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2006 Canada Lynx Assessment
Final Report

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Minnesota

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Prepared By:

Stuart L. Paulus, Ph.D.
Steve Loch

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Contents

EXECUTIVE SUMMARY E-1

1.0 INTRODUCTION 1

1.1 Study Overview 1-1

1.2 Previous Lynx Studies at Mine Site 1-1

1.3 Study Purpose 1-2

2.0 STATUS OF THE SPECIES 2-1

2.1. Background Documents Used to Prepare Assessment 2-1

2.2. Status of the Species 2-1

2.2.1. Species and Critical Habitat Description 2-1

2.2.2. Distribution 2-1

2.2.3. Population Dynamics 2-2

2.2.4. Habitat Requirements 2-4

2.2.5. Range of Lynx within the Contiguous United States 2-5

3.0 STUDY AREA AND METHODS 3-1

3.1. Study Area 3-1

3.2. Methods 3-1

3.2.1. Literature Review and Personal Communications 3-1

3.2.2. Database Queries 3-1

3.2.3. Field Surveys 3-1

3.2.4. DNA Analysis 3-3

3.2.5. Lynx Habitat Use and Density 3-3

4.0 RESULTS 4-1

4.1. Literature Review 4-1

4.2. Database Queries 4-1

4.3. Field Surveys 4-1

4.3.1. Snow Tracking Survey 4-1

4.3.2. Individual Lynx Movements and Sign 4-2

4.4. DNA Analysis 4-3

4.5. Lynx Density 4-3

4.6. Lynx Habitat Use 4-4

4.6.1. Mine Site 4-4

4.6.2. Non Mine Site 4-4

4.7. Other Observations 4-5

5.0 FACTORS AFFECTING CANADA LYNX AND THEIR HABITATS WITHIN THE STUDY AREA 5-1

5.1. Factors Identified in Final Rule 5-1
5.2. Other Lynx Risk Factors 5-1
5.3. Current Non-federal Regulatory and Conservation Mechanisms within the study area 5-2

6.0 LIKELY EFFECTS TO CANADA LYNX FROM THE MINE PROJECT 6-1

6.1. Determination of Effects 6-1
6.1.1. Types of Effects 6-1
6.1.2. Factors Affecting Lynx Productivity 6-1
6.1.3. Recreation 6-5
6.1.4. Forest/Backcountry Roads and Trails 6-6
6.1.5. Factors Affecting Lynx Mortality 6-6
6.1.6. Factors Affecting Lynx Movements 6-8
6.1.7. Other Large-scale Risk Factors 6-9
6.2. Conservation Measures 6-10
6.2.1. Factors Affecting Lynx Productivity 6-10
6.2.2. Factors Affecting Lynx Mortality 6-12
6.3. Factors Affecting Lynx Movements 6-13
6.4. Other Large-scale Risk Factors 6-13

7.0 REFERENCES 7-1

List of Tables

1 Miles Surveyed for Lynx in Each Township 4-2
2 Lynx Identified by DNA Analysis of Scat 4-3

List of Figures

1 Study Location 1-3
2 Contiguous United States Range of the Canada Lynx 2-9
3 Study Area 3-5
4 Lynx Sightings 3-7
5 Lynx Sightings in Minnesota since 2000 3-9
6 General Location of Surveys 4-7
7 Survey Routes Township 60 North Range 14 West 4-9
8 Survey Routes Township 60 North Range 13 West 4-11
9 Survey Routes Township 59 North Range 14 West 4-13
10 Survey Routes Township 59 North Range 13 West 4-15
11 Survey Routes Township 59 North Range 12 West 4-17
12 Survey Routes, Lynx Tracks, and Lynx Sign Township 60 North Range 12 West 4-19
13 Survey Routes, Lynx Tracks, and Lynx Sign Township 58 North Range 13 West 4-21
14 Survey Routes, Lynx Tracks, and Lynx Sign Township 59 North Range 11 West 4-23
15 Lynx Scat Collection Sites 4-25
16 Lynx 2 Activity Township 60 North Range 11 West and Township 60 North Range 12 West 4-27
17 Lynx 2 Activity Township 58 North Range 12 West and Township 58 North Range 13 West 4-29

EXECUTIVE SUMMARY

We studied Canada lynx (lynx; *Lynx canadensis)* abundance, movement, and habitat use in the vicinity of the PolyMet Mining Company, Inc. (PolyMet), NorthMet Mine and Ore Processing Facilities Project site in St. Louis County, Minnesota. Lynx are a federally-listed threatened species. The mine site is in the core area used by lynx in Minnesota, and the U.S. Fish and Wildlife Service has proposed critical habitat designations near the project site. Information collected during the study will support mine project environmental review and permitting efforts and help identify additional data collection requirements. The information also supports federal Endangered Species Act consultation for the proposed project.

The study area extended out approximately 6 miles (9.6 kilometers [km]) from the project site and encompassed an area of approximately 250 square miles (647 square km). The status of lynx in the area was determined from the literature, database queries, and interviews with persons knowledgeable about lynx in northern Minnesota. Field surveys were conducted during January through March 2006. Seven townships within the study area were intensively surveyed for lynx and their sign. When lynx or other felid tracks were found, tracks were followed for at least 1.5 miles (2.5 km), or until a lynx scat or hair sample was found. Scat found along tracks was collected and the DNA was analyzed to determine the species, age, and sex, and to determine if individual lynx found during the survey were related (close family members).

About 25% of lynx sightings in Minnesota since 2000 have occurred in St. Louis County. The Superior National Forest genetic reference collection and NRRI studies shows that 20 unique lynx have been found within 18 miles (30 km) of the study area. We surveyed transects on 33 days and snow-tracked lynx on 11 days. Approximately 539 miles (862 km) were surveyed within the study area, and 77 miles (123 km) in townships adjacent to the study area. Tracks were intercepted at 22 locations during transect surveys. Another 37 lynx track intercepts were found incidentally during periods when we were not conducting transect surveys. We tracked three lynx during the study and followed lynx tracks for about 8.6 miles (13.8 km) in the study area and 1.7 miles (2.8 km) adjacent to the study area. Eight scat were analyzed for their DNA. Based on DNA analysis, three unique female lynx were identified in the study area, and a fourth female was found adjacent to the study area. We observed suitable habitat for lynx throughout the study area, except where lands had been disturbed by past or ongoing mining operations. Patches of mature jack pine (*Pinus banksiana*) with a dense cover of balsam fir (*Abies balsamea*) in the understory, and pole jack pine forest with a dense understory of balsam fir and other conifers were important lynx habitats. These habitats also were important to snowshoe hare (*Lepus canadensis*), an important prey of lynx. Residents reported lynx in the study area, including a lynx with kittens, and lynx taken by trappers.

Numerous habitat and human-disturbance factors influence lynx use of an area. Factors most important in the study area include timber management, mining activity, and habitat fragmentation. The mine project would remove forestlands, reduce the amount of available habitat for lynx, and increase habitat fragmentation; some of this habitat could be reclaimed after mine closure. However, large tracts of land associated with the Superior National Forest and adjacent to the mine project would be managed for lynx and other wildlife habitat. These lands would also reduce the amount of habitat fragmentation within the region and help to maintain travel corridors between areas of suitable habitat.

To conserve lynx in the area, PolyMet would continue to follow lynx studies being conducted in the region and implement recommendations from those studies that are appropriate for the project site. PolyMet would also reclaim the mine site, maintain vegetated buffers around the project site, close the site to recreation until after the site is reclaimed, minimize the number of roads constructed in the mine project area, and educate workers on the need to observe speed limits and take measures to protect lynx and other wildlife.

1.0 INTRODUCTION

1.1 Study Overview

PolyMet Mining Company, Inc. (PolyMet) proposes to construct an open-pit low-grade polymetallic mineral mine at the NorthMet Mine and Ore Processing Facilities Project site (mine site) in northern Minnesota, located approximately 60 miles (96 kilometers [km]) north of Duluth, and 6 miles (9.6 km) south of Babbitt, Minnesota (Figure 1). PolyMet plans to mine and process polymetallic ore from the northwest portion of the Duluth Complex. The ore contains copper, nickel, gold, platinum, palladium, and cobalt.

The proposed mine site is located in St. Louis County on the eastern end of the Mesabi Iron Range. The mine site is 1.5 to 2 miles (2.4 to 3.2 km) south of the active Northshore Mining Company open-pit taconite mine and 8.3 miles (13.3 km) east of Cliffs Erie's taconite processing operations. The mine site encompasses approximately 3,015 acres (1,220 hectares [ha]) in Township 59 North, Range 13 West, Sections 1, 2, 3, 9, 10, 11, and 12 in St. Louis County, Minnesota. The property is zoned for mining, and PolyMet has a 100 percent leasehold interest in the property. Most of the mineral rights are owned by RGGS, and the surface is managed by the U.S. Department of Agriculture (USDA) Forest Service (Forest Service). The mine site, which is in a previously logged forest area, is located in the Partridge River drainage, about 3 miles (4.8 km) south of Iron Lake and the Laurentian Divide. The Partridge River is in the watershed of the East St. Louis River, which discharges into Lake Superior.

PolyMet plans to operate a processing facility (mill site) at the Cliffs Erie (former LTV) mill near Hoyt Lakes, Minnesota, which will produce copper cathode, and separate platinum/palladium group metals sulfide and nickel/cobalt hydroxide concentrates, for off-site shipment and treatment. Ore would be transported between the mine site and mill site by using the privately run Cliffs Erie Railroad located along the Dunka Road.

This project would impact over 3,000 acres (1,215 ha) of habitat used by wildlife, including Canada lynx (*Lynx canadensis;* lynx), a federally-listed threatened species residing in northern Minnesota. The lynx is a medium-sized cat with long legs; large, well-furred paws; long tufts on its ears; and a short, black-tipped tail (McCord and Cardoza 1982). The lynx's long legs and large feet make it highly adapted for hunting in deep snow. Lynx are highly specialized predators of snowshoe hare. In general, lynx habitat can be described as boreal forests that have cold winters with deep snow, and that provide a snowshoe hare (*Lepus canadensis)* prey base (Quinn and Parker 1987; McKelvey et al. 2000b; Mowat et al. 2000).

