjective" survey sites in 2002 and four in 2003, collecting 174 total samples, analyzing 166, and identifying 77 to species (Figure 11, Table 8).

Canada lynx detections—We made three definite (DNA-based) Canada lynx detections, all on the east side of Yellowstone Lake (Table 9; Figure 12): a female (female DNA) in summer 2001 (NLDP); a female accompanied by a male kitten in winter 2003 (snow tracking; DNA of a male); and an adult male in winter 2004 (snow tracking; DNA of a male). Three probable detections were also made on the east side of Yellowstone Lake (snow tracking), including one case of a female accompanied by one kitten. Two possible tracks were observed from a helicopter during a survey of Middle Creek, East Sector, but no landing site was available to permit close inspection of tracks. In addition, one probable and one possible detection (snow tracking) were made at Mary Mountain (2001) and Le Hardy Rapids (2002), respectively, in the Central Plateau sector.

Canada lynx food habits—Three Canada lynx scats contained remains of snowshoe hares (hair, bones, claws) or snowshoe hare stomachs (e.g., lichens). Canada lynx scats DNA was present in each scat.

Detections of prey and other carnivores—Snowshoe hares, red squirrels, American marten, coyotes, and weasels (*Mustela frenata and/or M. erminea*) were commonly encountered on snow tracking surveys (Table 10). Encounter rates for snowshoe hares appeared higher in the East sector compared to the remainder of the park.

Using a variety of methods, we detected nearly all other small, medium, and large carnivores known to occur in Yellowstone National Park, including wolverines in three park sectors on five total occasions (Table 11). Gray wolves, grizzly bears, and black bears were routinely detected. Sign of digging badgers (*Taxidea taxus*) were detected in the Lamar Valley. Fishers (*Mustela pennanti*) were not detected.

Canada lynx sightings and follow-up investigations of tracks—We interviewed nine persons and made one field excursion to verify reports of Canada lynx or their tracks. One interview with a

very experienced backcountry ranger convinced us he had likely observed a Canada lynx near the Ninemile Trailhead along the East entrance road. In the remaining cases, animal descriptions provided by observers were consistent with characteristics of Canada lynx or bobcat (n =3), inconsistent (n = 2), and insufficient to evaluate reports (n = 3). We did not locate carnivore tracks at the observation site during our only field excursion.

Discussion

Canada lynx persisted in the park at low density. However, their distribution is largely restricted to the East and possibly the Central Plateau sectors. We did not detect Canada lynx in other portions of the park, but they may have occurred there as well, as our detection techniques did not detect extant individuals with certainty. The distribution of detections was consistent with our formal snow tracking data which suggested that the highest densities of snowshoe hares occurred in the East sector. This portion of the park is dominated by andesitic soils that exceed other park soils in moisture-holding capacity and nutrients (Despain 1990). Andesitic soils better support subalpine and Engelmann spruce forests and dense understory vegetation that provides sufficient horizontal and vertical cover for snowshoe hares (Despain 1990). Growing conditions for boreal forest habitats within 100 m of Yellowstone Lake may be enhanced by fine soil materials (clay-sized particles) deposited in terraces that were formed incident to historic lake fluctuations (R. Renkin, pers. comm.). Frequent storms also create conifer windfalls along the lakeshore, causing breaks in the forest canopy and encouraging regeneration of dense young conifers and deciduous shrubs needed by snowshoe hares.

Our cumulative detections of Canada lynx in the park from 2001–2004 likely represented at least four individuals, including two kittens born in two different years. The presence of offspring indicates that resident, breeding individuals were present, an important finding because Canada lynx reproduction has not been previously documented in the park and rarely in the Greater Yellowstone Ecosystem. As in most carnivores, reproducing Canada lynx females are typically resident, as opposed to nomadic or transient (Brainerd 1985, Koehler 1990, Squires and Laurion 2000). Although detections of offspring do not confirm the presence of a viable, reproductively-stable population in the park or ecosystem, they do suggest that reproduction of resident females may contribute to population persistence. Recruitment from local sources could wholly or partially drive population dynamics and viability of Canada lynx in the park and the ecosystem, in concert with distant populations that provide may provide ingress from northwest Montana or Canada (McKelvey 2000). Canada lynx rapidly increase in the southern portion of their range due to ingress from northern population centers (Mech 1973, Gunderson 1978).

Our conclusion that Canada lynx persist in the park was consistent with recent DNA-based detections by U.S. Forest Service personnel using hair snares, snow tracking, and animal captures—the species persists at low densities in the Yellowstone Ecosystem, but appears to be limited in distribution (Figure 13). Of approximately 15 hair snare grids deployed by U.S.F.S. and NPS units in the ecosystem from 1998 to present, only six grids, distributed across three portions of the ecosystem, detected Canada lynx. In addition, most U.S.F.S. and NPS units have completed surveys using snow tracking, but only three have made DNA-based detections.

Our snow tracking surveys conducted on skis, snowmobiles, and from aircraft collectively cost slightly less than hair-snare surveys and we detected all but one Canada lynx, including two definite tracks, using this method. We also detected a broader variety of other carnivores using snow tracking surveys. Although ski-based surveys allowed consistent and close documentation of fresh tracks, deep (>1 m) un-crusted snow present from January to early March limited survey distances. Logistics of accessing survey locations in remote areas of the park (+10 miles) often took more time than the survey itself. Frequent snowfall often covered tracks.

Helicopter-based surveys provided the best access to PH, but we could not verify tracks from the ground when trees and/or steep terrain precluded landing. Dense forest canopies also limited our ability to see tracks from the air and strong winds often prevented low-level flight needed to detect tracks. However, helicopters were very effective for searching for tracks and landing in highly remote areas that contained a patchwork of flat meadows. Airplane-based surveys were largely ineffective for detecting rare carnivores in forested areas due to high minimum air speeds and because landings were both infeasible and not permitted. However, airplanes enabled quick, inexpensive assessments of relative prey numbers over large open areas such as recent burns and sites with sparse or intermittent forest cover. For example, airplane-based surveys that we conducted early during the study in the Bechler sector allowed us to determine that extensive ski-based searches of PH there would likely be unproductive because of very low snowshoe hare densities.

We detected a variety of carnivores using hair-snares, including one female Canada lynx in an area where we repeatedly made detections using snow tracking surveys. Hairs of nearly all carnivores were readily collected from vegetation or the ground and reliably identified if sufficient DNA was extracted. An advantage of hair snares is that they can be deployed during seasons with favorable weather. However, deployment and repeated visits to hair collection stations in the park backcountry, even in absence of snow pack, was physically challenging and logistically difficult. Rain, wind, and sunshine may also have reduced the quality and quantity of hair samples. In our case, fires in 2000 and 2003 burned > 23,000 total acres of habitat on and near our NLDP grid. Extreme fire and human suppression activity (aircraft, ground crews, vehicles) may have affected Canada lynx movements and behavior, possibly reducing our detections using hair snares.

We detected wolverines in three park sectors on five total occasions, suggesting they were moderately well distributed in the park. We did not detect fisher, even though our surveys included habitats likely to attract this mustelid. Fisher could have been present. They have not been detected on NLDP grids in the U.S. Northern Rockies where they are known to occur (J. Malloy, pers. comm.) and their tracks sizes and stride lengths overlap those of martens (Murie 1954; J. Halfpenny, pers. comm.).

Conclusions and Recommendations

The weak signal of Canada lynx presence and restricted distribution points to reduced population viability of this species in the ecosystem. This condition is not surprising for a species at the periphery of its continental range. Wet boreal forests that characterize snowshoe hare and Canada lynx habitat in the U.S. Rocky Mountains, including the Yellowstone Ecosystem, are

highly fragmented on gradients of aspect and elevation and support Canada lynx in lower densities than suitable habitats in Canada and Alaska (Dolbeer and Clark 1975, Koehler and Aubry 1994).

Because only a single, limited ecological study of Canada lynx has been completed in the Yellowstone Ecosystem, our knowledge would increase dramatically as a result of successful population and telemetry-based studies in the park (Squires and Laurion 2000). The information would be of great interest to forest managers who develop silvicultural and fire management prescriptions. However, this study would be logistically difficult and would involve risks for personnel. Inferences to Canada lynx at an ecosystem scale would be limited by small sample sizes (Ruggiero et al. 1994).

In the absence of intensive studies on Canada lynx in the park, we recommend that this survey be repeated at 10-year intervals with the same search intensity and spatial extent as 2000–2004. Because the numbers and distribution of Canada lynx may improve due to increases in snowshoe hare abundance that are expected from post-fire (1988) lodgepole pine regeneration, future surveys must necessarily be geographically broad. We also recommend that snowshoe hare studies be continued to document trends in this prey's abundance, distribution, underlying demographic characteristics, and functional relationships with the Canada lynx.

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Table 1. Cover types (Mattson and Despain 1985) rated as prime habitat for Canada lynx in Yellowstone National Park, 2001–2004.

Habitat Potential	Forest Type	Forest Successional Stage
High	Engelmann spruce and subalpine fir	Climax
	Engelmann spruce & subalpine fir & non-forest	Climax
	Whitebark pine, Engelmann spruce & subalpine fir	Climax
	Lodgepole pine	Combinations of Climax, Late, Middle, and Pigmy
	Lodgepole pine and non-forest	Late
	Lodgepole, Engelmann spruce & subalpine fir	Pygmy
	Deciduous shrub-fields	
Medium	Lodgepole	Combinations of Climax, Late, Middle, Early, post-disturbance, and non-forest, but no stands burned in 1988 or more recently.
Low	Aspen	All stages
	Whitebark pine	Climax
	Douglas-fir	Climax, Climax & non-forest
	Douglas-fir and Lodgepole	Early lodgepole, middle lodgepole, climax Douglas-fir
	Douglas-fir and Whitebark pine	Climax
Excluded	Douglas-fir	Early, post disturbance
	Lodgepole pine	Early
	Lodgepole and non-forest	Early
	Whitebark pine	Early, Post-disturbance
	Whitebark pine & non-forest	Early
	Krummholtz	
	Krummholtz and non-forest	
	Non-forest	
	Water	

Table 2. Ski-based backcountry snow tracking effort, Yellowstone National Park, 2001–2004.

Year	No. Formal Transects	Total Length Formal Surveys (km)	Mean (range) Formal Transect Length (km)	No. Informal Transects	Total Length Informal Surveys (km)	Mean (range) Informal Transect Length (km)
2001	28	116.8	4.2 (0.8-8.5)	21	209.0	10.0 (0.8-90.3)
2002	41	214.6	5.2 (0.7-21.0)	51	373.8	7.3 (0.9-19.5)
2003	34	232.0	6.8 (1.1-23.2)	22	186.8	8.5 (0.4-30.4)
2004	0	–	–	42	281.5	6.7 (1.6-13.1)
Totals	103	563.4	–	136	1051.1	–

Table 3. Snow tracking survey effort by sector, Yellowstone National Park, 2001-2004.

	Formal Surveys		Informal Surveys	
Sector	No. Surveys	Total Distance (km)	No. Surveys	Total Distance (km)
Bechler	4	21.8	3	33.7
Canyon	8	40.9	6	41.9
Central Plateau	25	125.1	17	126.8
East	34	180.7	62	403.9
Gallatin	9	54.9	8	61.8
Northeast	2	13.6	10	57.5
Old Faithful	12	68.4	14	88.3
South	6	42.3	14	136.9
West	3	15.8	1	10.2
Bechler-N.E. Entrance[1]	–	–	1	90.3
Totals	103	563.4	136	1051.1

[1] One 90-km survey was conducted from the Bechler Ranger Station to the Northeast Entrance in March 2001, crossing several sectors.

Table 4. Snowmobile-based snow tracking effort along Yellowstone National Park roads, 2001–2004.

Year	No. Transects	Total Length Surveys (km)	Mean (range) Transect Length (km)
2001	2	21.4	10.7 (5.7 – 15.7)
2002	4	159.3	39.8 (2.3 – 62.8)
2003	35	568.6	16.2 (7.8 – 52.8)
2004	0	–	–
Totals	41	749.3	–

Table 5. Aircraft-based snow tracking effort, Yellowstone National Park, 2001–2004.

Survey	Year	Type	Transect Length (km)	Sector
Bechler 1	2001	Airplane[1]	116.7	Bechler
Bechler 2	2001	Airplane	98.5	Bechler
East Lake/Pelican	2001	Airplane	182.9	East
Gallatin	2001	Airplane	83.2	Gallatin
Bechler 3	2002	Airplane	87.5	Bechler
East Lake	2004	Helicopter[2]	83.9	East
Middle Creek	2004	Helicopter	40.5	East
Total	–	–	693.2	–

[1]Piper Supercub.
[2]B3 Jet Bell Ranger.