Based on sightings of lynx since 2000, the mine site is in the core area used by lynx in Minnesota. Approximately 100 lynx have been reported in St. Louis County since 2000 (MNDNR 2006), including verified, probable, and unverified sightings. The nearest sightings were approximately 6 miles from the mine site. Lynx showing evidence of reproduction have been found within 20 miles (32 km) of the mine site. Long-term studies have shown that lynx favor mixed forests in Minnesota (McKelvey et al. 2000a). Observations of lynx based on trapping records and visual observations show that lynx are more likely to be found in northeastern Minnesota than other portions of the state. Since lynx have been seen near the mine site, and habitats used by prey species are common on the site, the potential exists for lynx to use or travel through the mine site. Thus, the mine project may affect lynx.

1.2 Previous Lynx Studies at Mine Site

Several wildlife studies, including surveys for lynx, have been conducted at or near the mine site. Terrestrial and aquatic ecosystems in the vicinity of the mine site were studied as part of the Minnesota Environmental Quality Board Regional Copper-Nickel Study (Johnson and Lieberman 1979; Sather et al. 1979) in the late 1970s. In July and August of 1999, Foth and Van Dyke (1999) conducted general surveys for plant and animal species of concern on the mine project site. The Forest Service prepared an Environmental

Assessment (EA) for the Reservoir Analysis Area in 1999 (USDA Forest Service 1999). The analysis area included portions of the proposed mine project site, primarily near the Dunka Road.

ENSR (2000, 2005) conducted studies of wildlife and their habitats at the mine site during winter 2000 and summer 2004. ENSR also conducted surveys of wildlife and their habitats on lands immediately to the east of the mine project site, as part of the Mesaba Mine Project site evaluation for Teck Cominco America, Inc., during fall and winter of 2002 and 2003. These studies included efforts to locate lynx on the mine site from track and bait station surveys.

1.3 Study Purpose

Since portions of the site are located on federally-administered lands, a Biological Assessment (BA) will be prepared in accordance with Section 7 of the federal Endangered Species Act (ESA; the Act) of 1973, as amended (19 U.S.C. 1536 [c], 50 CFR 402.14[c]). The ESA requires that federal agencies "insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat of such species." The purpose of the Act is to provide a means for conserving the ecosystems upon which threatened and endangered species depend, and to provide a program for protecting these species.

As part of ESA consultation, the U.S. Fish and Wildlife Service (USFWS) has requested that PolyMet conduct studies of lynx to better determine their occurrence, abundance, and habitat use on and near the mine project site. This information also will be used to support mine project environmental review and permitting efforts and to identify additional data collection requirements.

Lynx surveys were conducted from January through March 2006 in the vicinity of the mine site to gather baseline information on lynx occurrence and habitat use near the proposed mine site, mill site, and transportation corridor between the mine site and mill site. This document provides results from these surveys.

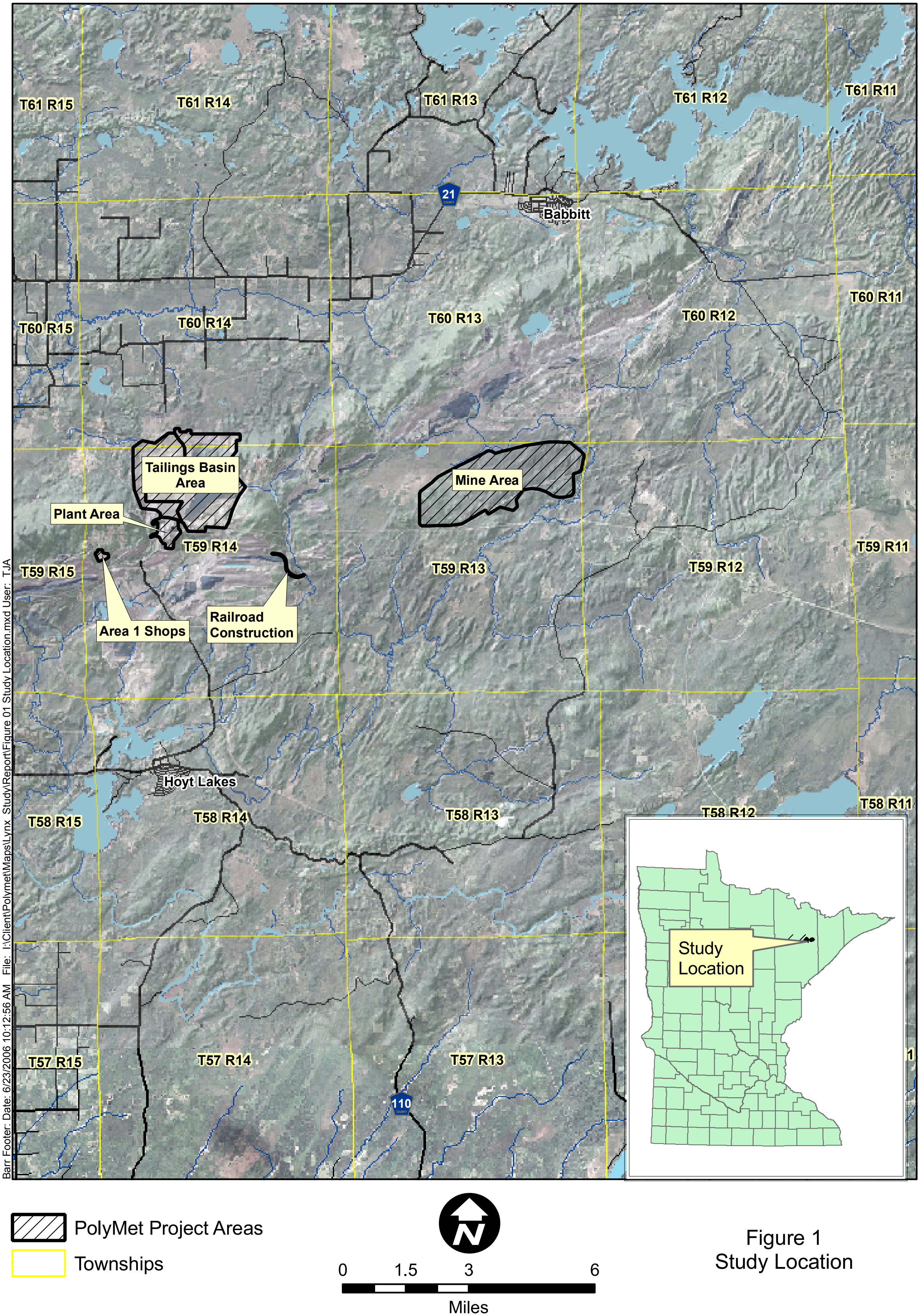


Figure 1
Study Location

2.0 STATUS OF THE SPECIES

2.3. Background Documents Used to Prepare Assessment

This section is based on information (and references cited therein) in the *Canada Lynx Conservation Assessment and Strategy* (Ruediger et al. 2000), *Ecology and Conservation of Lynx in the United States* (Ruggiero et al. 2000a), *Endangered and Threatened Wildlife and Plants: Determination of Threatened Status for the Contiguous U.S. Distinct Population Segment of the Canada Lynx and Related Rule; Final Rule* (Federal Register 2000), *Biological Opinion on the Effects of National Forest Land and Resource Management Plans and Bureau of Land Management Land Use Plans on Canada Lynx (Lynx canadensis) in the Contiguous United States* (U.S. Fish and Wildlife Service 2000), and *Endangered and Threatened Wildlife and Plants: Notice of Remanded Determination of Status for the Contiguous U.S. Distinct Population Segment of the Canada Lynx; Clarification of Findings; Final Rule* (Federal Register 2003).

2.4. Status of the Species

2.4.1. Species and Critical Habitat Description

The lynx is a medium-sized cat with long legs. Adult males average 22 pounds (10 kilograms [kg]) in weight and 33.5 inches (85 cm) in length (head to tail), and females average 19 pounds (8.5 kg) and 32 inches (82 cm; Quinn and Parker 1987). The lynx's long legs and large feet make it highly adapted for hunting in deep snow.

The bobcat *(Lynx rufus)* is a North American relative of the lynx. Compared to the lynx, the bobcat has smaller paws, shorter ear tufts, and a more spotted pelage (coat), and only the top of the tip of the tail is black. The paws of the lynx have twice the surface area as those of the bobcat. The lynx also differs from the bobcat in its body proportions; lynx have longer legs, with hind legs that are longer than the front legs, giving the lynx a ''stooped'' appearance (Quinn and Parker 1987). Bobcats are largely restricted to habitats where deep snows do not accumulate (Koehler and Hornocker 1991). Hybridization (breeding) between lynx and bobcat was first documented in 2002 in Minnesota (Schwartz et al. 2004).

Classification of the lynx (also called the North American lynx) has been subject to revision. In accordance with Wilson and Reeder (1993), the USFWS currently recognizes the lynx in North America as *Lynx canadensis.* The USFWS previously used the scientific name *L. lynx canadensis* for the lynx (Jones et al. 1992). Other scientific names still in use include *Felis lynx* or *F. lynx canadensis* (Jones et al. 1986; Tumlison 1987).

No critical habitat has been designated for the lynx in the contiguous United States. However, the USFWS has proposed critical habitat designations for portions of Minnesota, including portions of the study area. These include portions of Township 60 North, Range 12 West; Township 60 North, Range 13 West; Township 60 North, Range 14 West; Township 59 North, Range 13 West; and Township 59 North, Range 14 West. However, the mine project area has not been identified for critical habitat designation.

2.4.2. Distribution

The historical and present range of the lynx north of the contiguous U.S. includes Alaska and the portion of Canada extending from the Yukon and Northwest Territories south across the U.S. border and east to New Brunswick and Nova Scotia (Figure 2). In the contiguous U.S., lynx historically occurred in the Cascades Range of Washington and Oregon; the Rocky Mountain Range in Montana, Wyoming, Idaho, eastern Washington, eastern Oregon, northern Utah, and Colorado; the western Great Lakes Region; and the northeastern U.S. region from Maine southwest to New York (McCord and Cardoza 1982, Quinn and Parker 1987).

In the contiguous U.S., the distribution of the lynx is associated with the southern boreal forest, comprising of subalpine coniferous forest in the West and primarily mixed coniferous/deciduous forest in the East (Aubry et al. 2000). In Canada and Alaska, lynx inhabit the classic boreal forest ecosystem known as the taiga (McCord and Cardoza 1982; Quinn and Parker 1987; McKelvey et al. 2000a; Agee 2000). Within these general forest types, lynx are most likely to persist in areas that receive deep snow, for which the lynx species is highly adapted (Ruggiero et al. 2000a).