Table 6. Camera-based forest carnivore detection efforts in Yellowstone National Park, 2001–2004.

Year	No. Sites	Total Camera Nights	Mean (range) Camera Nights/Site
2001	0	-	-
2002	7	170	24 (2 -26)
2003	0	-	-
2004	0	-	-

Table 7. Hair-snare-based detection effort using the U.S. Forest Service National Lynx Detection Protocol, east-central Yellowstone National Park, 2001–2003.

		Samples Collected[1]		Samples Analyzed[2]		Samples Identified[3]	
Year	No. Transects	Hair-snare	Other[4]	Hair-snare	Other[4]	Hair-snare	Other[4]
2001	32	45	124	24	22	8	8
2002	35	29	67[a]	26	59[a]	18	34[b]
2003	21[c]	21	50	19	47	11	29
Total	–	95	241	69	128	37	71

[1]Samples collected by NPS staff in the field or collected in the genetics laboratory directly from hair-snares, pie plates, or scent pads.

[2] Wildlife Genetics Laboratory, Rocky Mountain Research Laboratory, U.S. Forest Service, Missoula, Montana. Not all samples collected in the field were analyzed because laboratory personnel eliminated degraded hair samples, samples that were vegetation, and sample vials submitted from the field that apparently contained no hair.

[3]Some samples, particularly ungulates, were identified merely by visual inspection rather than by DNA analysis, including 6 samples from "other" in 2002 and 8 samples from "other" in 2003.

[4]Hair samples from the tree supporting the snare, surrounding trees, the ground, pie plates or scent pads, or from scats or bones at the transect site.

[a] Includes six samples collected near hair-snares that were left in place the previous summer.

[b] Includes five samples collected near hair-snares left in place the previous summer.

[c]Number of transects reduced because of safety concerns stemming from wildfire.

Table 8. Hair-snare-based detection effort for subjectively chosen sites, Yellowstone National Park, 2002–2003.

Year	Site	No. Transects (Total Stations)	Samples Collected[1]		Samples Analyzed[2]		Samples Identified[3]	
			Hair-snare	Other[4]	Hair-snare	Other[4]	Hair-snare	Other[4]
2001	–	–	–	–	–	–	–	–
2002	Sylvan Meadows	1 (5)	0	0	0	0	0	0
	Mud Volcano	2 (10)	3	4	3	3	2	3
	East Entrance	1 (11)	6	5	6	4	0	1
	Pumice Point	1 (2)	0	1	0	1	0	1
	Pumice-Rock Point	1 (3)	0	3	0	3	0	2
	Grant Village	1 (2)	0	1	0	1	0	1
2003	East Entrance	5 (25)	3	10	2	10	2	4
	Gardiner-Mol Heron	6 (30)	14	42	14	39	8	17
		10 (41)	6	33	5	32	4	13
	Tower Junction	10 (50)	7	36	7	36	7	12
	Northeast Entrance							
	Total	38 (179)	39	135	37	129	23	54

[1]Samples collected by NPS staff in the field or collected in the laboratory directly from hair-snares, pie plates, scent pads, etc. by laboratory personnel.

[2] Wildlife Conservation Genetics Laboratory, Rocky Mountain Research Laboratory, U.S. Forest Service, Missoula, Montana. Not all samples collected in the field were analyzed because laboratory personnel eliminated samples unlikely to originate from carnivores.

[3]Some samples, particularly ungulates, were identified merely by visual inspection rather than by DNA analysis, including one Pumice Point sample in 2002 from "other," one Gardiner-Mol Heron sample in 2003 from "other," one Tower Junction sample from "hair-snare" and nine from "other" in 2003, and three Northeast Entrance samples from "other" in 2003.

[4]Hair samples from the tree supporting the snare, surrounding trees, the ground, pie plates or scent pads, or from scats or bones at the transect site.

Table 9. Canada lynx detections in Yellowstone National Park, 2001-2004.

Year	Method	Location[1,2]	Sex & Age	Track Reliability[3]
2001	Hair-snare survey; DNA Verification	Cub Creek	Female	Definite
2001	Snow tracking survey	Mary Mountain	–	Possible
2001	Snow tracking survey	Cub Creek	–	Probable
2002	Snowmobile-based survey	Le Hardy Rapids	–	Probable
2003	Snow tracking survey; DNA verification of bed site	Clear Creek	Female & male kitten	Definite
2004	Snow tracking survey; DNA verification of bed site	Meadow Creek	Male	Definite
2004	Snow track survey	Columbine Creek	–	Probable
2004	Snow tracking survey	Columbine Creek	Female & 1 kitten	Probable
2004	Aircraft-based survey	Middle Creek	–	Possible
2004	Aircraft-based survey	Middle Creek	–	Possible

[1] Coordinates for the locations of Canada lynx detections are protected under the National Parks Omnibus Management Act, Section 207, but are archived in park files.

[2] A definite track of a Canada lynx was also documented by project personnel in Mill Creek, Gallatin National Forest, 2003.

[3]Definite: species identity verified by DNA tests and all gait patterns and print measurements were supportive of Canada lynx presence; probable: nearly all gaits and prints were supportive, but some aspects of tracks were non-interpretable and/or non-supportive, and hair samples were unavailable; possible: most interpretable evidence was supportive, but details of prints or gaits were consistently unclear.

Table 10. Rates snowshoe hare, red squirrel, American marten, and coyote were detected on formal snow tracking transects Yellowstone National Park, 2001-2004.

Sector	Year	Distance Surveyed (km)	No. of Transects	Detections per km			
				Snowshoe Hare	Red Squirrel	American Marten	Coyote
Bechler	2001	21.8	4	0.0	5.4	1.7	0.0
	2002	-	-	-	-	-	-
	2003	-	-	-	-	-	-
Canyon	2001	6.7	2	2.2	3.0	0.5	0.2
	2002	30.8	5	3.5	6.8	2.1	0.2
	2003	3.4	1	0.9	1.2	0.6	0.0
Central Plateau	2001	27.6	7	1.6	5.8	1.6	0.5
	2002	60.7	12	3.9	5.1	1.9	0.7
	2003	36.8	6	2.0	5.7	1.6	0.2
East	2001	27.7	7	14.3	12.4	3.1	0.2
	2002	64.0	11	5.0	2.4	1.1	0.3
	2003	89.1	16	11.4	9.4	1.9	0.9
Gallatin	2001	8.1	2	2.0	2.4	0.0	1.5
	2002	11.8	3	4.0	3.0	3.0	0.3
	2003	35.0	4	4.3	1.7	1.2	0.0
Northeast	2001	7.4	1	2.0	2.6	0.8	0.1
	2002	6.2	1	0.3	53.2	1.3	0.2
	2003	–	–	–	–	–	–
Old Faithful	2001	15.3	5	0.4	7.1	1.6	0.2
	2002	28.3	5	0.7	2.7	0.9	0.3
	2003	24.8	2	1.8	4.2	1.0	0.2
South	2001	9.3	2	3.9	6.7	4.2	1.0
	2002	10.2	2	0.0	0.4	0.2	1.0
	2003	22.8	2	0.8	1.7	0.8	0.1
West	2001	13.4	2	1.1	4.7	1.7	0.0
	2002						
	2003	2.4	1	0.0	0.8	0.0	0.0

Table 11. Carnivores detected in Yellowstone National Park, 2001-2004.

Species Detected[a]	Year	Method	Location
Bobcat (possible)	2001	Airplane-based survey	Fan Creek trailhead
Bobcat (definite)	2001	Hair-snare survey	Bear Creek
Bobcat (possible)	2002	Snow tracking survey	Nez Perce Trail
Bobcat (possible)	2002	Snow tracking survey	Fawn Creek Trail
Bobcat (possible)	2002	Snow tracking survey	Clear Creek
Bobcat (definite)	2002	Hair-snare survey	Bear Creek
Bobcat (definite)	2002	Hair-snare survey	Middle Creek
Bobcat (possible)	2003	Snow tracking survey	Cub Creek
Bobcat (probable)	2004	Snow tracking survey	Columbine Creek
Cougar (definite)	2002	Snow tracking survey	Clear Creek
Cougar (definite)	2002	Snow tracking survey	Clear Creek
Cougar (probable)	2002	Snow tracking survey	Witch Creek
Cougar (probable)	2003	Snow tracking survey	Clear Creek
Cougar (probable)	2003	Snow tracking survey	Teton Overlook
Cougar (probable)	2003	Snowmobile-based survey	Terrace Point
Cougar (probable)	2003	Snow tracking survey	Central Plateau
Cougar (possible)	2003	Snow tracking survey	Turbid Lake
Cougar (possible)	2003	Snowmobile-based survey	Seven-mile bridge
Cougar (probable)	2004	Snow tracking survey	Columbine Creek
Cougar (possible)	2004	Snow tracking survey	Clear Creek
Cougar (definite)	2003	Hair-snare survey	Rose Creek
Wolverine (definite)	2002	Snow tracking survey	Clear Creek
Wolverine (possible)	2002	Airplane-based survey	Ouzel Creek
Wolverine (probable)	2003	Snow tracking survey	West 191
Wolverine (possible)	2003	Snow tracking survey	Fawn Pass
Wolverine (probable)	2004	Helicopter-based survey	Rocky Creek
River otter (probable)	2001	Snow tracking survey	Mud Volcano
River otter (probable)	2001	Snow tracking survey	Arnica Creek
River otter (probable)	2001	Snow tracking survey	Heart Lake Trail
River otter (probable)	2002	Snow tracking survey	Delacy Creek Trail
River otter (probable)	2003	Snow tracking survey	Sportsman Lake Trail
River otter (probable)	2003	Snowmobile-based survey	West Entrance road
River otter (probable)	2003	Snow tracking survey	Burnt Creek
Red fox (probable)	2001	Snow tracking survey	Fawn Pass Trail
Red fox (definite)	2003	Hair-snare survey	Bear Creek
Red fox (probable)	2004	Snow tracking survey	Columbine Creek
Red fox (probable)	2004	Snow tracking survey	Terrace Point
Coyote	–	Snow tracking, hair-snare surveys, cameras	Numerous detections
Gray wolf	–	Snow tracking and hair-snare surveys	Numerous detections
Grizzly bear	–	Snow tracking and hair-snare surveys	Numerous detections
Black bear	–	Snow tracking and hair-snare surveys	Numerous detections
American marten	–	Snow tracking and hair-snares surveys	Numerous detections
Weasels[1]	–	Snow tracking survey	Numerous detections

[a] Definite: species identity verified by DNA tests and all gait patterns and print measurements were supportive of Canada lynx presence; probable: nearly all gaits and prints were supportive, but some aspects of tracks were non-interpretable and/or non-supportive, and hair samples were unavailable; possible: most interpretable evidence was supportive, but details of prints or gaits were consistently unclear.

[1] Longtail (*Mustela frenata*) and shortail (*M. erminea*) weasels.

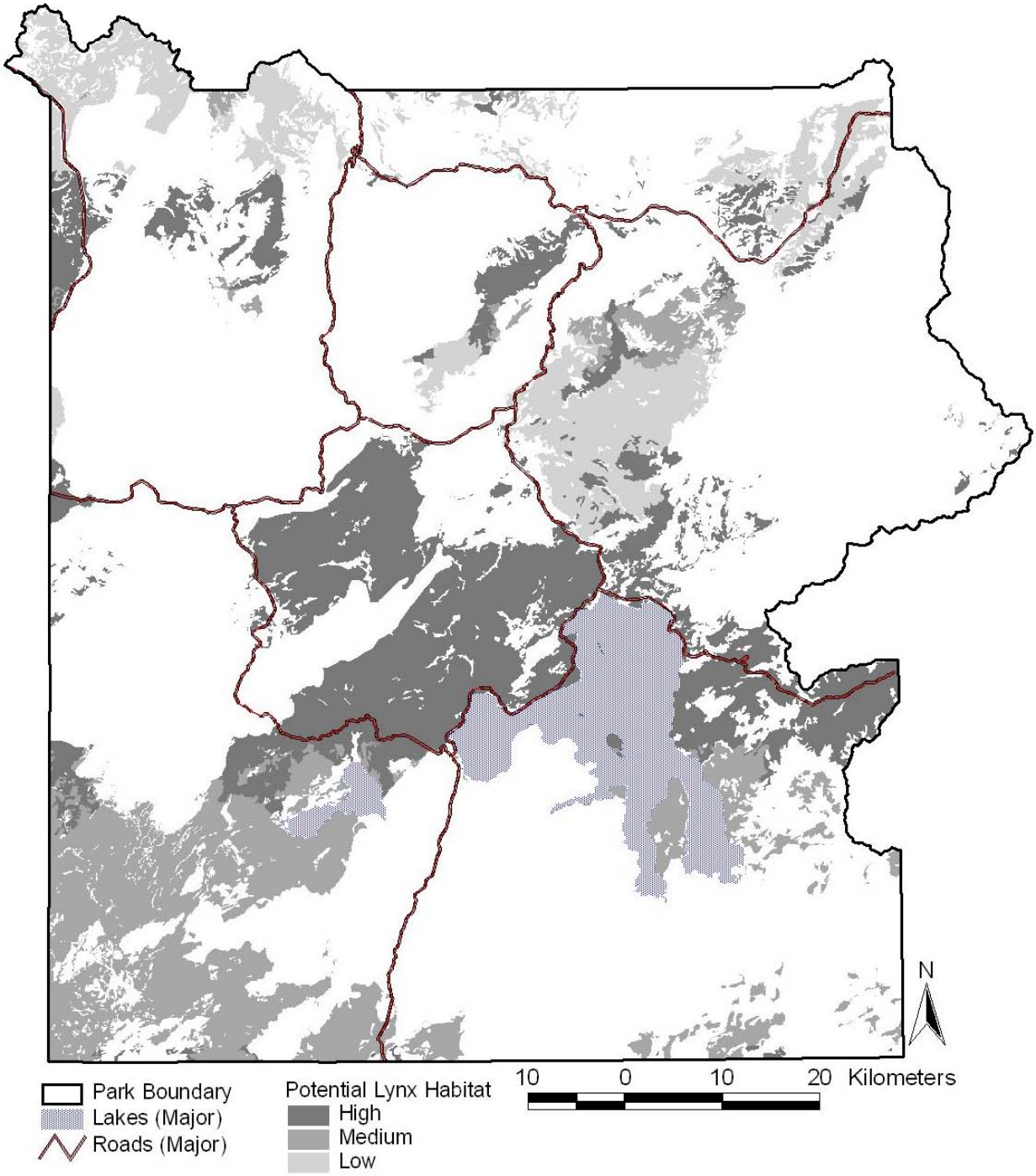

Figure 1. Prime habitat for Canada lynx identified in Yellowstone National Park, 2001–2004. See table 1 for basis.

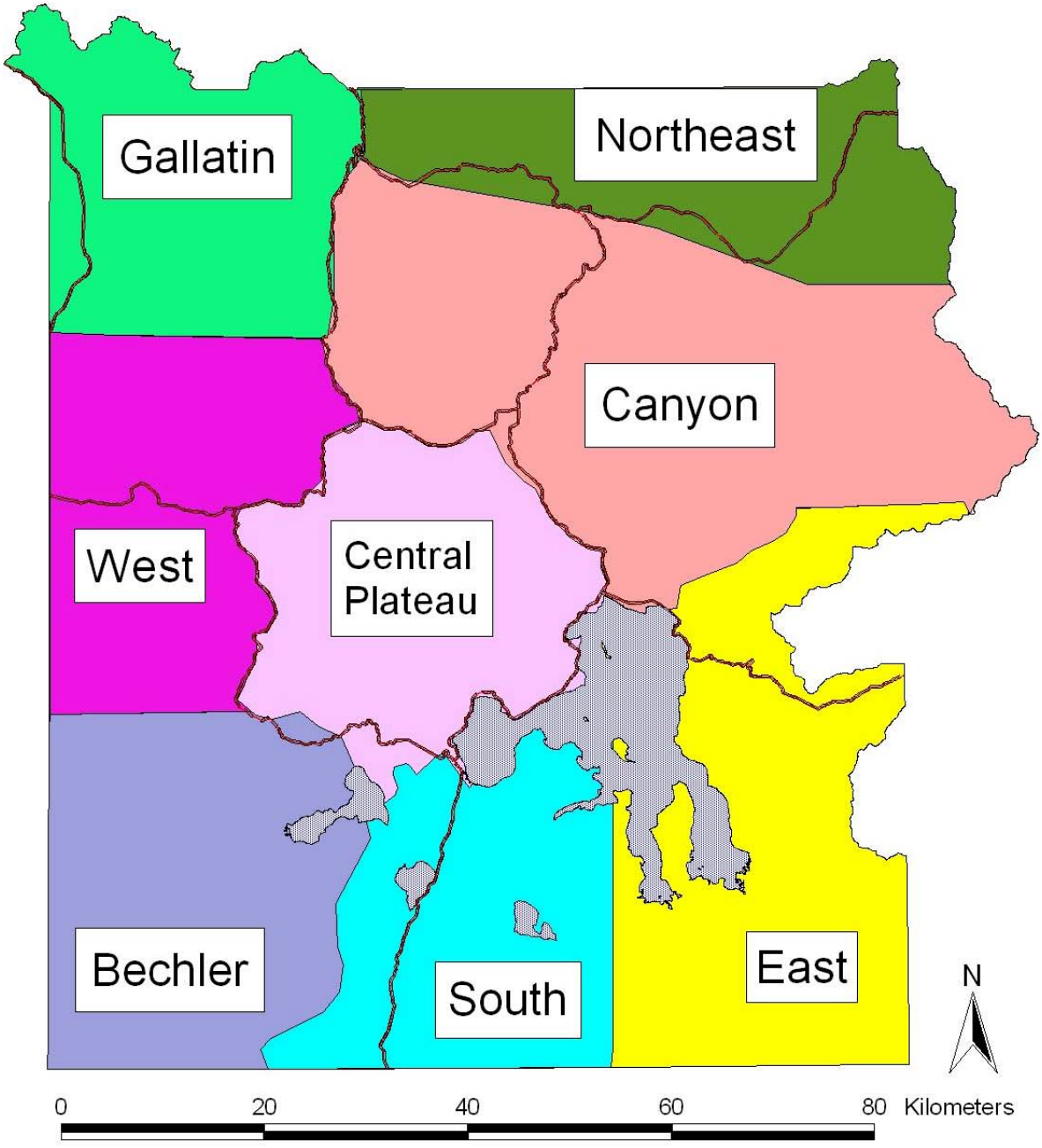

Figure 2. Canada lynx habitat sectors, Yellowstone National Park.

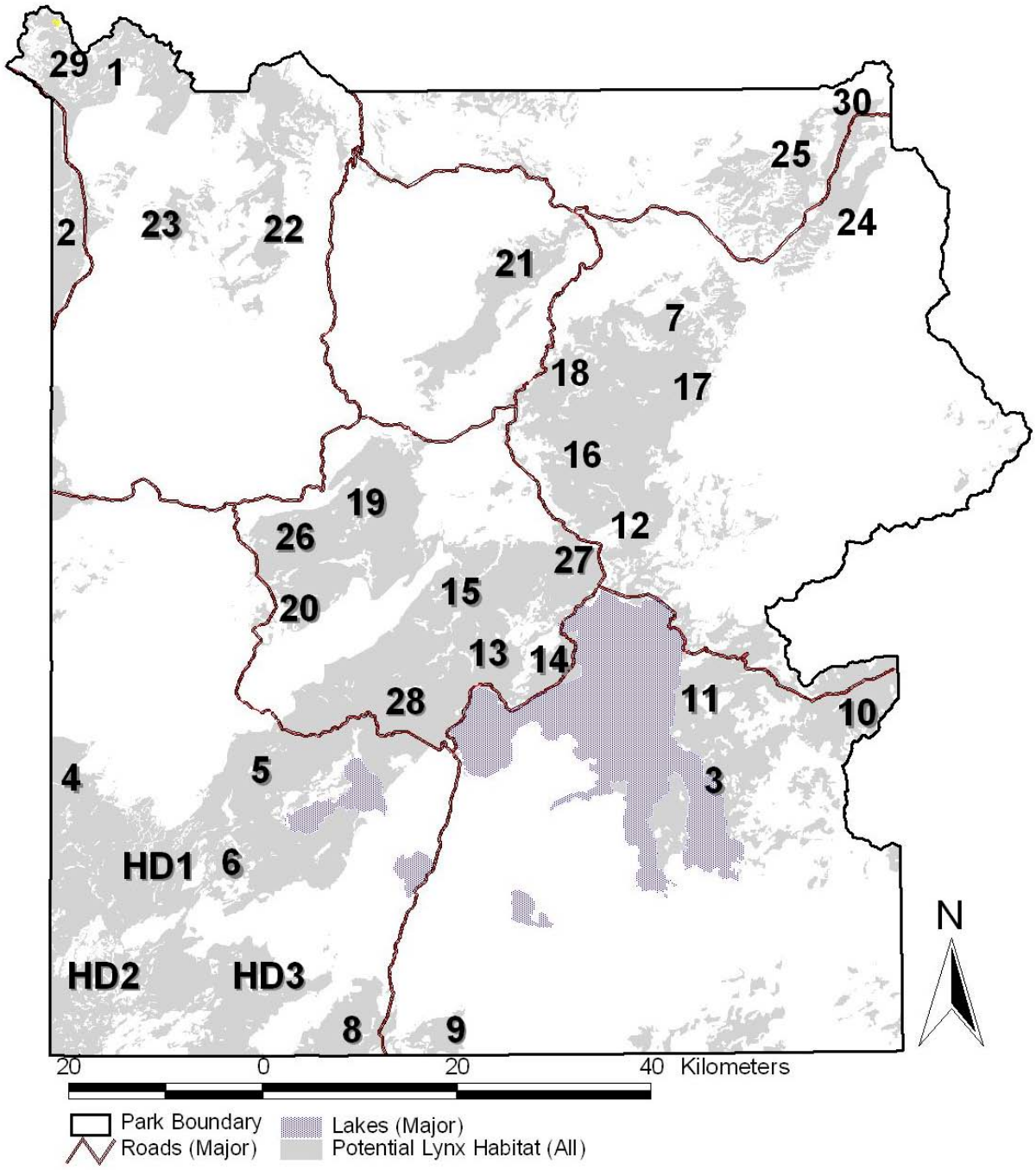

Figure 3. Locations (starting points) of ski-based snow-tracking surveys, Yellowstone National Park, 2001-2003. 1: East Fork Specimen Creek, 2: 191 West, 3: Columbine Creek, 4: Boundary Creek, 5: Lonestar-Shoshone, 6: Shoshone Geyser Basin, 7: Amethyst, 8: Spirea Creek, 9: Snake River, 10: East Gate, 11: Cub Creek, 12: Stonetop Mountain, 13: Arnica Creek, 14: Natural Bridge, 15: Mary Mountain, 16: Wapiti Lake Trail, 17: Burnt Creek, 18: Washburn Hot Springs, 19: Cygnet Lakes, 20: Nez Perce, 21: Lost Creek, 22: West Gardners Hole, 23: Fawn Pass, 24: Amphitheatre Creek, 25: Pebble Creek, 26: Mesa Pit-Nez Perce, 27: Mud Volcano, 28: Craig Pass, 29: Specimen Creek, HD1–3: East Bechler Helicopter Drops.