Lynx in the contiguous U.S. are part of a larger metapopulation whose core is located in the northern boreal forest of central Canada; lynx populations emanate from this area (Buskirk et al. 2000; McKelvey et al. 2000a, b). The boreal forest extends south into the contiguous U.S. along the Cascade and Rocky Mountain Ranges in the West, the western Great Lakes Region, and the Appalachian Mountain Range of the northeastern U.S. At its southern margins, the boreal forest becomes naturally fragmented into patches of varying size as it transitions into other vegetation types. These southern boreal forest habitat patches are small relative to the extensive northern boreal forest of Canada and Alaska, which constitutes the majority of the lynx range.

Many of these southern boreal forest habitat patches within the contiguous U.S. are able to support resident populations of lynx and their primary prey species. It is likely that some of the habitat patches act as sources of lynx (recruitment is greater than mortality) that are able to disperse and potentially colonize other patches (McKelvey et al. 2000b). Other habitat patches act as ‘‘sinks’’ in which lynx mortality is greater than recruitment and lynx are lost from the overall population. The ability of naturally dynamic habitat to support lynx populations may change as the habitat undergoes natural succession following natural or manmade disturbances (i.e., fire, clearcutting). In addition, fluctuations in the prey populations may cause some habitat patches to change from being sinks to sources and vice versa. The term ‘‘resident population’’ refers to a group of lynx that has exhibited long-term persistence in an area based on a variety of factors, such as evidence of reproduction, successful recruitment into the breeding cohort, and maintenance of home ranges. The word ‘‘transient’’ refers to a lynx moving from one place to another within suitable habitat. The word “dispersing’’ refers to lynx that have left suitable habitat for various reasons, such as competition or lack of food. When dispersing lynx leave suitable habitat and enter habitats that are unlikely to sustain them, these individuals are considered lost from the metapopulations unless they return to boreal forest.

2.4.3. Population Dynamics

2.4.3.1. Density

Lynx numbers and snowshoe hare densities in the contiguous U.S. generally do not get as high as those in the center of their range in Canada, and there is no evidence they ever did so in the past (Hodges 2000a, b; McKelvey et al. 2000a). It appears that northern and southern hare populations have similar cyclic dynamics, but that in southern areas both peak and low densities are lower than in the north (Hodges 2000b). However, it is unclear whether hare populations cycle everywhere in the contiguous U.S. Relatively low snowshoe hare densities at southern latitudes are likely a result of the naturally patchy, transitional boreal habitat that prevents hare populations from achieving densities similar to those of the expansive northern boreal forest (Wolff 1980, Buehler and Keith 1982, Koehler 1990, Koehler and Aubry 1994). Additionally, the presence of more predators and competitors of hares at southern latitudes may inhibit the potential for high-density hare populations with extreme cyclic fluctuations (Wolff 1980). As a result of naturally lower snowshoe hare densities, lynx densities at the southern part of the range rarely achieve the high densities that occur in the northern boreal forest (Aubry et al. 2000).

2.4.3.2. Lynx and Snowshoe Hare Relationships

The association between lynx and snowshoe hare is considered a classic predator-prey relationship (Saunders 1963a; van Zyll de Jong 1966; Quinn and Parker 1987). In northern Canada and Alaska, lynx populations fluctuate on approximately 10-year cycles that follow the cycles of hare populations (Elton and Nicholson 1942; Hodges 2000a, b; McKelvey et al. 2000a). Generally, researchers believe that when hare populations are at their cyclic high, the interaction of predation and food supply causes the populations to decline drastically (Buehler and Keith 1982; Krebs et al. 1995; O’Donoghue et al. 1997). There is little evidence of regular snowshoe hare cycles in the Northeast and southern Quebec (Hoving 2001), but hare populations do fluctuate widely in this region. Hare fluctuations in this region may be more influenced by forest practices, weather, and other ecological factors. Snowshoe hare provide the quality prey necessary to support high-density lynx populations (Brand and Keith 1979). Red squirrels *(Tamiasciurus hudsonicus)* are an important alternate prey (O'Donoghue et al. 1997, 1998a; Apps 2000; Aubry et al. 2000). Lynx also prey opportunistically on other small mammals and birds, particularly when hare populations decline (Nellis et al. 1972; Brand et al. 1976; McCord and Cardoza 1982; O'Donoghue et al. 1997, 1998a). However, a shift to alternate food sources may not sufficiently compensate for the decrease in hares consumed to be adequate for lynx reproduction and kitten survival (Brand and Keith 1979, Koehler 1990, Koehler and Aubry 1994). When snowshoe hare densities decline, the lower quality diet causes sudden decreases in the productivity of adult female lynx and decreased survival of kittens, if any are born during this time; as a result, recruitment of young into the population nearly ceases during cyclic lows of snowshoe hare populations (Nellis et al. 1972; Brand et al. 1976; Brand and Keith 1979; Poole 1994; Slough and Mowat 1996; O'Donoghue et al. 1997; Mowat et al. 2000).

2.4.3.3. Home Range and Dispersal

Lynx require very large areas containing boreal forest habitat. In the Northeast, lynx were most likely to occur in areas containing suitable habitat that were greater than 40 mi^2 (100 km^2; Hoving 2001). The requirement for large areas also is demonstrated by home ranges that encompass many square miles. The size of lynx home ranges varies by the animal's gender and age, abundance of prey, season, and the density of lynx populations (Hatler 1988; Koehler 1990; Poole 1994; Slough and Mowat 1996; Aubry et al. 2000; Mowat et al. 2000). Based on a limited number of studies in southern boreal forests, the average home range is 58 mi^2 (151 km^2) for males, and 28 mi^2 (72 km^2) for females (Aubry et al. 2000). Recent home range estimates from Maine are 27 mi^2 (70 km^2) for males and 20 mi^2 (52 km^2) for females. However, documented home ranges in both the southern and northern boreal forest vary widely from 3 to 300 mi^2 (8 to 800 km^2; Saunders 1963b; Brand et al. 1976; Mech 1980; Parker et al. 1983; Koehler and Aubry 1994; Apps 2000; Mowat et al. 2000; Squires and Laurion 2000). Generally, it is believed that larger home ranges, such as have been documented in some areas in the southern extent of the species' range in the West, are a response to lower-density snowshoe hare populations (Koehler and Aubry 1994, Apps 2000, Squires and Laurion 2000).

Lynx are highly mobile and have a propensity to disperse. Long-distance movements (greater than 60 miles [100 km]) are characteristic (Mowat et al. 2000). Lynx disperse primarily when snowshoe hare populations decline (Ward and Krebs 1985; Koehler and Aubry 1994; O'Donoghue et al. 1997; Poole 1997). Subadult lynx also disperse even when prey is abundant (Poole 1997), presumably as an innate response to establish home ranges. Lynx also make exploratory movements outside their home ranges. Lynx are capable of moving extremely long distances (greater than 300 miles [500 km]; Brainerd 1985; Washington Department of Wildlife 1993; Poole 1997; Mowat et al. 2000); for example, a male was documented traveling 380 miles (620 km; Brainerd 1985). While it is assumed lynx would prefer to travel where there is forested cover, the literature contains many examples of lynx crossing large, unforested openings. The ability of both male and female lynx to disperse long distances, crossing unsuitable habitats, indicates they are capable of colonizing suitable habitats and finding potential mates in areas that are isolated from source lynx populations.

2.4.3.4. Mortality

Common causes of mortality for lynx include starvation of kittens (Quinn and Parker 1987, Koehler 1990), and trapping (Ward and Krebs 1985; Bailey et al. 1986). Lynx mortality due to starvation has been shown in cyclic populations of the northern taiga, during the first 2 years of snowshoe hare scarcity (Pool 1994, Slough and Mowat 1996). During periods of low snowshoe hare numbers, starvation can account for up to two-thirds of all natural lynx deaths. Trapping mortality may be additive rather than compensatory during the low period of the snowshoe hare cycle (Brand and Keith 1979). Hunger-related stress, which induces dispersal, may increase exposure of lynx to other forms of mortality such as trapping and vehicle collisions (Brand and Keith 1979; Carbyn and Patriquin 1983; Ward and Krebs 1985; Bailey et al. 1986).

Predation on lynx by mountain lion (*Felis concolor*), coyote (*Canis latrans*), wolverine (*Gulo gulo*), gray wolf (*Canus lupus*), and other lynx has been observed (Berrie 1974; Koehler et al. 1979; Pool 1994; Slough and

Mowat 1996; O'Donoghue et al. 1997; Apps 2000; Squires and Laurion 2000). Squires and Laurion (2000) reported two of six mortalities of radio-collared lynx in Montana were due to mountain lion predation.

2.4.3.5. Interspecific Relationships with Other Carnivores

Buskirk et al. (2000) described the two major competition impacts to lynx as exploitation (competition for food) and interference (avoidance). Of several predators examined (birds of prey, coyote, gray wolf, mountain lion, bobcat, and wolverine), it was deemed that coyotes were the most likely to pose local or regionally important exploitation impacts to lynx, and coyotes and bobcats were deemed to possibly impart important interference competition effects on lynx. Mountain lions were described as interference competitors, possibly impacting lynx during summer and in areas lacking deep snow in winter, or when high elevation snow packs develop crust in the spring.

In southern portions of snowshoe hare range, predators may limit hare populations to lower densities than in the taiga (Dolbeer and Clark 1975, Wolff 1980, Koehler and Aubry 1994). Exploitation competition may contribute to lynx starvation and reduced recruitment. During periods of low snowshoe hare numbers, starvation accounted for up to two-thirds of all natural lynx deaths in the Northwest Territories of Canada (Poole 1994).

Parker et al. (1983) discussed anecdotal evidence of competition between bobcats and lynx. On Cape Breton Island, Nova Scotia, lynx were found to be common over much of the island prior to bobcat colonization. Concurrent with the colonization of the island by bobcats, lynx densities declined and their presence on the island became restricted to the highlands, the one area where bobcats did not become established.

Predation on adult lynx has rarely been observed and recorded in the literature. Predators of lynx include mountain lion, coyote, wolverine, gray wolf, and other lynx. The magnitude or importance of predation on lynx is unknown.

2.4.3.6. Behavioral Response to Humans

Staples (1995) described lynx as being generally tolerant of humans. Other anecdotal reports also suggest that lynx are not displaced by human presence, including moderate levels of snowmobile traffic (Mowat et al. 2000) and ski area activities (Roe et al. 1999).