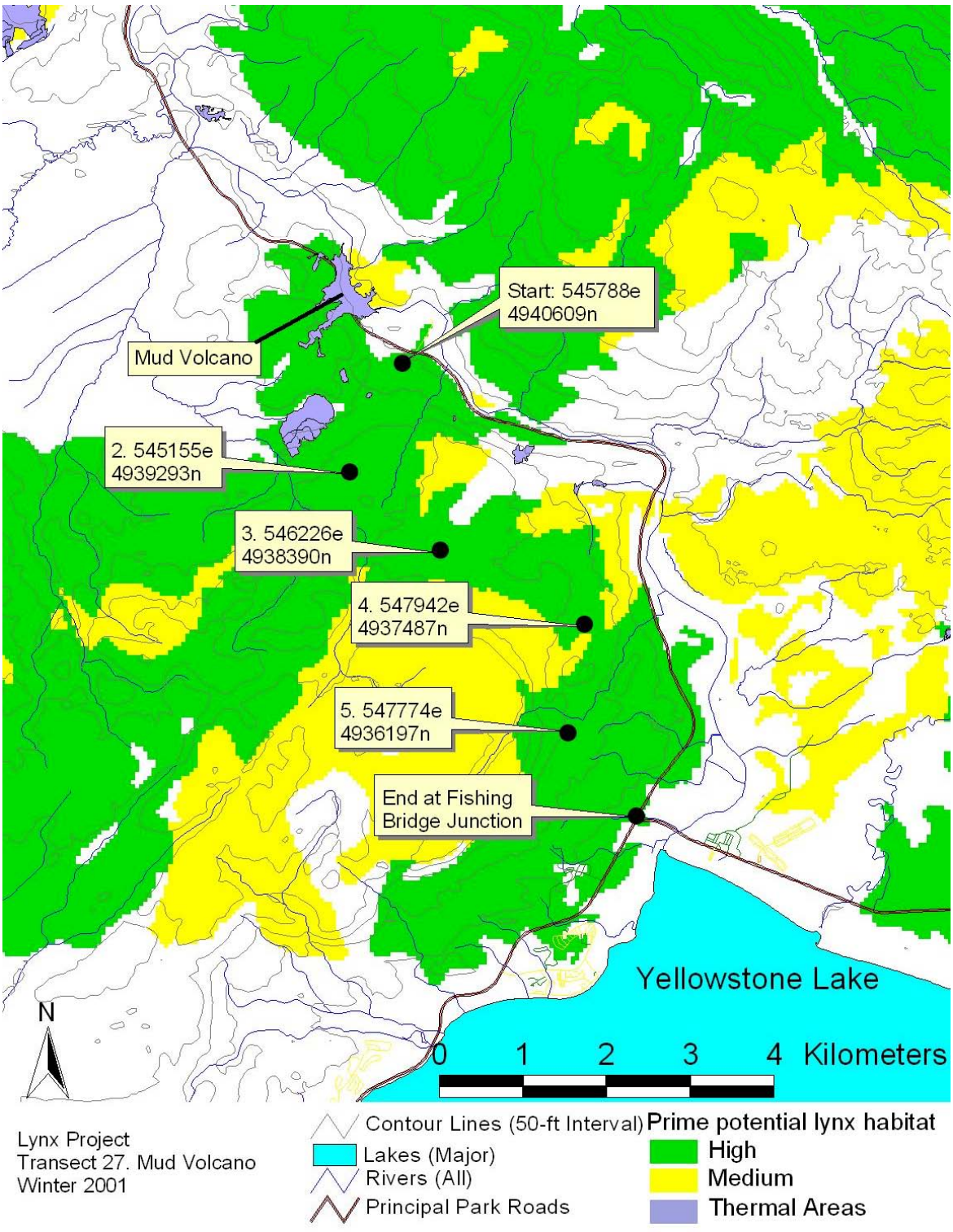

Figure 4. Location and route of a snow-tracking survey near Mud Volcano, Yellowstone National Park.

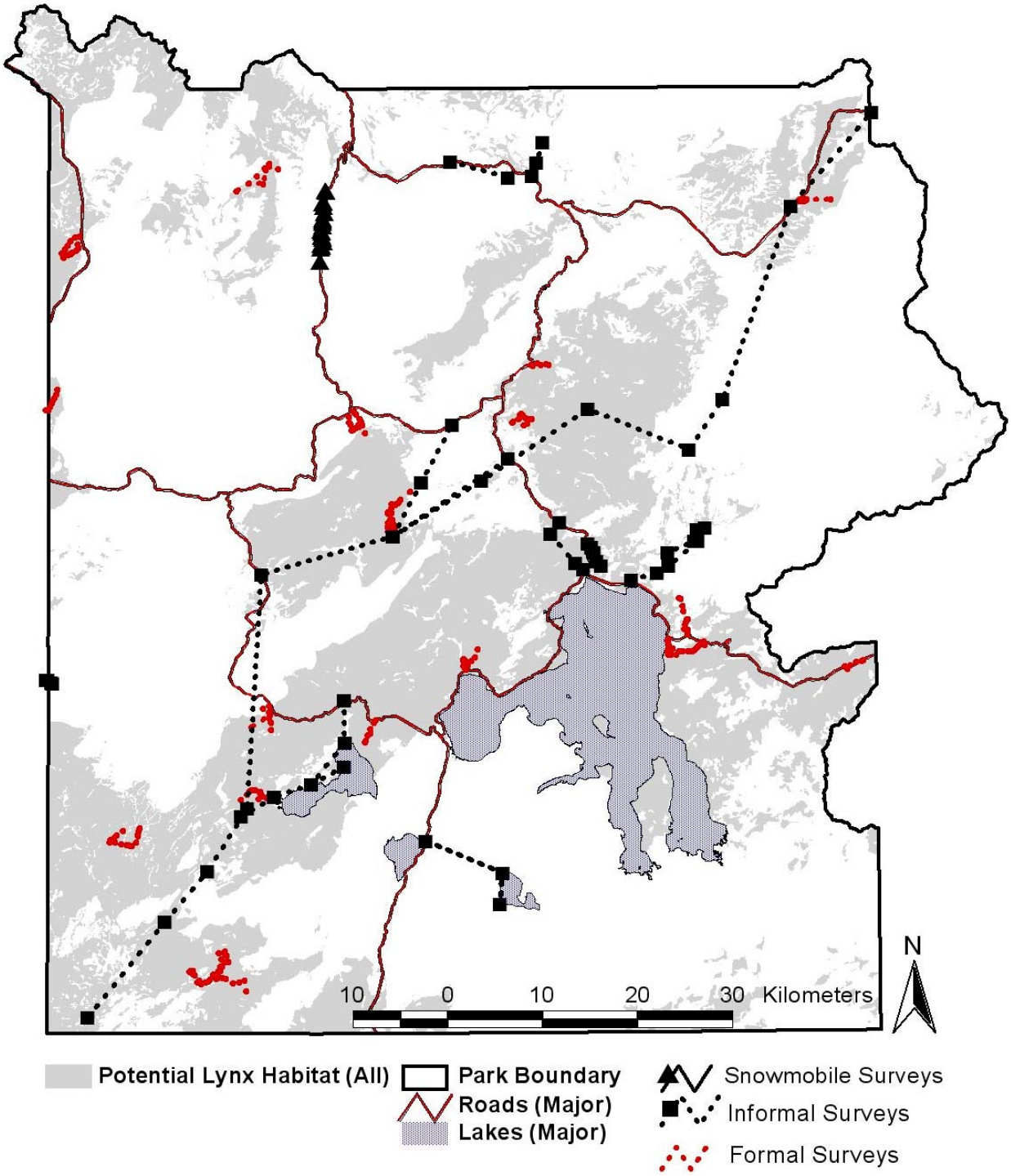

Figure 5. Snow tracking surveys, Yellowstone National Park, 2001.

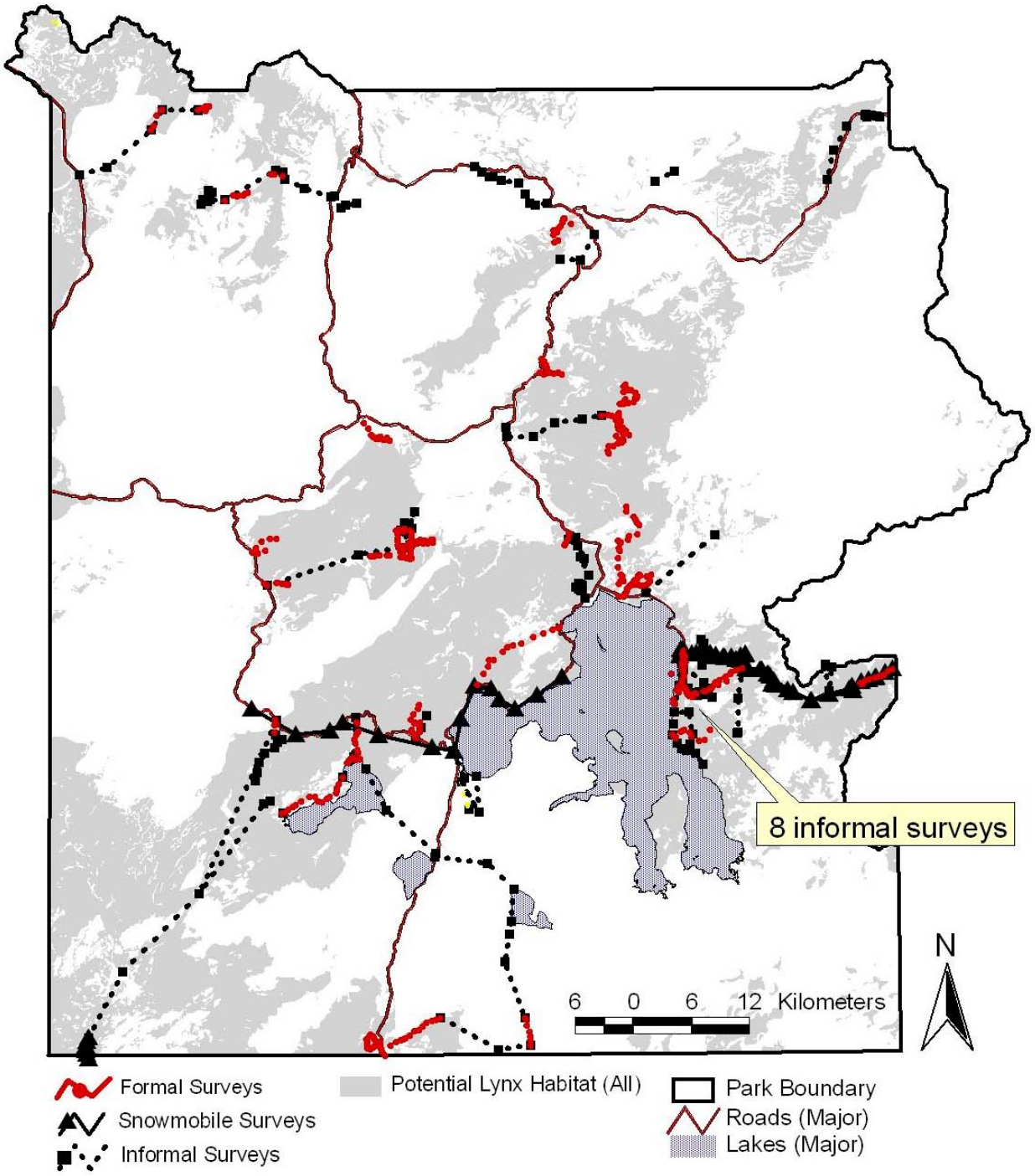

Figure 6. Snow tracking surveys, Yellowstone National Park, 2002.

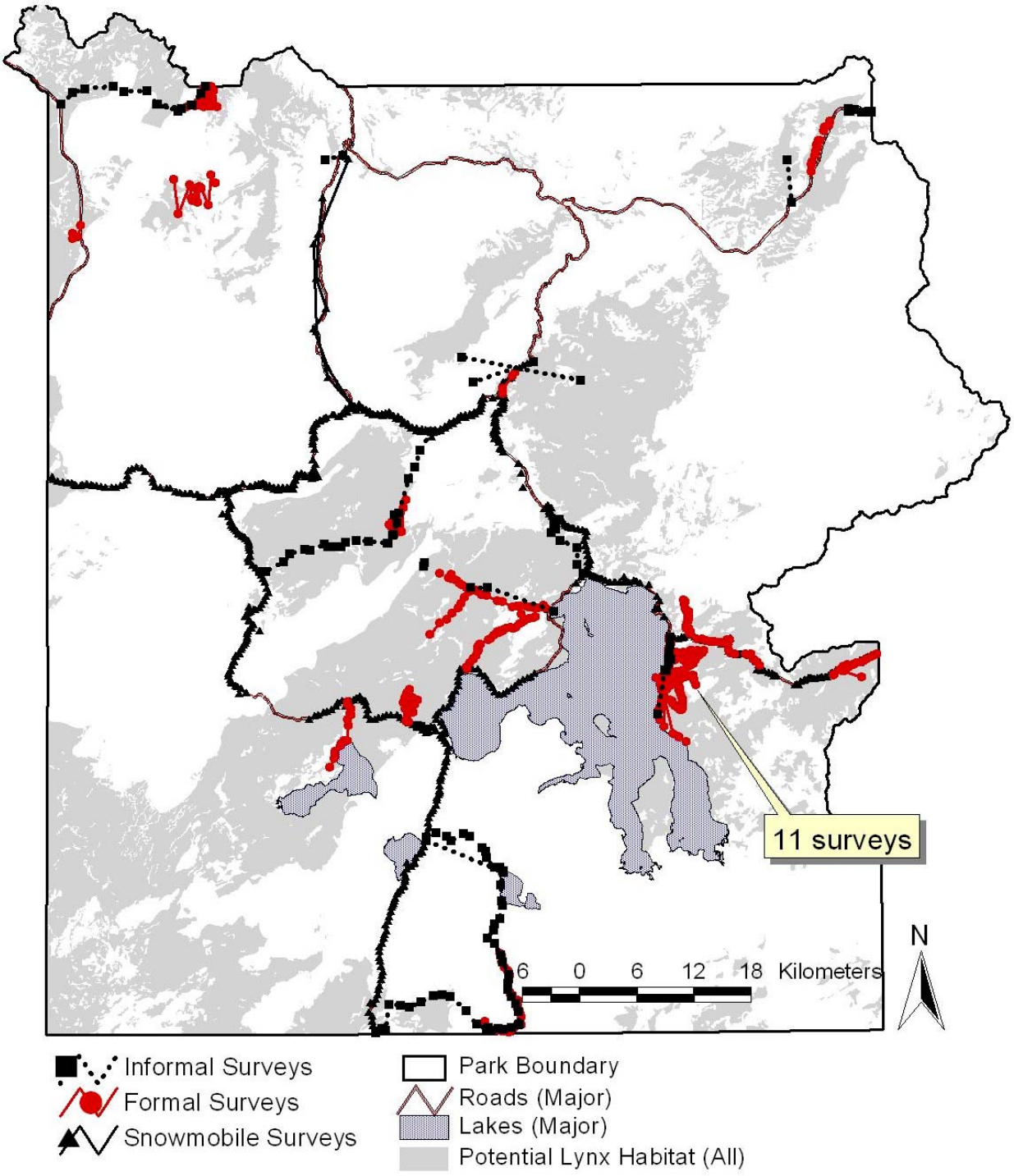

Figure 7. Snow tracking surveys, Yellowstone National Park, 2003.