In a lightly roaded study area in northcentral Washington, logging roads did not appear to affect habitat use by lynx (McKelvey et al. 2000c). In contrast, six lynx in the southern Canadian Rocky Mountains crossed highways within their home ranges less than would be expected (Apps 2000). The latter study area contained industrial road networks, twin-tracked railway, and 2-4-lane highways with average daily traffic volumes of about 1,000 to 8,000 vehicles per day.

2.4.4. Habitat Requirements

To understand habitat relationships of lynx one must first understand the habitat relationships of snowshoe hares. Snowshoe hares use spruce (*Picea* spp.) and fir forests with dense understories that provide forage, cover to escape from predators, and protection during extreme weather (Wolfe et al. 1982; Monthey 1986; Hodges 2000a, b). Generally, earlier successional (younger) forest stages have greater understory structure than do mature forests and, therefore, support higher hare densities (Fuller 1999; Hodges 2000a, b). Lynx generally concentrate their hunting activities in areas where hare populations are high (Koehler et al. 1979; Parker 1981; Ward and Krebs 1985; Major 1989; Murray et al. 1994; O'Donoghue et al. 1997, 1998a). In Maine, snowshoe hare abundance and lynx occurrence are positively associated with late regeneration forests (forest stands that are growing back 12 to 30 years after being clear-cut and have greater than 50 percent canopy closure), evidence that lynx are selecting habitat primarily on the abundance of primary prey (Hoving 2001).

2.4.4.1. Diet

Snowshoe hares are the primary prey to lynx, comprising 35 to 97 percent of the diet throughout the range of the lynx (Koehler and Aubry 1994). Other prey species include red squirrel, grouse (*Bonasa umbellus*, *Dendragopus obscurus, Canachites canadensis*, *Lagopus* spp.), flying squirrel (*Glaucomys sabrinus*), ground squirrel (*Spermophilus parryii*, *Spermophilus richardsonii*), porcupine (*Erethrizon dorsatum*), beaver (*Castor canadensis*), mice (*Peromyscus* spp.), voles (*Microtus* spp.), shrews (*Sorex* spp.), fish, and ungulates as carrion or occasionally as prey (Saunders 1963a; van Zyll de Jong 1966; Nellis et al. 1972; Brand et al. 1976; Brand and Keith 1979; Koehler 1990; Staples 1995; O'Donoghue et al. 1998b).

The importance of other prey species, especially red squirrel, increases in the diet during periods when snowshoe hares become scarce (Brand et al. 1976; O'Donoghue et al. 1998b; Apps 2000; Mowat et al. 2000). However, Koehler (1990) suggested that a diet of red squirrels alone might not be adequate to ensure lynx reproduction and survival of kittens.

Most research has focused on the winter diet. Summer diets are poorly understood throughout the range of lynx. Mowat et al. (2000) reported that summer diets consist of less snowshoe hare and more alternate prey species than winter diets.

There has been limited research on the lynx diet in the southern portions of its range. Southern populations may prey on a wider diversity of species than northern populations because of lower snowshoe hare densities and differences in small mammal communities. In areas characterized by patchy distribution of lynx habitat, lynx may prey opportunistically on other species that occur in adjacent habitats, including white-tailed jackrabbit (*Lepus townsendii*), black-tailed jackrabbit (*Lepus californicus*), sage grouse (*Centrocercus urophasianus*), and Columbian sharp-tailed grouse (*Tympanichus phasianellus*; Quinn and Parker 1987, Lewis and Wenger 1998).

2.4.4.2. Den Site Selection

Lynx den sites are found where coarse woody debris, such as downed logs and windfalls, provides denning sites with security and thermal cover for lynx kittens (McCord and Cardoza 1982, Koehler 1990, Koehler and Brittell 1990, Slough 1999, Squires and Laurion 2000). The integral component for all lynx den sites appears to be the amount of downed, woody debris present rather than the age of the forest stand (Mowat et al. 2000). In Washington, lynx denned in lodgepole pine *(Pinus contorta),* spruce, and subalpine fir *(Abies lasiocarpa)* forests older than 200 years with an abundance of downed woody debris (Koehler 1990). A den site in Wyoming was located in a mature subalpine fir/lodgepole pine forest with abundant downed logs and dense understory (Squires and Laurion 2000).

2.4.5. Range of Lynx within the Contiguous United States

Within the contiguous U.S., the lynx's range coincides with that of the southern margins of the boreal forest along the Appalachian Mountains in the Northeast, the western Great Lakes, and the Rocky Mountains and Cascade Mountains in the West (Figure 3). In these areas, the boreal forest is at its southern limits, becoming naturally fragmented into patches of varying size as it transitions into subalpine forest in the West and deciduous temperate forest in the east (Agee 2000). Because the boreal forest transitions into other forest types to the south, scientists have difficulty mapping its exact boundaries (Elliot-Fisk 1988). Precisely identifying and describing the distribution of lynx habitat also is difficult because there are several vegetation and landform classifications and descriptions that have been published for various parts of North America (USDA Forest Service and Bureau of Land Management 1999). However, the term ''boreal forest'' broadly encompasses most of the vegetative descriptions of this transitional forest type that makes up lynx habitat in the contiguous U.S. (Agee 2000).

Lynx in the contiguous U.S. are part of a larger metapopulation whose center is located in the northern boreal forest of central Canada; lynx populations emanate from this area (Buskirk et al. 2000; McKelvey 2000a, b). When there is a high in the lynx population in central Canada, it acts like a wave radiating out to the margins of the lynx range. The magnitude of the lynx population high emanating from the central Canadian boreal forest varies for each cycle (McKelvey et al. 2000a, b). This wave can be produced by local populations reacting to environmental conditions, dispersers, or a combination of these (McKelvey et al. 2000a). Schwartz et al. (2002) concluded this wave is driven by dispersers, based on findings of a high level of gene flow between lynx in Alaska, Canada, and the western U.S.

An example of the cyclic population ‘‘wave’’ occurred in the 1960s and 1970s, when numerous lynx were reported in the contiguous U.S. far from source populations. These records of dispersing lynx correlate to unprecedented cyclic lynx highs in Canada (Adams 1963; Harger 1965; Mech 1973; Gunderson 1978; Thiel 1987; McKelvey et al. 2000a; Mowat et al. 2000). These dispersers frequently were documented in areas, such as Wisconsin, that are close to source populations of lynx in Canada or possibly northeastern Minnesota and that contain some boreal forest. But there also have been a number of occurrences of dispersers in unsuitable habitats far from source populations, such as North Dakota prairie (Adams 1963; Gunderson 1978; Thiel 1987; McKelvey et al. 2000a).

Lynx populations in the northeastern U.S. and southeastern Canada are separated from those in northcentral Canada by the St. Lawrence River. There is little evidence of regular hare or lynx population cycles in this area (Hoving 2001), but wide fluctuations in lynx and snowshoe hare populations do occur. On a smaller scale, fluctuating populations in the core of this area (Quebec's Gaspé Peninsula, western New Brunswick, and northern Maine) can potentially influence lynx distribution up to several hundred miles distant.

Lynx dispersing during periods of population highs will occupy many patches of boreal habitat at the periphery of their range. Some patches will be suitable to maintain a long-term population and some will not. Where the boreal forest habitat patches within the contiguous U.S. are large, with suitable habitat, prey, and snow conditions, resident populations of lynx are able to survive throughout the low period of the approximately 10-year cycle. The influx of lynx from populations in Canada at the high point of the cycle augments these resident populations. It is likely that some of these habitat patches within the contiguous U.S. are able to act as sources of lynx (where recruitment is greater than mortality) that are able to disperse and potentially colonize other patches (McKelvey et al. 2000b).

In other areas, the lynx that remain in an area after a cyclic population high may be so few or in naturally marginal habitat that they are not able to persist or establish local populations, although some reproduction may occur. Such areas naturally act as population sinks (McKelvey et al. 2000b). Sink habitats are most likely those places on the periphery of the southern boreal forest where habitat naturally becomes patchier and more distant from larger lynx populations. Lynx found in these sink habitats are considered dispersers, but are usually included within the species range. Changes in the habitat conditions or cyclic fluctuations in the prey populations may cause some habitat patches to change from being sinks to sources and vice versa. Through this natural process, local lynx populations in the contiguous U.S. may ‘‘blink’’ in and out as the metapopulation goes through the 10-year cycle. Where habitat is of high enough quality and quantity, resident lynx populations are able to become established or existing populations are augmented, aiding in their long-term persistence.

Some maps (e.g., Hall and Kelson 1959) incorrectly portray the range of the lynx by encompassing peripheral records from areas that are not within boreal forest or do not have cold winters with deep snow, such as prairie or deciduous forest. Such maps have led to a misperception that the historic range of the lynx in the contiguous U.S. was once much more extensive than ecologically possible. Records of lynx outside of southern boreal forest in peripheral habitats that are unable to support lynx represent long-distance dispersers that are lost from the metapopulation unless they return to boreal forest and contribute to the persistence of a population. These unpredictable and temporary occurrences are not included within either the historic or current range of lynx because they are well outside of lynx habitat. This includes records from Connecticut, Indiana, Iowa, Massachusetts, Nebraska, Nevada, North Dakota, Ohio, Pennsylvania, South Dakota, and Virginia (Hall and Kelson 1959; Burt 1954 *as cited in* Brocke 1982; Gunderson 1978; McKelvey et al. 2000a). States that support some boreal forest and have frequent records of lynx are assumed to be the historic and current species range; these states include Colorado, Idaho, Maine, Michigan, Minnesota, Montana, New Hampshire, New York, Oregon, Utah, Vermont, Washington, Wisconsin, and Wyoming.

2.4.5.1. Lynx Distribution within Great Lakes Region

The majority of lynx occurrence records in the Great Lakes Region are associated with the mixed deciduous-coniferous forest type (McKelvey et al. 2000a). Within this general forest type, the highest frequency of lynx occurrences have been in white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), jack pine (*Pinus* *banksiana*), white pine (*P. strobus*), red pine (*P. resinosa*) black spruce (*Picea mariana*), and mixed black spruce and tamarack (*Larix laricina*) forest types. These forest types are found primarily in northern Minnesota, northern Wisconsin, and Michigan's Upper Peninsula.

Although the mixed deciduous-coniferous forest covers an extensive area in the Great Lakes Region, much of this area may be marginal habitat for lynx because it is a transitional forest type at the edge of the snowshoe hare range. Habitat at the edge of hare range supports lower hare densities (Buehler and Keith 1982) that may not be sufficient to support lynx reproduction. Furthermore, appropriate habitat with snow depths that allow lynx a competitive advantage over other carnivores (e.g., coyotes) occur only in limited areas in northeastern Minnesota, extreme northern Wisconsin, and Michigan's Upper Peninsula.

The historic status of lynx in the Great Lakes Region is uncertain. Minnesota has a substantial number of lynx reports (McKelvey et al. 2000a), which is expected because of the connectivity of the boreal forest with that of Ontario, Canada, where lynx occur. Wisconsin and Michigan have substantially fewer records of lynx (McKelvey et al. 2000a). Researchers have debated whether lynx in this region are simply dispersing individuals emigrating from Canada, are members of a resident population, or are a combination of a resident population and dispersing individuals (Sando 1998; McKelvey et al. 2000a). Recent research efforts in Minnesota have confirmed a resident population of lynx. Reproduction has been documented in all years since 2001. However, there are a few records of lynx occurrence in Michigan and Wisconsin during this same period.

2.4.5.2. Historical Records of Lynx in Northern Minnesota

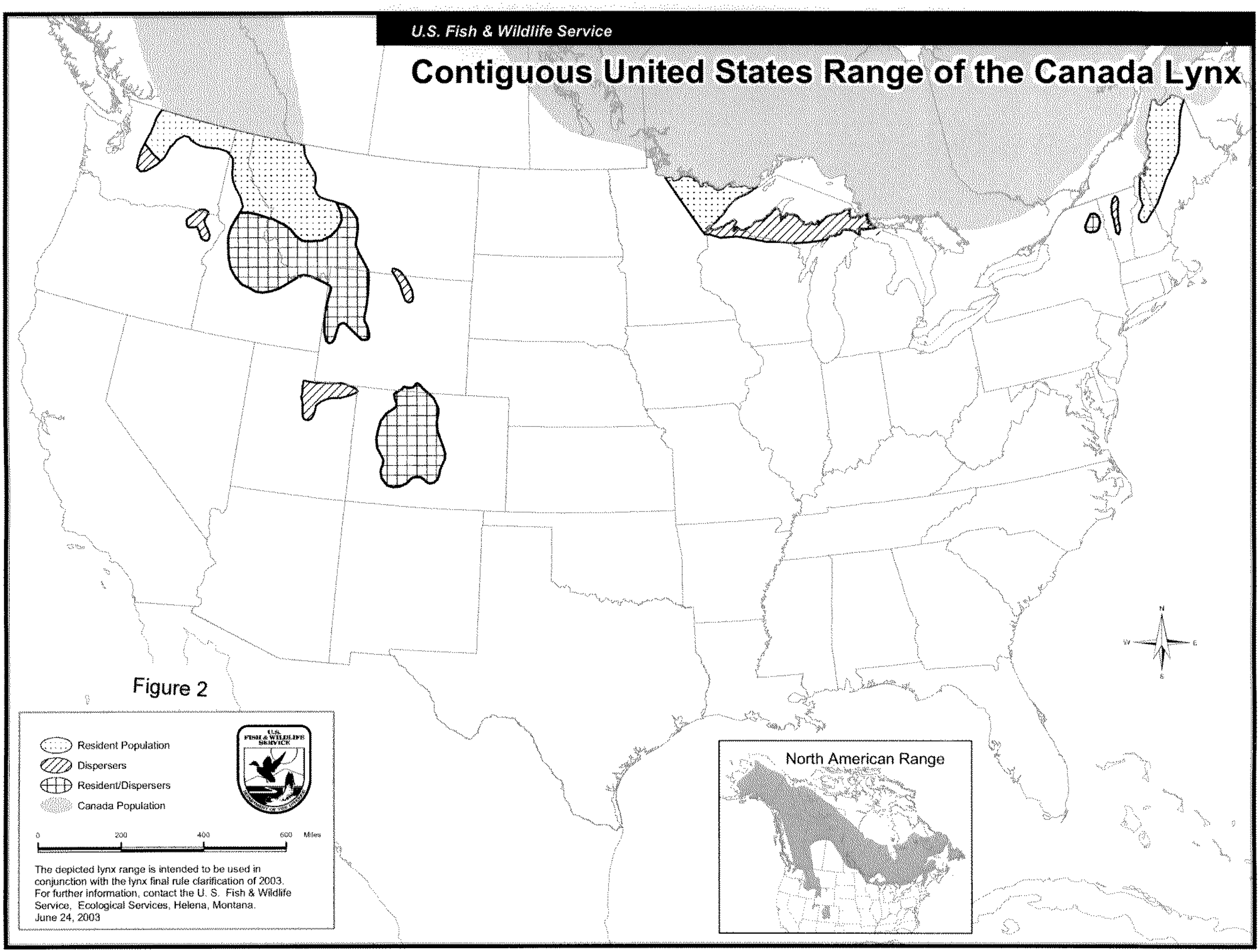
The majority of lynx occurrence records in Minnesota are from the northeastern portion of the State; however, dispersing lynx have been found throughout Minnesota outside of typical lynx habitat (Gunderson 1978; Mech 1980; McKelvey et al. 2000a). In northeastern Minnesota, where deep snow accumulates, suitable lynx and snowshoe hare habitat is present. Much of this area is protected as designated wilderness, including the Boundary Waters Canoe Area. Furthermore, these habitats are contiguous with the boreal forest in southern Ontario. Until 1965, there was a bounty on lynx in Minnesota. In 1976, the lynx was classified as a game species, and harvest seasons were established (DonCarlos 1994). Minnesota harvest and bounty records 1930 and later are available. Approximate 10-year lynx cycles are apparent in the data, with population highs in 1940, 1952, 1962, and 1973 (Henderson 1978; McKelvey et al. 2000a). During a 47-year period (1930–1976), the Minnesota lynx harvest was substantial, ranging from approximately 0 to 400 per year (Henderson 1978). These harvest returns for Minnesota are believed to be influenced by influxes of lynx from Canada, particularly in the 1960s and 70s (Henderson 1978; Mech 1980; DonCarlos 1994; McKelvey et al. 2000a). The harvest season was closed in 1984 when an anticipated lynx cyclic high did not occur in the early 1980s (DonCarlos 1994), and remains closed today.

Reproduction and maintenance of home ranges by lynx in Minnesota was documented in the early 1970s (Mech 1973, 1980), which may be evidence of a resident population. During the early 1970s, the second highest lynx harvest returns in the 20th century occurred throughout Canada. The great numbers of lynx trapped in Minnesota during this period likely included immigrants from Canada (McKelvey et al. 2000b). Lynx were consistently trapped over 40 years during cyclic lows, which may indicate that a resident population occurred historically.

2.4.5.3. Observations of Lynx in the Vicinity of the Mine Site Since 2000

Trapping records and visual observations of lynx show that lynx are more likely to be found in northern, and especially northeastern, Minnesota than other portions of the state. Based on sightings of lynx since 2000, the mine site is in the core area used by lynx in Minnesota. Approximately 200 lynx have been reported in St. Louis County since 2000 (MNDNR 2006), including verified, probable, and unverified sightings. The nearest sightings were approximately 6 miles from the mine site. Lynx showing evidence of reproduction have been found within 20 miles (32 km) of the mine site.

The vast majority of sightings are incidental encounters, and as such, tend to be clustered along roads and other places frequented by observant and interested people. Thus, while these reports tell us something (however incomplete) about where lynx are, they provide no information about where lynx do not occur. Similarly, we cannot know the relationship between the number of reports and the number of lynx in Minnesota at the time of the reports (MNDNR 2006). The majority of confirmed and unconfirmed sightings in Minnesota have been made in three counties—Lake, Cook, and St. Louis. Of the 396 sightings reported to the Minnesota Natural Heritage and Nongame Research Program since 2000, 78 percent have occurred in these three counties.


U.S. Fish & Wildlife Service
Contiguous United States Range of the Canada Lynx
North American Range
Resident Population
Dispersers
Resident/Dispersers
Canada Population
0
200
400
600
Miles
The depicted lynx range is intended to be used in conjunction with the lynx final rule clarification of 2003. For further information, contact the U. S. Fish & Wildlife Service, Ecological Services, Helena, Montana.
June 24, 2003
N
S
E
W
Figure 2

3.0 STUDY AREA AND METHODS

3.3. Study Area

The primary survey area for lynx was determined based on discussions with the USFWS (Burke 2006). The study area extended out approximately 6 miles from the proposed disturbance area, or about 7 miles from the Dunka Road between the eastern boundary of the mine site and western boundary of the mill site (Figure 3). This area should encompass much of the home range of lynx that may be found near the mine project. Within this area, surveys were primarily conducted in the following seven townships: Township 58 North, Range 13 West; Township 59 North, Ranges 12, 13, and 14 West; and Township 60 North, Ranges 12, 13, and 14 West. This area is approximately 250 mi^2.

3.4. Methods

3.4.1. Literature Review and Personal Communications

We reviewed the *Supplemental Site Specific Resource Information, August 1999,* report prepared by Foth and Van Dyke (1999). This report provided information on lynx found in the study area. We reviewed the Forest Service *Biological Evaluation (BE) for the Reservoir Analysis Area, Laurentian Ranger District, Superior National Forest* and *Environmental Assessment for the Reservoir Analysis Area, Superior National Forest, Laurentian Ranger District* (Phillips 1999, USDA Forest Service 1999). This evaluation was attached to the District Ranger's initial review of PolyMet's June 2, 1999, Plan of Operation. We reviewed the *Winter 2000 Wildlife Survey for the Proposed NorthMet Mine Site, St. Louis County, Minnesota* (ENSR 2000) and the *NorthMet Mine Summer Fish and Wildlife Study* (ENSR 2005).

We conducted telephone and in-person interviews with biologists and other agency staff with the MNDNR, USFWS, and Forest Service Superior National Forest; law enforcement personnel and the public living near the study area; and private conservation organizations that are familiar with lynx use of the study area.

3.4.2. Database Queries

We queried the MNDNR lynx sightings database for sightings that have occurred in the vicinity of the study area since 2000 (http://www.dnr.state.mn.us/ecological_services/nhnrp/research/lynx_sightings.html). We reviewed the Natural Resources Research Institute (NRRI) lynx website (http://www.nrri.umn.edu/lynx/) for records of radio-marked lynx within the survey area. We also reviewed the Superior National Forest's lynx genetic reference database for records of lynx occurrence within 15 miles (25 km) of the study area.