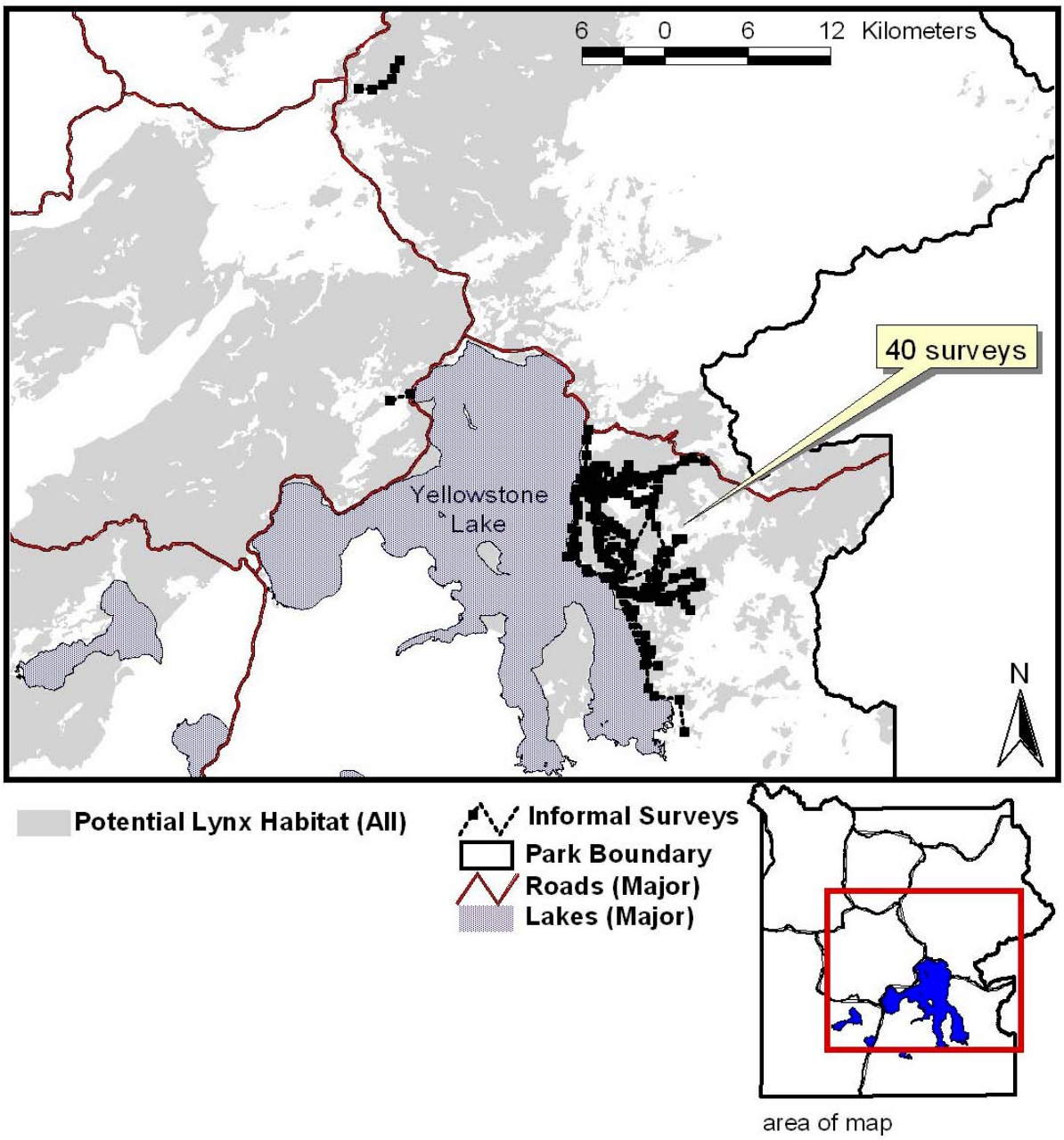

Figure 8. Snow tracking surveys, Yellowstone National Park, 2004.

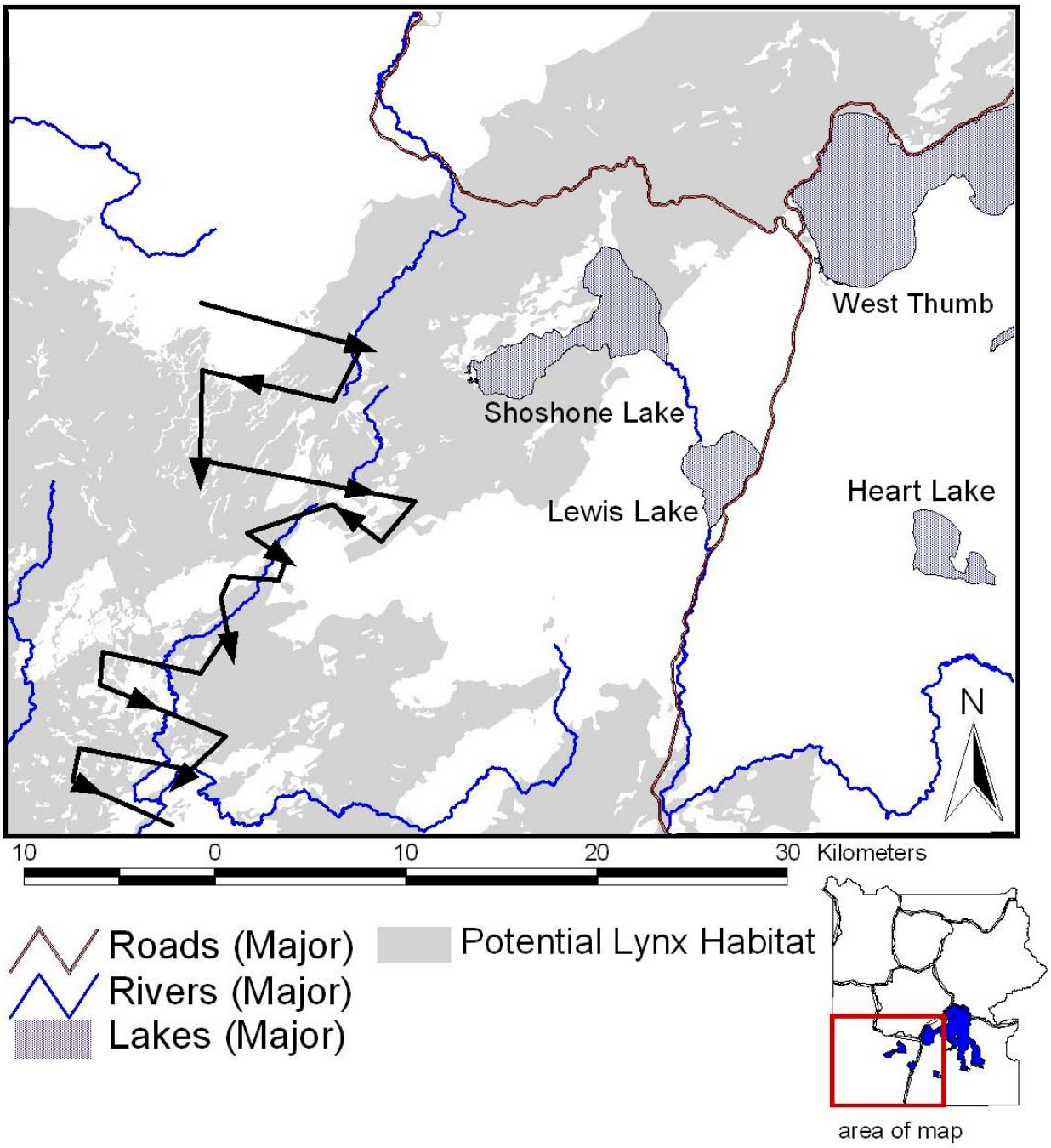

Figure 9. Example of an airplane-based snow tracking survey, Yellowstone National Park, 2002.

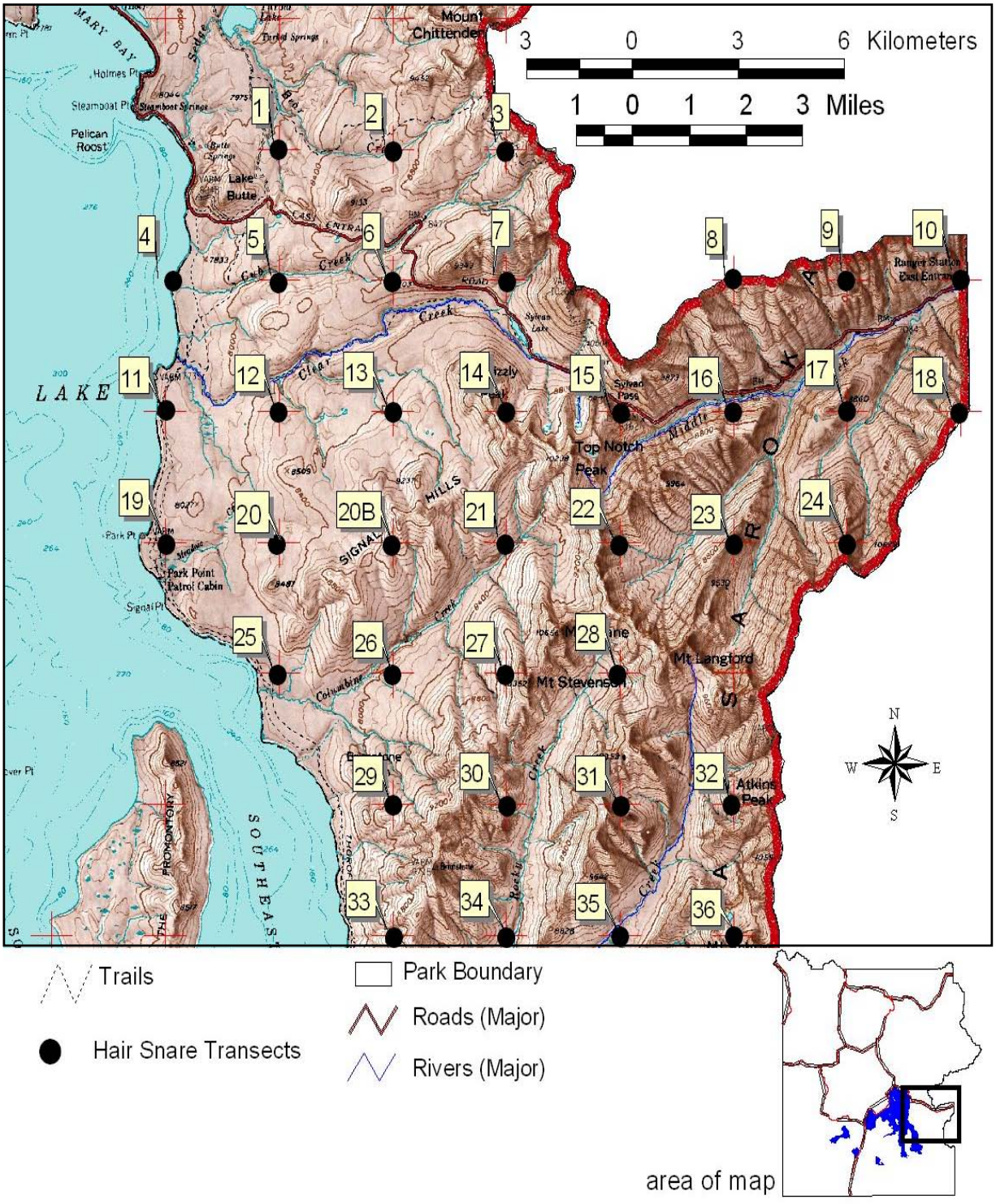

Figure 10. Layout for the formal (National Lynx Detection Protocol) hair-snare survey grid, east-central Yellowstone National Park, 2001-2003.

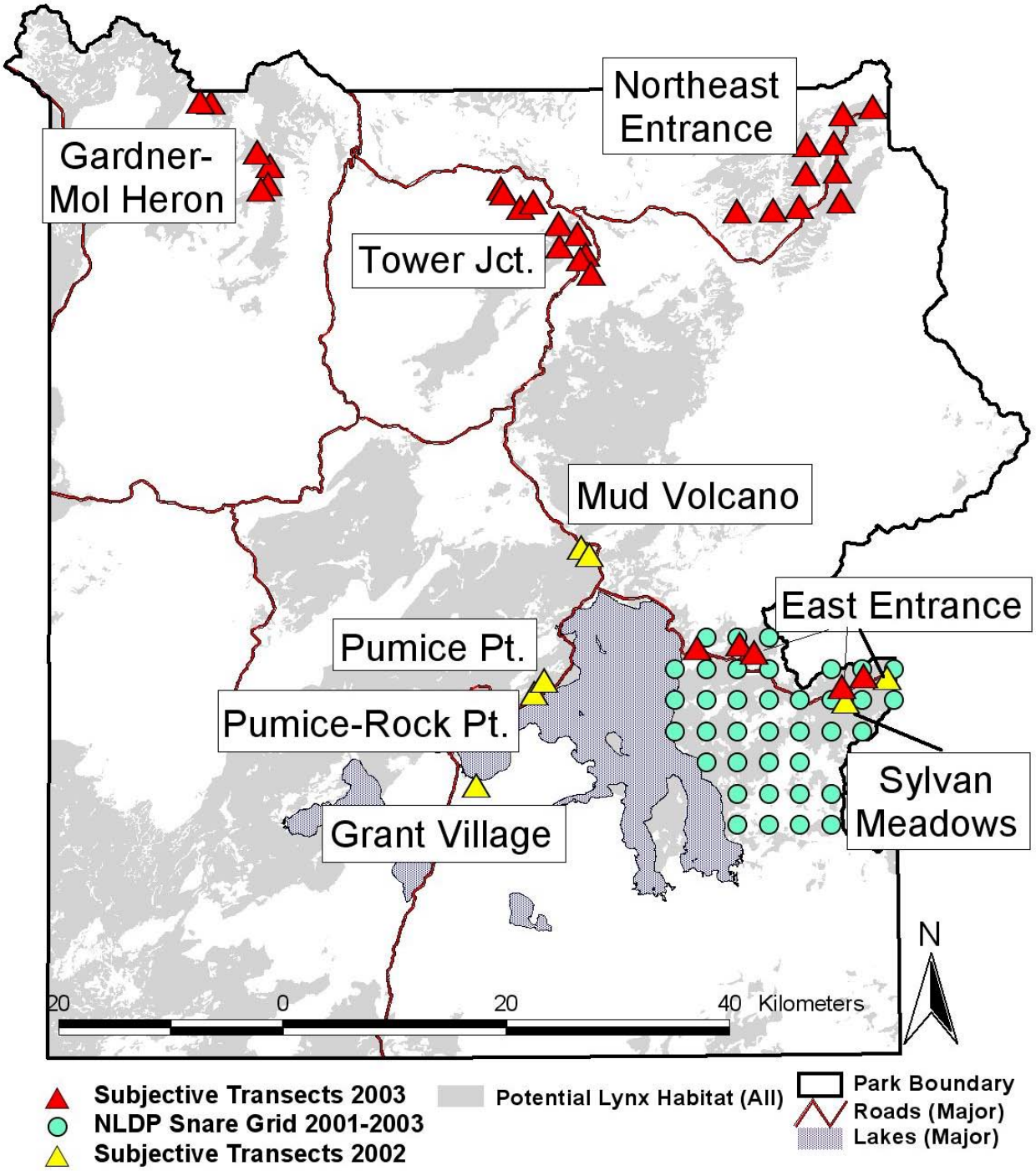

Figure 11. Hair-snare locations in Yellowstone National Park, 2001-2003.

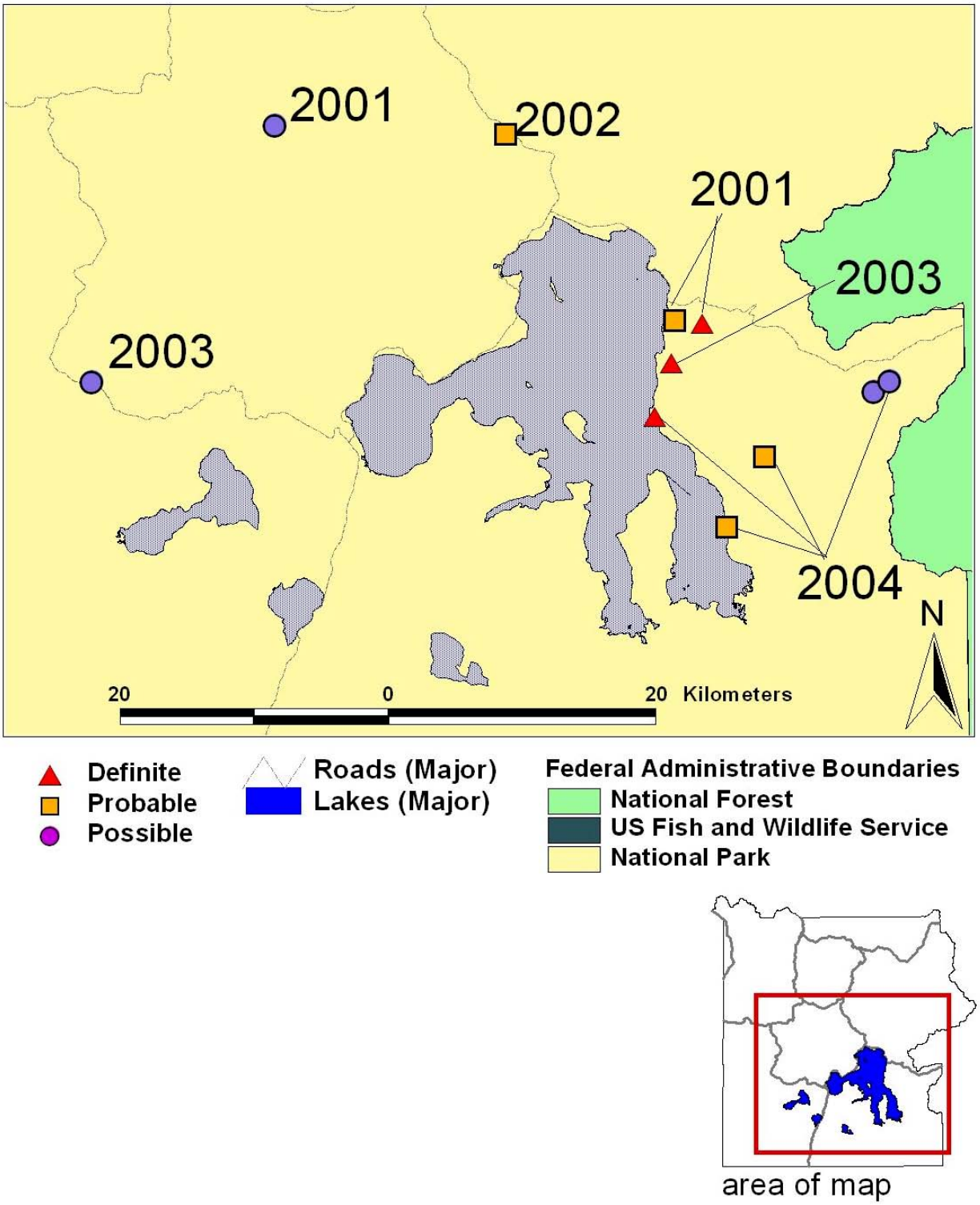

Figure 12. Canada lynx detections in Yellowstone National Park, 2001-2004.

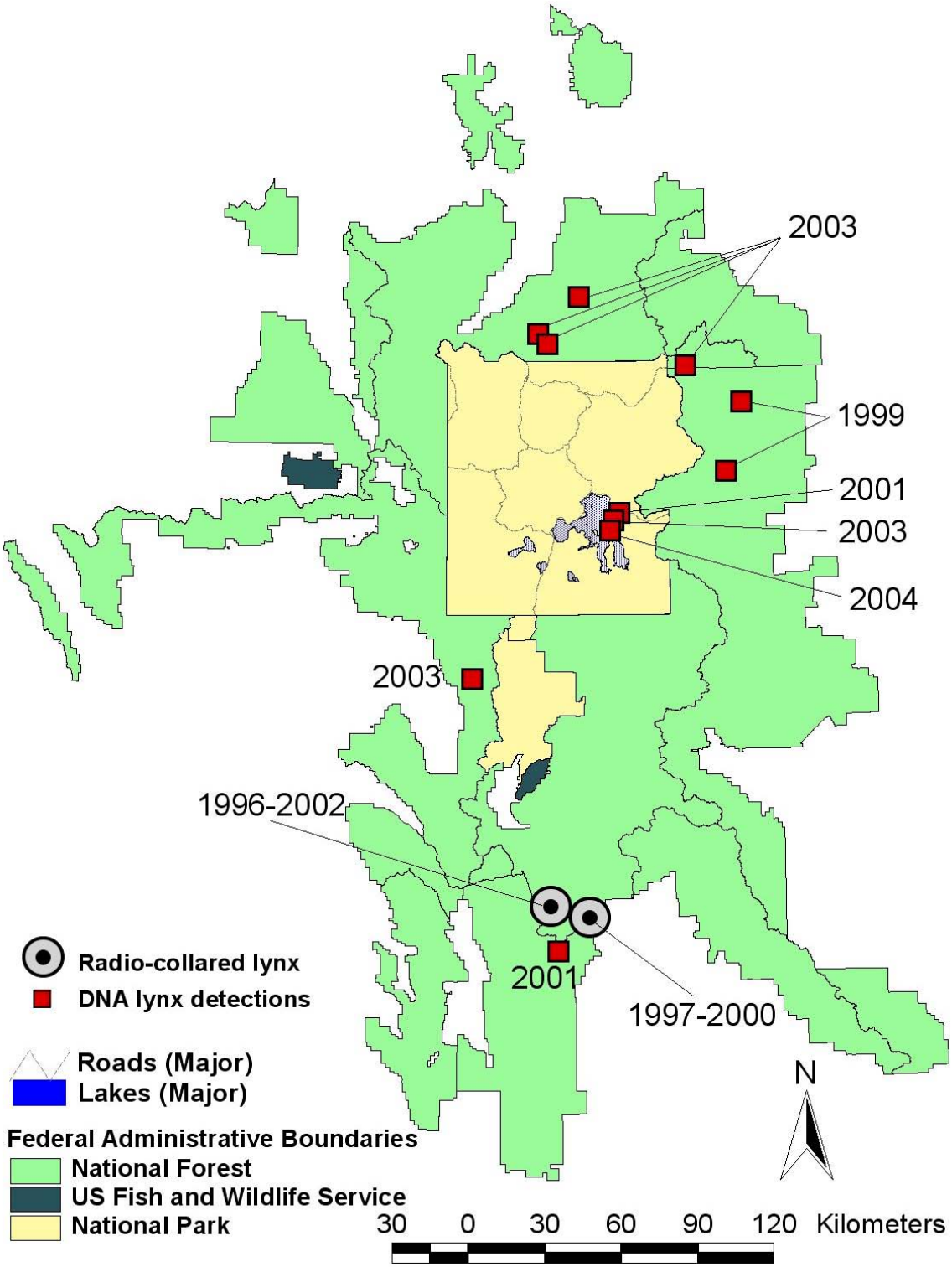

Figure 13. DNA-based detections of Canada lynx using hair snares, snow tracking, or captures for research in the Yellowstone Ecosystem, 2000-2004. Data from this study, Squires et al. (2003), and courtesy of the Gallatin, Caribou-Targhee, and Shoshone National Forests.