3.4.3. Field Surveys

Field surveys for lynx and other felids (bobcat and mountain lion) were conducted during January through March 2006. Survey methodology was based on the protocol described in the *Lynx Survey Plan for the Proposed NorthMet Mine Site, St. Louis County Minnesota* (ENSR 2006).

3.4.3.1. Survey Objectives

The objectives of the field surveys were to:

- record lynx and other wild felids and their sign observed in the study area;
- for each felid trail found, attempt to obtain and analyze a DNA sample from scat or hair to identify the individual felid making the track and to establish a genetic reference collection of individual lynx in the area;
- estimate how many lynx were in the study area; and

- estimate the habitat use and range of lynx in the study area.

3.4.3.2. General Survey Methodology

Biologists experienced tracking lynx and other felids (Mr. Steve Loch and Dr. Stuart Paulus) conducted field surveys from late January through March 2006. All seven townships in the study area were surveyed during the survey period. In addition, some time was spent surveying for felids in townships adjacent the survey area (Township 60 North Range 11 West; Township 59 North, Range 11 West; Township 58 North, Range 12 West; and Township 57 North, Range 14 West) while traveling to or from a survey township, or when accessing, or attempting to access, townships within the study area.

During surveys, information on felid, felid sign, and felid habitat use observed in the study area was recorded. Felid sign included trails, tracks, scat, hair, resting beds, and foraging sign (e.g., prey kills; McKelvey et al. 2006). The locations of felids, their sign, and the habitats used were recorded using a Garmin Map 76S Global Positioning System (GPS), and recorded on aerial photographs or topographic maps. A survey route log was made using GPS track logs and maps. The time of day was also recorded during surveys.

3.4.3.3. Snow Tracking Surveys

Surveys were conducted during the day from a snowmobile, four-wheel drive vehicle, or on foot. Transects were primarily located along forest roads, logging roads, skid trails, roadways, river and stream channels or flood plains, power transmission line rights-of-way, and railroad grades. In addition, transects were occasionally surveyed on foot in habitats favored by lynx.

The study area was divided into zones that were systematically searched for lynx and other felids. We attempted to survey a minimum of 50 miles (80 km) of unique trail per township. Surveys began at least 24 hours after a snow event, or, if high winds obscured or obliterated snow trails, 24 hours after the winds had subsided. Surveys were conducted at least 24 hours or more after a snowfall to provide a reasonable chance of detecting tracks. Surveys continued after a snowfall as long as snow conditions were suitable to accurately identify and follow felid tracks. Through March 14th, we did not conduct snow track surveys if a surface crust had formed on the snow. After March 14, due to freeze-thaw cycles, we conducted surveys only between 24 to 36 hours after a snowfall, or 24 hours or more after thawing of the snow. Generally, we surveyed transects in protected forest habitats during those periods when we felt that wind might be a factor affecting track condition and detection. To the extent possible, we avoided surveying transects when the surface of the snow pack appeared as though it might have been recently wind swept by trains or logging trucks, or by wind channeling (e.g., along transmission line rights-of-way or abandoned railroad tracks). We also avoided surveying roadway transects that had been plowed when it appeared we might not see all animal trails beyond the clutter of the snow debris.

When surveying, we attempted to maintain visual contact along a continuous sight line so any animal that had walked to that line since the last significant snowfall would be detected. Survey vehicles were driven at a speed suitable for detecting all felid tracks, and we stopped to evaluate any potential felid tracks intercepted. We surveyed a transect at a much slower rate where animal tracks that might interfere with detection of felid trails had accumulated, especially those of snowshoe hares or ungulates. Also, when less than an inch of fresh snow covered a subsurface crust, the rate of travel while surveying transects was reduced because snow tracks were not as conspicuous.

When a animal trail was encountered, the trail was evaluated, based on the appearance of the track and trail, for its possibility of being felid. Generally, lynx or other felid tracks were conspicuous and readily identifiable; however, since coyote and wolf were present in the study area, we stopped to evaluate all snow tracks produced by felids or canids. We also examined all trails of large fishers (*Martes pennanti*), especially when the track showed a walking gait.

When a felid trail was encountered, the track intercept was identified using a GPS waypoint. When a felid traveled a road or similar linear feature, a track intercept was recorded with GPS to obtain a waypoint where the felid crossed the road.

We attempted to follow each felid trail for at least 1.5 miles (2.5 km), or until a scat or hair sample was found. A record of the trail route was recorded using GPS. Once found, we collected a scat sample; no hair samples were collected. Snow tracking to collect scat was conducted at the time the felid trail was detected, or within a day or two, depending on the weather forecast, available daylight, or other scheduling factors. When a scat sample was collected, we recorded the type of sample collected and assigned it a reference label identifying the waypoint established at the collection site. When a scat sample was not collected, we took photographs of the print, track, and trail to depict print definition, stride, and straddle of the track set. We also recorded the number of felids associated with the trail.

3.4.4. DNA Analysis

Scat were placed in a paper bag at the collection site and later thawed and air dried at room temperature. Each scat was transferred to a vial containing 18-mesh silica desiccant to inhibit enzyme activity that degrades DNA. Samples were sent to the Forest Service Rocky Mountain Research Station Wildlife Ecology Unit laboratory in Missoula, Montana. In the laboratory, DNA was extracted from up to 220 milligrams of sample from each scat using the *QIAMP DNA Stool Minikit* (*QIAGEN Inc*., Germany). Each sample was then amplified at the 16S rRNA region of the mitochondrial genome and subjected to restriction enzyme assays to identify species (Mills et al. 2001).

The samples were then analyzed using microsatellite DNA to identify individuals. All samples were amplified at microsatellite markers *Lc106, Lc109, Lc110, Lc111, Lc118,* and *Lc120* and the resultant products visualized on a *LICOR* DNA analyzer (Lincoln, Nebraska).

All samples were run a minimum of three times to avoid genotyping error such as allelic dropout or false alleles. Genotypes were scored by two independent observers. If there were discrepancies in the scoring, the samples were run an additional three times at the marker under question. DNA was re-extracted from scat samples that initially failed to amplify (showed poor quality DNA). Any samples that failed to amplify at four loci or displayed inconsistent scores at four of six loci were discarded.

The samples were further tested for lynx-bobcat hybridization (see Schwartz et al. 2004) and sex.

3.4.5. Lynx Habitat Use and Density

A detailed assessment of habitat types was conducted during 2004 for the mine project site (ENSR 2005). A general assessment of habitats within the study area, but outside of the proposed mine project site, was conducted for this study. We noted relative abundance of potential lynx prey based on snow tracks, specifically snowshoe hares, grouse, and deer, as well as the characteristics of the associated vegetation where potential prey densities were relatively high. We used aerial imagery to assess the extent of mining operations, recent logging (within 5 years), and significant lynx habitat types observed while snow tracking lynx or surveying. Habitat features used and traversed by lynx in this study were noted when following lynx trails and while collecting or attempting to collect scat/hair samples. We noted areas where snowshoe hare activity was relatively high and also widespread. We also noted deer activity and yarding areas and relative abundance of grouse.

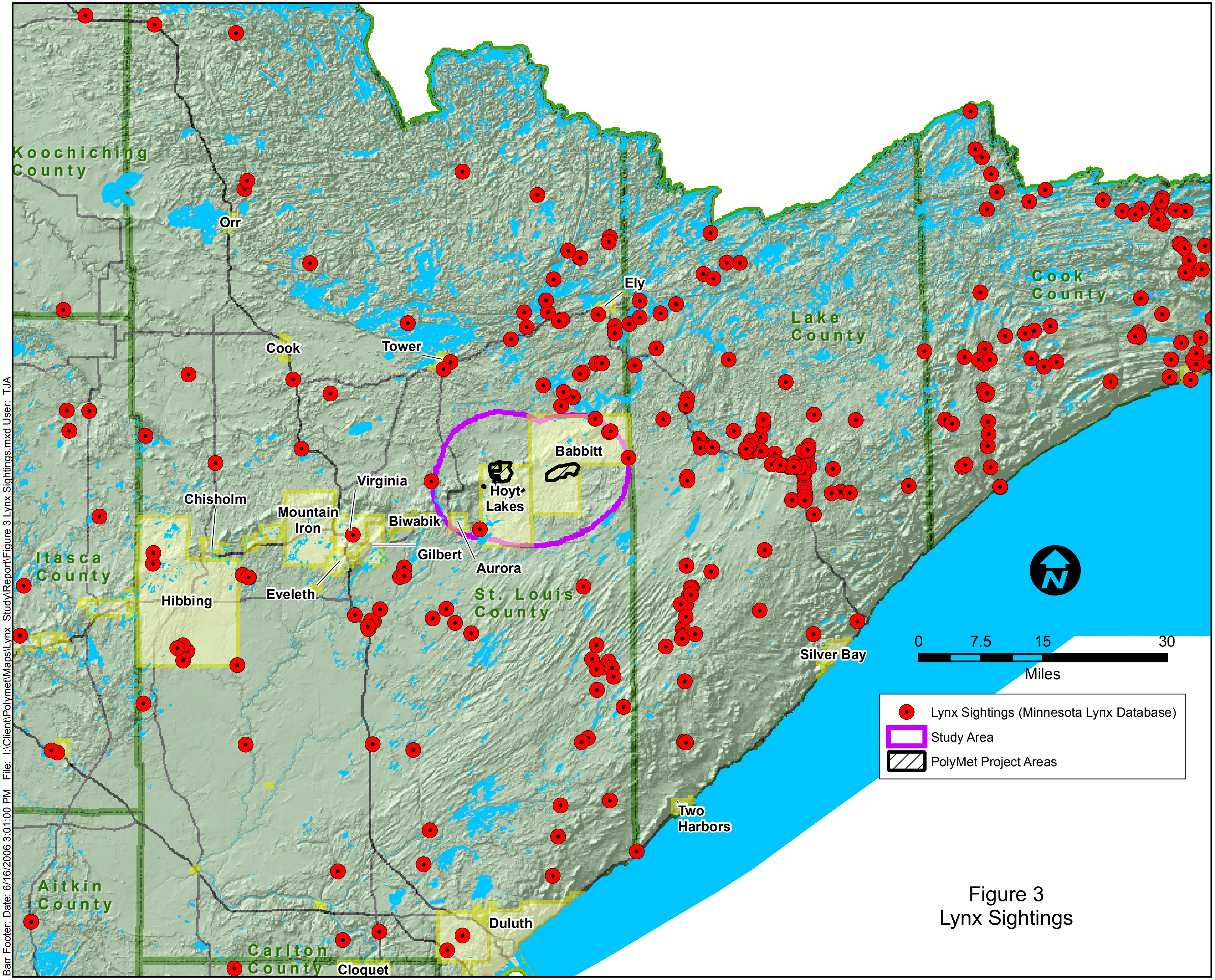


Figure 3
Lynx Sightings

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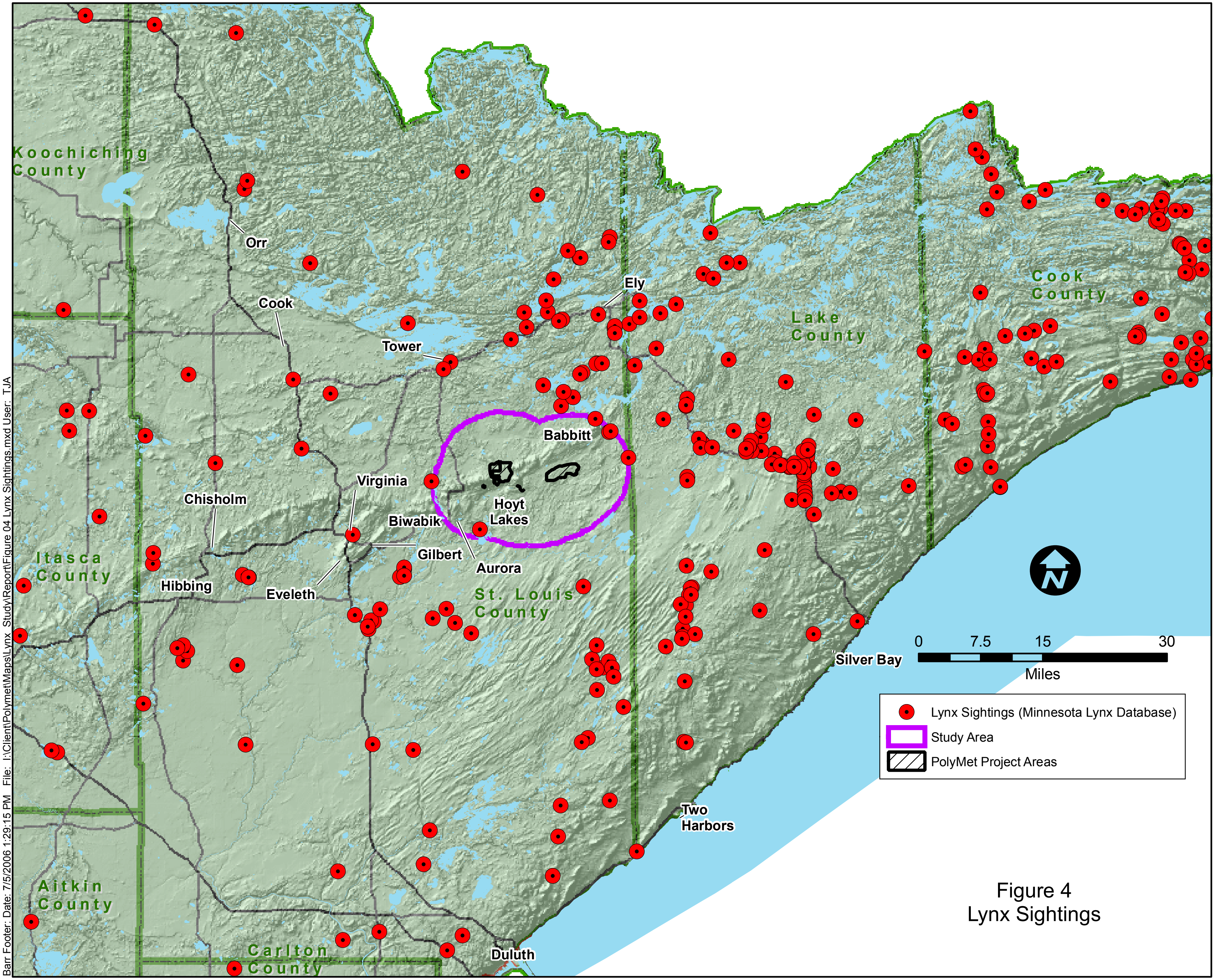
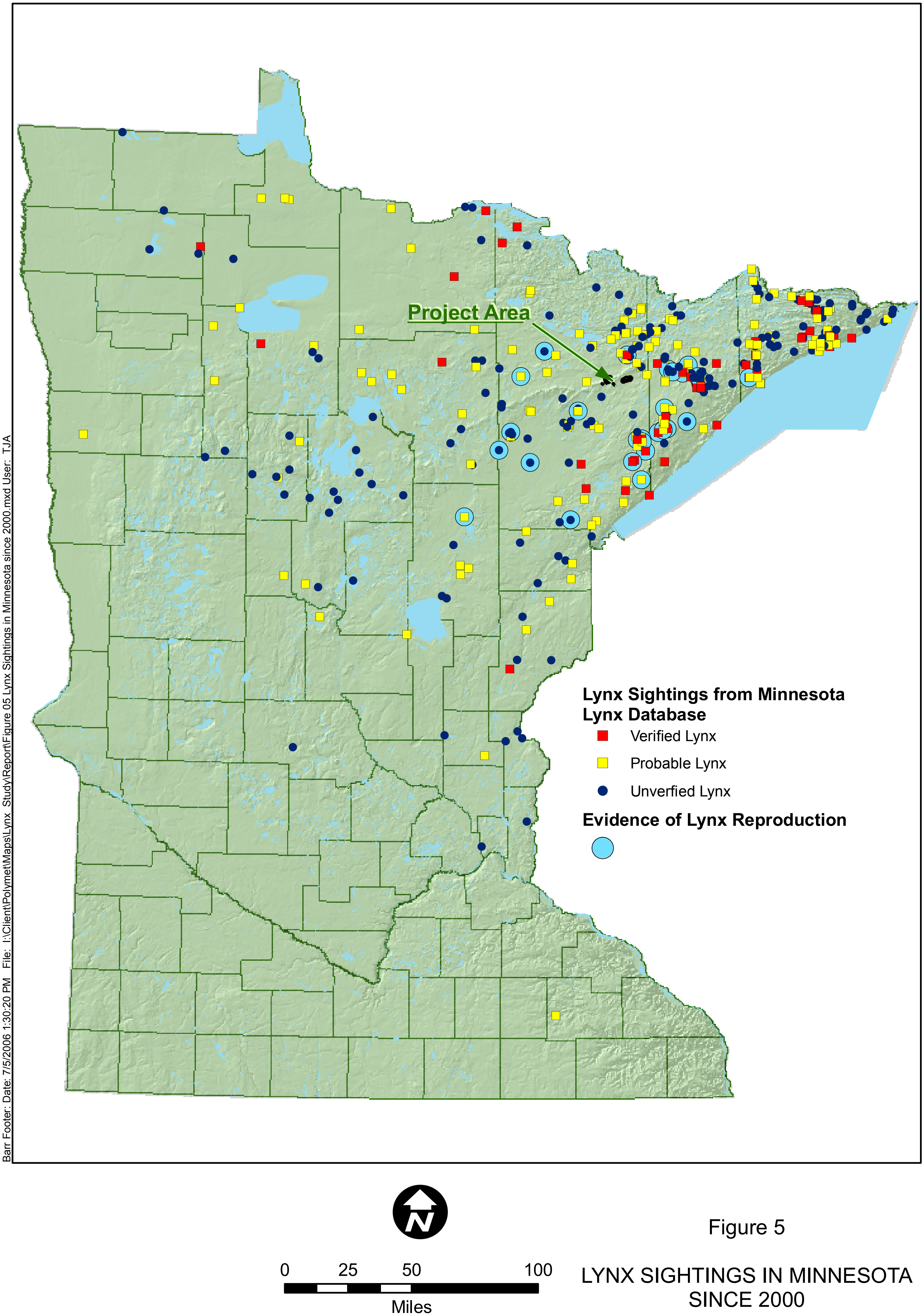


Figure 4
Lynx Sightings



Barr Footer: Date: 7/5/2006 1:30:20 PM File: I:\Client\Polymet\Maps\Lynx Study\Report\Figure 05 Lynx Sightings in Minnesota since 2000.mxd User: TJA

Figure 5

LYNX SIGHTINGS IN MINNESOTA SINCE 2000

4.0 RESULTS

4.3. Literature Review

No evidence of lynx use of the mine site was found during bait and tracking surveys for lynx conducted during winter 2000 (ENSR 2000), or during other surveys at the mine site since 1999 (Foth and Van Dyke 1999, Phillips 1999, USDA Forest Service 1999, ENSR 2005).

4.4. Database Queries

Lynx sightings in the vicinity of the survey area and in Minnesota are shown in Figures 4 and 5 (MNDNR 2006). The majority of confirmed and unconfirmed sightings in Minnesota have been made in the three counties to the east of Itasca County: Lake, Cook, and St. Louis counties. Of the 408 sightings reported to the Minnesota Natural Heritage and Nongame Research Program since 2000, 78 percent have been in these three counties. Approximately 100 lynx have been sighted in St. Louis County since 2000, and 14 of these lynx had evidence of reproductive activity.

The Superior National Forest genetic reference collection and NRRI studies show that 20 unique lynx have been found within 18 miles (30 km) of the study area (NRRI 2006). Six of these lynx were radio-collared, and three of these spent some time within the study area.

4.5. Field Surveys

4.5.1. Snow Tracking Survey

Snow tracking surveys were conducted from January 26 to March 25, 2006. We surveyed transects on 33 days and snow-tracked lynx on 11 days with both activities occurring on some days. The majority of time was spent surveying for felids within the study area. We did not observe bobcat, cougar, or wolverine or their sign in the survey area.

Approximately 539 miles (862 km) of transect were surveyed in the study area, and 77 miles (123 km) were surveyed in townships adjacent the study area (Figures 6 through 14; Table 1). Within the study area, we averaged approximately 16 miles (30 km) of transect per day.