Appendix 1. Formal, informal, and snowmobile-based snow tracking transects completed winter 2001-2004, Yellowstone National Park.

Date	Sector	Location	Survey Distance (km)	Type
1/31/2001	Central Plateau	Virginia Cascade	6.1	Formal
2/9/2001	East	Middle Creek	0.8	Formal
2/10/2001	East	Middle Creek	2.9	Formal
2/11/2001	Old Faithful	Lonestar to Shoshone	3.9	Formal
2/13/2001	Canyon	Moss Cr, Wapiti Lake, Bluff to Pelican	4.7	Formal
2/14/2001	Canyon	Washburn Hot Springs	2.0	Formal
2/15/2001	Central Plateau	Natural Bridge (Power line)	2.6	Formal
2/18/2001	Old Faithful	Lonestar to Shoshone	2.4	Formal
2/18/2001	West	191 West	4.8	Formal
2/20/2001	Northeast	Thunderer	7.4	Formal
2/26/2001	Old Faithful	Shoshone West	0.8	Formal
2/28/2001	Old Faithful	Shoshone West	5.5	Formal
2/28/2001	Central Plateau	Virginia Cascade	2.7	Formal
3/3/2001	Bechler	Bechler	6.4	Formal
3/4/2001	West	191 West	8.5	Formal
3/6/2001	Old Faithful	Craig Pass	2.7	Formal
3/13/2001	Central Plateau	Mary Mountain	4.6	Formal
3/15/2001	Central Plateau	Mary Mountain	6.4	Formal
3/15/2001	Gallatins	Fawn Pass Trail (West)	6.0	Formal
3/16/2001	Central Plateau	Mary Mountain	3.8	Formal
3/16/2001	East	Lake Butte Overlook (Turbid Lake)	4.4	Formal
3/16/2001	Gallatins	Fawn Pass Trail (West)	2.1	Formal
3/17/2001	East	Clear Creek	6.2	Formal
3/29/2001	Bechler	Bechler	4.3	Formal
3/29/2001	Central Plateau	Arnica Creek	1.4	Formal
3/30/2001	Bechler	Bechler	7.9	Formal
3/31/2001	Bechler	Bechler	3.1	Formal
4/13/2001	East	Clear Creek	2.3	Formal
12/20/2001	East	Clear Creek	8.7	Formal
12/21/2001	East	Clear Creek	2.4	Formal
12/26/2001	South	Craig Pass	4.0	Formal
12/27/2001	South	Spirea Creek	5.3	Formal
1/2/2002	East	Clear Creek	1.7	Formal
1/3/2002	East	Clear Creek	2.7	Formal
1/5/2002	Old Faithful	Craig Pass	4.3	Formal
1/8/2002	Central Plateau	Mary Mountain	4.8	Formal
1/8/2002	Central Plateau	Mary Mountain	5.0	Formal
1/9/2002	Central Plateau	Mary Mountain	7.0	Formal
1/10/2002	Central Plateau	Mary Mountain	4.7	Formal
1/10/2002	Canyon	Washburn Hot Springs	5.5	Formal
1/11/2002	Central Plateau	Mary Mountain	0.7	Formal
1/14/2002	Central Plateau	Virginia Cascade	5.4	Formal
1/23/2002	Gallatins	Sportsman Lake	2.4	Formal
1/24/2002	Gallatins	Sportsman Lake	2.5	Formal
1/29/2002	East	Clear Creek	4.0	Formal

Appendix 1 (cont.)

Date	Sector	Location	Survey Distance (km)	Type
1/30/2002	East	Clear Creek	2.3	Formal
1/31/2002	East	Columbine Creek	0.9	Formal
2/4/2002	Central Plateau	Mud Volcano	1.3	Formal
2/5/2002	East	Middle Creek	3.8	Formal
2/6/2002	East	Lake Butte Overlook (Turbid Lake)	7.0	Formal
2/7/2002	Old Faithful	Delacy Creek	14.1	Formal
2/11/2002	East	Columbine Creek	2.6	Formal
2/12/2002	East	Columbine Creek	11.9	Formal
2/13/2002	East	Clear Creek	6.2	Formal
2/21/2002	Old Faithful	Lonestar to Shoshone	1.5	Formal
2/21/2002	Central Plateau	Nez Perce	2.8	Formal
2/21/2002	South	South-East Bechler: Harebell	3.0	Formal
2/22/2002	Central Plateau	Natural Bridge (Power line)	5.8	Formal
2/22/2002	South	Snake River/South Boundary	7.2	Formal
2/25/2002	Old Faithful	North Shore Shoshone Lake	3.9	Formal
2/26/2002	Old Faithful	North Shore of the Shoshone	4.4	Formal
3/13/2002	Canyon	Moss Cr, Wapiti Lake, Bluff to Pelican	2.9	Formal
3/14/2002	Canyon	Moss Cr, Wapiti Lake, Bluff to Pelican	8.3	Formal
3/15/2002	Canyon	Moss Cr, Wapiti Lake, Bluff to Pelican	8.7	Formal
3/16/2002	East	Moss Cr, Wapiti Lake, Bluff to Pelican	20.9	Formal
3/16/2002	Central Plateau	Mesa Pit	6.5	Formal
3/20/2002	Gallatins	Fawn Creek (East)	7.0	Formal
3/21/2002	Canyon	Tower Lost Creek	5.3	Formal
3/29/2002	Central Plateau	Natural Bridge (Power line)	5.2	Formal
12/16/2002	Northeast	Barronette	6.2	Formal
12/31/2002	Central Plateau	Arnica Creek	11.5	Formal
1/6/2003	East	Clear Creek	9.1	Formal
1/7/2003	East	Clear Creek	7.8	Formal
1/8/2003	East	Clear Creek	14.5	Formal
1/15/2003	East	Lake Butte Overlook (Turbid Lake)	4.1	Formal
1/29/2003	Central Plateau	Mary Mountain	4.9	Formal
1/29/2003	Central Plateau	Mary Mountain	2.5	Formal
2/5/2003	Old Faithful	Craig Pass	16.9	Formal
2/4/2003	East	Middle Creek	5.4	Formal
2/4/2003	East	Middle Creek	6.6	Formal
2/4/2003	Old Faithful	Delacy Creek	7.9	Formal
2/5/2003	Central Plateau	Natural Bridge (Power line)	9.7	Formal
2/11/2003	Gallatins	Sportsman Lake	2.7	Formal
2/12/2003	Gallatins	Sportsman Lake	6.9	Formal
2/12/2003	Gallatins	Sportsman Lake	2.3	Formal
2/26/2003	East	Clear Creek	3.1	Formal
2/26/2003	East	Clear Creek	3.9	Formal
2/26/2003	East	Clear Creek	3.7	Formal
2/27/2003	East	Lake Butte Overlook (Turbid Lake)	2.5	Formal
2/27/2003	East	Clear Creek	1.1	Formal
3/1/2003	Gallatins	Fawn Creek (East)	23.2	Formal
3/3/2003	West	191 West	2.4	Formal

Appendix 1 (cont.)

Date	Sector	Location	Survey Distance (km)	Type
3/12/2003	South	Snake River/South Boundary	18.4	Formal
3/13/2003	South	South-East Bechler: Harebell	4.5	Formal
3/18/2003	East	Clear Creek	6.5	Formal
3/18/2003	East	Columbine Creek	4.9	Formal
3/19/2003	East	Clear Creek	9.3	Formal
3/20/2003	East	Lake Butte Overlook (Turbid Lake)	2.6	Formal
3/20/2003	East	Clear Creek	4.1	Formal
3/25/2003	Central Plateau	Beach Lake	8.8	Formal
3/26/2003	Central Plateau	Beach Lake	4.3	Formal
3/26/2003	Central Plateau	Beach Lake	6.6	Formal
4/4/2003	Canyon	Washburn Hot Springs	3.4	Formal
2/1/2001	Northeast	Frog Rock	6.3	Informal
2/22/2001	Bechler	Thirsty Creek	0.8	Informal
2/26/2001	Old Faithful	Delacy Creek to Shoshone Lake	4.5	Informal
2/26/2001	Old Faithful	Shoshone Lake	5.7	Informal
2/27/2001	Old Faithful	Cove Cabin	4.1	Informal
2/28/2001	Old Faithful	Cove Cabin	4.1	Informal
3/1/2001	Old Faithful	Cove Cabin	4.1	Informal
3/1/2001	Old Faithful	Shoshone Geyser Basin	4.1	Informal
3/2/2001	Old Faithful	Cove Cabin	4.0	Informal
3/2/2001	Old Faithful	Shoshone Lake	7.0	Informal
3/4-16/2001	Other	Bechler Ranger Station to NE Entrance	90.3	Informal
3/12/2001	Central Plateau	Mary Mountain	14.6	Informal
3/14/2001	Central Plateau	Mary Mt. Cabin	6.4	Informal
3/16/2001	Central Plateau	Mary Mt. Cabin	13.3	Informal
3/22/2001	Old Faithful	Delacy Creek	4.4	Informal
3/25/2001	East	Pelican Valley	15.1	Informal
4/16-18/2001	South	Heart Lake	8.8	Informal
4/18/2001	Northeast	Hellroaring	3.8	Informal
4/24/2001	Central Plateau	Buffalo Ford Picnic Area-Mud Volcano	1.5	Informal
11/30/2001	Central Plateau	Howard Eaton Trail: Yellowstone River	2.7	Informal
12/31/2001	South	Riddle Lake	3.5	Informal
1/7/2002	Central Plateau	Cygnet Lakes	8.3	Informal
1/11/2002	South	Riddle Lake	3.0	Informal
1/11/2002	Central Plateau	Mary Mt. Cabin	5.3	Informal
1/12/2002	Central Plateau	Mary Mt. Cabin	15.4	Informal
1/14/2002	Northeast	Warm Springs	1.5	Informal
1/22/2002	Gallatins	Swan Lake to Fawn Pass	14.2	Informal
1/22/2002	Gallatins	Fawn Pass Trail to Sportsman Lake	15.0	Informal
1/23/2002	Gallatins	Fawn Pass Cabin	4.4	Informal
1/24/2002	Gallatins	Sportsman Lake to Fawn Pass Trailhead	15.0	Informal
2/1/2002	Old Faithful	Lonestar Geyser	19.5	Informal
2/2/2002	Northeast	Blacktail Drive	9.1	Informal
2/6/2002	Old Faithful	Delacy Creek	11.6	Informal
2/6/2002	East	Turbid Lake	1.0	Informal
2/10/2002	South	Heart Lake	9.2	Informal

Appendix 1 (cont.)

Date	Sector	Location	Survey Distance (km)	Type
2/11/2002	East	Clear Creek	3.0	Informal
2/20/2002	South	Heart Lake	9.3	Informal
2/21/2002	South	Heart Lake	13.7	Informal
2/22/2002	West	Harebell Cabin	10.2	Informal
2/22/2002	East	Turbid Lake	0.9	Informal
2/25/2002	Old Faithful	Delacy Beach	6.5	Informal
2/27/2002	Bechler	Three Rivers	13.9	Informal
2/28/2002	Bechler	Three Rivers	18.9	Informal
2/28/2002	East	Clear Creek	3.8	Informal
3/1/2002	South	Little Thumb Creek	2.5	Informal
3/12/2002	Canyon	Chittenden Bridge	9.2	Informal
3/13/2002	East	Pelican Valley	2.1	Informal
3/16/2002	South	West Thumb Geyser Basin	3.1	Informal
3/18/2002	South	Riddle Lake to Grant RS	7.3	Informal
3/20/2002	Northeast	Warm Springs (Northeast Entrance)	1.6	Informal
3/20/2002	Northeast	Barronette Trail	5.9	Informal
3/22/2002	Canyon	Tower Creek	5.1	Informal
3/25/2002	Central Plateau	Elephant Back	4.1	Informal
3/25/2002	East	Clear Creek	6.7	Informal
3/25/2002	East	Pelican Valley	9.3	Informal
3/26/2002	East	Clear Creek	6.4	Informal
3/27/2002	East	Thorofare Trail	6.9	Informal
3/27/2002	East	Clear Creek to Park Point	8.6	Informal
3/27/2002	East	Astrigent Knob	9.3	Informal
3/28/2002	East	Clear Creek	3.8	Informal
3/28/2002	East	Turbid Lake Road	2.6	Informal
3/29/2002	Canyon	Tower Creek	5.1	Informal
3/30/2002	East	Clear Creek	10.5	Informal
4/2/2002	Old Faithful	Lonestar Geyser	7.7	Informal
4/4/2002	Central Plateau	Mud Volcano	7.2	Informal
4/21/2002	Gallatins	Swan Lake Flats	3.2	Informal
9/5/2002	East	Signal Hills	7.0	Informal
10/15/2002	East	East Entrance Road	5.2	Informal
11/8/2002	Northeast	Slough Creek	2.2	Informal
12/1/2002	South	Heart Lake	8.8	Informal
12/1/2002	South	Heart Lake	8.8	Informal
12/28/2002	Old Faithful	Craig Pass	1.1	Informal
1/2/2003	Northeast	Bannock Trail	2.8	Informal
1/2/2003	Gallatins	Upper Terrace to Snow Pass	1.8	Informal
1/30/2003	Central Plateau	Mary Mountain	12.1	Informal
2/2/2003	East	Clear Creek	3.9	Informal
2/10/2003	Gallatins	Sportsman Lake	4.1	Informal
2/13/2003	Northeast	Sportsman Cabin	19.8	Informal
2/13/2003	Gallatins	Sportsman Lake	4.1	Informal
2/22/2003	Canyon	Cascade Creek	12.6	Informal
2/22/2003	Canyon	Cascade Lake	6.7	Informal
2/27/2003	Central Plateau	Mary Mountain	15.8	Informal

Appendix 1 (cont.)

Date	Sector	Location	Survey Distance (km)	Type
3/5/2003	Northeast	Pebble Creek	4.5	Informal
3/11/2003	South	Trailhead - Heart Lake	10.0	Informal
3/12/2003	South	Heart Lake - Harebell Cabin	30.4	Informal
3/13/2003	South	South Boundary Trail	18.7	Informal
3/17/2003	East	Clear Creek	4.6	Informal
3/17/2003	East	Ninemile Trail	3.2	Informal
3/25/2003	Central Plateau	Upper Central Plateau	0.4	Informal
3/26/2003	Central Plateau	Beach Lake	9.2	Informal
3/31/2003	Central Plateau	Mud Volcano area	7.5	Informal
12/29/2003	East	Clear Creek	3.1	Informal
12/30/2003	Central Plateau	Buffalo Picnic area	1.3	Informal
12/30/2003	East	Clear Creek to Columbine Creek	10.1	Informal
1/7/2004	East	Clear Creek	2.3	Informal
1/8/2004	East	Clear Creek	3.0	Informal
1/13/2004	East	Clear Creek to Park Point	3.5	Informal
1/14/2004	East	Clear Creek	2.7	Informal
1/27/2004	Canyon	Glacial Boulder	3.1	Informal
1/28/2004	East	Ninemile Trail	2.9	Informal
1/29/2004	East	Clear Creek	8.1	Informal
2/2/2004	East	Clear Creek	4.2	Informal
2/2/2004	East	Ninemile Trail	3.6	Informal
2/2/2004	East	Clear Creek	3.4	Informal
2/3/2004	East	Clear Creek to Columbine Creek	9.4	Informal
2/4/2004	East	Columbine Creek	3.9	Informal
2/9/2004	East	Ninemile Trail	3.6	Informal
2/9/2004	East	Clear Creek to Park Point	5.7	Informal
2/9/2004	East	Clear Creek	4.0	Informal
2/10/2004	East	Clear Creek	3.2	Informal
2/10/2004	East	Clear Creek	2.0	Informal
2/10/2004	East	Clear Creek	4.6	Informal
2/11/2004	East	Clear Creek	11.9	Informal
2/11/2004	East	Clear Creek	7.8	Informal
2/23/2004	East	Ninemile Trail to Columbine Creek	13.1	Informal
2/24/2004	East	Columbine Creek	7.3	Informal
2/24/2004	East	Columbine Creek	7.1	Informal
2/25/2004	East	Columbine Creek to Thorofare Trail	5.6	Informal
2/25/2004	East	Columbine Creek	7.5	Informal
3/1/2004	East	Ninemile Trail to Columbine Creek	13.1	Informal
3/2/2004	East	Signal Hills	10.8	Informal
3/3/2004	East	Columbine Creek to Thorofare Trail	9.0	Informal
3/3/2004	East	Columbine Creek to Park Point	7.5	Informal
3/4/2004	East	Columbine Creek	3.7	Informal
3/8/2004	East	Ninemile Trail to Columbine Creek	12.3	Informal
3/9/2004	East	Columbine Creek to Rocky Creek	10.3	Informal
3/9/2004	East	Columbine Creek to Park Point	9.7	Informal
3/10/2004	East	Columbine Creek	9.5	Informal
3/10/2004	East	Signal Hills	12.5	Informal

Appendix 1 (cont.).

Date	Sector	Location	Survey Distance (km)	Type
3/15/2004	East	Clear Creek	6.9	Informal
3/17/2004	East	Clear Creek to Meadow Creek	11.6	Informal
3/18/2004	East	Ninemile Trail	3.7	Informal
3/18/2004	Central Plateau	Natural Bridge	1.6	Informal
3/22/2004	East	Ninemile Trail to Columbine Creek	12.3	Informal
3/16/2004	East	Cub and Clear Creeks	7.4	Informal
3/23/2004	East	Columbine Creek to Thorofare Trail	6.2	Informal
1/5/2001	Gallatins	Mammoth to Norris	15.7	Snowmobile
1/8/2001	Gallatins	Mammoth to Norris	5.7	Snowmobile
1/31/2002	East	Lake to East	54.2	Snowmobile
2/13/2002	East	Lake to East	62.8	Snowmobile
2/20/2002	Old Faithful	West Thumb to Old Faithful	40.0	Snowmobile
3/1/2002	Bechler	Bechler	2.3	Snowmobile
1/5/2003	Central Plateau	Lake to West Thumb	8.5	Snowmobile
1/9/2003	East	Lake to East	16.7	Snowmobile
1/14/2003	West	Madison to Norris	7.2	Snowmobile
1/14/2003	West	Madison to Norris	6.2	Snowmobile
1/14/2003	West	Madison to Norris	6.1	Snowmobile
1/14/2003	West	West to Norris	6.8	Snowmobile
1/14/2003	West	Madison to West	3.0	Snowmobile
1/16/2003	Central Plateau	Mud Volcano to East	0.7	Snowmobile
1/16/2003	Canyon	Canyon to Mud Volcano	14.7	Snowmobile
1/16/2003	Canyon	Norris to Canyon	18.4	Snowmobile
1/20/2003	South	West Thumb to South	16.9	Snowmobile
2/3/2003	South	West Thumb to South	33.7	Snowmobile
2/3/2003	Central Plateau	Lake to West Thumb	8.9	Snowmobile
2/4/2003	Central Plateau	Canyon to Mud Volcano	22.4	Snowmobile
2/5/2003	Old Faithful	Old Faithful to Madison	18.7	Snowmobile
2/6/2003	Old Faithful	West Thumb to Old Faithful	18.3	Snowmobile
2/6/2003	East	Lake to East	39.2	Snowmobile
2/6/2003	Old Faithful	Old Faithful to Madison	22.4	Snowmobile
2/18/2003	East	Lake to East	8.8	Snowmobile
2/18/2003	Central Plateau	Canyon to Mud Volcano	23.9	Snowmobile
2/18/2003	Canyon	Norris to Canyon	18.5	Snowmobile
2/19/2003	West	West to Norris	52.8	Snowmobile
2/19/2003	Old Faithful	Old Faithful to Madison	23.1	Snowmobile
2/25/2003	Gallatins	Mammoth to Norris	19.3	Snowmobile
2/25/2003	Canyon	Norris to Canyon	10.5	Snowmobile
2/25/2003	Central Plateau	Canyon to Lake	17.4	Snowmobile
2/25/2003	East	Lake to Nine Mile	8.2	Snowmobile
2/27/2003	East	Lake to East	7.8	Snowmobile
2/27/2003	East	Lake to East	17.9	Snowmobile
2/28/2003	East	Nine Mile to Lake	7.9	Snowmobile
2/28/2003	Central Plateau	Lake to Canyon	18.1	Snowmobile
2/28/2003	Gallatins	Norris to Mammoth	23.9	Snowmobile
2/28/2003	Canyon	Canyon to Norris	15.6	Snowmobile

Appendix 1 (cont.)

Date	Sector	Location	Survey Distance (km)	Type
3/6/2003	West	Madison to Norris	16.3	Snowmobile
3/20/2003	East	Lake Butte Overlook (Turbid Lake)	9.9	Snowmobile

Appendix 2. Locations of NLDP hair snare transects and their attributes measured in 2002, Yellowstone National Park. Means are calculated for the five stations.

Site No.	UTM- E	UTM- N	Overstory Dominant Spp. - Mean %	Understory Dominant Spp. - Mean %	Mean Elevation (meters)	Mean Slope (%)	Aspect (range in degrees)
1	559997	4929827	PICO- 60	ABLA- 50	2472	6	234-20
2	561350	4929976	PIEN- 50	ABLA- 50	2648	4	226-348
3	566402	4929953	PIEN- 65	ABLA- 80	2797	14	220-303
4	557189	4926885	PIEN- 45	PIAL- 35	2400	1	260-30
5	559988	4926776	PIEN- 45	PICO- 40	2471	8	174-349
6	563157	4926788	PIEN- 65	Vaccinium sp.[1]-60	2557	2	270-328
7	566395	4926858	ABLA- 85	ABLA- 90	2663	11	209-232
8	572808	4926755	PIAL- 100	PIAL- 80	2971	24	188-224
9	576018	4926745	ABLA- 60	ABLA- 95	2674	28	164-197
10	579505	4926887	PSME- 85	PSME- 30	2259	29	324-175
11	556905	4923581	PICO- 60	PIEN- 205	2430	1	315-54
12	560014	4923506	PICO- 85	Vaccinium sp.[1]- 60	2510	2	269-342
13	563132	4923490	PICO- 75	Vaccinium sp.[1] -35	2623	1	310-14
14	566378	4923544	ABLA- 75	ABLA- 60	2780	6	35-102
15	569586	4923540	PIAL- 55	ABLA- 40	2652	39	46-132
16	572836	4923557	ABLA- 30	ABLA- 25	2371	23	342-178
17[a]	576023	4923548	ABLA- 85	ABLA- 60	2608	18	60-312
18	578884	4923892	PIAL- 55	ABLA- 75	2768	15	330-360
19	556778	4920388	PIEN- 55	Vaccinium sp.[1]- 35	2432	1	20-198
20	559919	4920345	PICO- 60	Vaccinium sp.[1]-35	2536	2	250-280
20B	563158	4920059	PIEN- 50	Vaccinium sp.[1]-35	2704	7	60-350
21	566346	4920228	PICO- 35	Vaccinium sp.[1]-55	2608	5	40-210
22	569846	4920487	PIAL- 85	PIAL- 90	2929	29	150-320
23	572865	4920496	ABLA- 55	Vaccinium sp.[1]- 45	2702	15	292-359
24[b]	576065	4920725	PIAL- 50	Vaccinium sp.[1]- 50	2976	13	285-318
25	559967	4917112	PICO- 65	Vaccinium sp.[1]- 50	2393	1	304-72
26	563136	4917109	PICO- 45	Vaccinium sp.[1]- 65	2475	8	300-326
27	566224	4917089	ABLA- 45	Vaccinium sp.[1]- 40	2705	8	224-264
28	569443	4917078	PIAL- 60	Vaccinium sp.[1]- 55	2757	8	208-350
29	563161	4913889	PIAL- 55	Vaccinium sp.[1]- 60	2595	9	276-46
30	566917	4914049	PICO- 65	Vaccinium sp.[1]- 80	2601	18	69-114
31	569710	4913412	PIAL- 45	ABLA- 50	2858	19	145-182
32	572793	4913930	ABLA- 45	Vaccinium sp.[1]- 85	2906	24	221-278
33	563171	4910679	PIEN- 35	ABLA- 75	2595	27	205-288
34	566331	4910702	PICO- 60	Vaccinium sp.[1]- 65	2489	16	40-106
35	569551	4910645	PICO- 80	Vaccinium sp.[1]- 85	2528	10	160-254
36	572536	4910812	PIAL- 40	Vaccinium sp.[1]- 40	2945	9	240-350

[1]PICO- *Pinus contorta* (Lodgepole pine); PIAL- *Pinus albicaulis* (Whitebark pine); ABLA- *Abies lasiocarpa* (Subalpine fir); PIEN- *Picia engelmannii* (Engelmann spruce); PSME- *Pseudopsuga menziesii* (Douglas fir)

[a] Site attributes measured during 2001.

[b] Site attributes measured during 2003.