Track intercepts were recorded by noting the locations where the lynx approached and left the transect. Lynx track intercepts were found at 22 locations (Figures 7 through 14). Individual lynx found during the surveys were identified based on their scat DNA characteristics (see Section 4.4 below; Table 2). Based on the results of DNA analysis and tracking surveys, we believe that two lynx, Lynx 2 and Lynx 3, made most of the trails found during transect surveys. Six intercepts made by the same lynx were recorded on transects within 18 feet (30 meters) of each other. The selection of routes to be surveyed was influenced by the location of lynx trails found earlier, so that additional lynx trail detections on transects would be made. We believe that nearly all lynx trails that crossed survey transects, at the time of the survey were recorded; however, at least two trails made by Lynx 2 were not detected because the lynx had traveled on a snowshoe hare trail. It is possible that other lynx trails made by a lynx following a hare or deer trail that crossed a transect were missed as well.

We recorded 37 lynx track intercepts that were encountered incidentally during periods when we were not conducting transect surveys. These detections usually occurred while traveling to or from survey transects or when checking for lynx trails near locations where lynx sign had previously been observed. Tracks of Lynx 2 and Lynx 4 were recorded incidental to transect surveys.

In the study area, we snow tracked lynx for approximately 6 miles (10.2 km) in Township 60 North, Range 12 West, and 2.6 miles (4.3 km) in Township 58 North, Range 13 West. We followed segments of lynx trail in four townships adjacent the survey area—Township 60 North, Range 11 West; Township 59 North, Range 112 West; Township 58 North, Range 12 West; and Township 57 North, Range 13 West—for approximately 1.7 miles (2.8 km).

Table 1. Miles Surveyed for Lynx in Each Township.

Townships in Study Area		Townships Outside of Study Area	
Township Surveyed	**Miles Surveyed in Township**	**Township Surveyed**	**Miles Surveyed in Township**
Township 58 North, Range 13 West	103.6	Township 57 North, Range 13 West	3.9
Township 59 North, Range 12 West	60.9	Township 58 North, Range 11 West	4.2
Township 59 North, Range 13 West	80.9	Township 58 North, Range 12 West	8.5
Township 59 North, Range 14 West	57.0	Township 58 North, Range 14 West	19.1
Township 60 North, Range 12 West	103.1	Township 59 North, Range 11 West	18.2
Township 60 North, Range 13 West	62.9	Township 59 North, Range 15 West	0.6
Township 60 North, Range 14 West	70.6	Township 60 North, Range 11 West	4.7
		Township 60 North, Range 15 West	8.5
		Township 61 North, Range 12 West	5.0
		Township 61 North, Range 13 West	3.6
		Township 61 North, Range 14 West	0.3
		Township 61 North, Range 15 West	0.7

4.5.2. Individual Lynx Movements and Sign

We tracked three lynx during the study. Nine scat were collected during the survey. Eight scat were deposited by the lynx being tracked, while one scat was collected where the lynx being tracked paused to scent mark a site where scat had been deposited by another lynx (Lynx 1).

Lynx 1. We collected a scat deposited by Lynx 1 while following Lynx 2 (Figures 12 and 16). Based on its position in the snow, we believe the scat was deposited prior to January 27.

Lynx 2. We followed this lynx for approximately 5 miles (8.5 km; Figures 12 and 16). Although the trail consisted of four discontinuous segments, all segments of trail were assumed to have been produced by Lynx 2 while she traveled more than 7 miles (12 km) on February 3 from a resting bed to a location approximately 2 miles (3.5 km) west, and then turned to the east on February 5 or 6. We collected two scat from a single segment of trail in Township 60 North, Range 12 West, and from another segment of trail in Township 60 North, Range 11 West.

Lynx 3. We followed this lynx for approximately 2.5 miles (4.3 km) in Township 58 North, Range 13 West, on March 11, 12, 13, and 24 (Figures 13, 15, and 17). The trail consisted of multiple, discontinuous segments and were likely traveled by Lynx 3 on March 11 and 12 (see Figures 13 and 17). We collected a scat from

Lynx 3 on March 13. We collected another scat on March 11 from a lynx that we believe was Lynx 3; however, DNA analysis was not able to confirm sex or identity of the lynx depositing the scat. These scat were collected approximately 10 miles (17 km) from the site where scat from this lynx was collected by a Superior National Forest Service biologist on March 9 in Township 57 North, Range 13 West (Ryan 2006; Forest Service sample GLNR-S-199).

Lynx 4. While traveling by snowmobile to survey routes within the study area on February 2, we encountered the tracks of Lynx 4 in a township adjacent to the study area (Township 59 North, Range 11 West; Figures 14 and 15). Three scat were collected on two segments of trail; two samples were submitted for DNA analysis. Lynx 4 was not detected in the survey area.

4.6. DNA Analysis

We submitted eight scat for DNA analysis to determine species, sex, and identity (Table 2; Appendix A). Five of the eight scat were collected within the survey area (L1, L2a, L2b, L3, L0). Based on DNA analysis of the scat, three unique female lynx were identified within the survey area, two within Township 60 North, Range 12 West (Lynx 1 and 2), and one within Township 58 North, Range 13 West (Lynx 3). Lynx 2 also was identified in a township adjacent to the study area (Township 60 North, Range 11 West). A fourth female lynx (Lynx 4) was identified in a township adjacent to the study area (Township 59 North, Range 11 West).

Table 2. Lynx Identified by DNA Analysis of Scat.

Individual	Identifier	Collection Date	Species	Sex	Sample	Township
Lynx 1	L1	February 4	Lynx	Female	Loch-S-06/P	Township 60 North, Range 12 West
Lynx 2	L2a	February 7	Lynx	Female	Loch-S-08/P	Township 60 North, Range 12 West
Lynx 2	L2b	February 8	Lynx	Female	Loch-S-09/P	Township 60 North, Range 12 West
Lynx 2	L2c	February 28	Lynx	Female	Loch-S-12/P	Township 60 North, Range 11 West
Unknown[1]	L0	March 11	Lynx	Unknown[1]	Loch-S-13/P	Township 58 North, Range 13 West
Lynx 3	L3	March 13	Lynx	Female	Loch- S-14/P	Township 58 North, Range 13 West
Lynx 4	L4a	February 2	Lynx	Female	Loch-S-03/P	Township 59 North, Range 11 West
Lynx 4	L4b	February 2	Lynx	Female	Loch-S-04/P	Township 59 North, Range 11 West

[1] Not able to determine identity or sex from DNA.

Genotypes of the four lynx varied from each other by a range of five to nine alleles. We determined that none of the four individuals was parent or progeny of each other, and none was an F1 lynx-bobcat hybrid (Schwartz et al. 2004).

4.7. Lynx Density

Three individual lynx were found in the study area (Figure 15), and one was found adjacent to the study area. It is possible that we did not detect all lynx that use the study area. It is reasonable to assume that since it was the breeding season and we only recorded female lynx, one or more male lynx used the study area, at least occasionally. We recorded one lynx in an adjacent township (Lynx 4), and it is possible that one or more lynx using nearby townships may have also used the study area. Based on past experience tracking lynx within 20 miles (32 km) of the study area, we feel that lynx density is relatively low in the survey area (approximately one lynx per 83 square miles [21,500 ha]) compared to other portions of Minnesota.

Only recently has the lynx population in Minnesota shown signs of recovering from an extended period of low numbers. Snowshoe hare population levels in Minnesota have declined from levels in the 1980s. As snowshoe hare populations recover, the number of lynx in or near the study area should also recover.

4.8. Lynx Habitat Use

Generally, lynx hunt within habitats where snowshoe hare are common or abundant. An essential aspect of habitat is dense conifer or mixed-forest cover that provides security for snowshoe hares. Most lynx hare kills occur in habitat where conifer saplings or young pole timber are prevalent and where a significant acreage of this habitat type is available. Lynx also hunt hares in high stem density deciduous cover, such as alder (*Alnus* spp.) in riparian areas, and blue joint (*Calamagrostis canadensis*), willow (*Salix sp*.), and bog birch (*Betula pumila*) in creek bottoms.

Communities used most often by lynx are young jack pine/balsam fir forests. Balsam fir often occurs as inclusions or “pockets” of regenerating saplings within other cover types (e.g., in mature jack pine stands or in maturing spruce/aspen stands), and along forest edges. Lynx also use coniferous or mixed deciduous/coniferous forest patches in regenerating logged areas, including 10- to 25-year-old stands of jack pine or balsam fir/aspen (*Populus tremuloides*) mixed forest. Other important habitat types include spruce/balsam fir and black spruce/tamarack forests.

Communities used by lynx often originate as a result of natural or “facilitated” regeneration after logging. However, fire and balsam budworm outbreaks also play a role in influencing forest stand composition and age in sites used by lynx.

Lynx use conifer plantations, especially where large stands of plantation forest occur in proximity to each other. Lynx use white spruce, jack pine, white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and mixed conifer plantations, especially forests ranging from 10 to 30 years in age. Recent studies of snowshoe hare and red squirrel pellet density suggest that hare and squirrel numbers are greatest in jack pine, red pine, black spruce, and mixed pole/young mature and mature forests; presumably, lynx would be more common in these habitats (Moen et al. 2004). Lynx in Minnesota have been observed hunting snowshoe hare in dense stands of conifer saplings and in young and mid-sized pole forest, especially balsam fir, spruce, and jack forests.

4.8.1. Mine Site

We found no lynx or lynx sign while surveying the mine site. Jack pine forest, favored by snowshoe hare, was found primarily in the eastern half of the site. However, most jack pine and other conifer forest consisted of older pole or young mature stands, which are less favored by snowshoe hare than sapling or young pole stands.

4.8.2. Non Mine Site

4.8.2.1. Habitat Suitability by Township

We observed suitable habitat for lynx throughout the study area, except where lands had been disturbed by historic or ongoing mining operations, including areas immediately adjacent to mine waste rock piles. Recent logging activity in the northern portion of Township 60 North, Range 14 West, and in the central region of Township 60 North, Range 13 West, north of Northshore Mine, has reduced the acreage of lynx habitat in this area for the short term, but may enhance the suitability of these areas for lynx in the next decade if conifers regenerate.

Township 58 North, Range 13 West. Lynx 3 was found in this township. Patches of suitable lynx habitat are distributed throughout much of the township.

Township 59 North, Range 12 West. No lynx sign was observed in this township. Lynx use of this township is likely, as lynx were found in five of the eight adjoining townships.

Township 59 North, Range 13 West. No lynx sign was observed in this township. Suitable habitat occurred throughout the township with the exception of sizeable patches of muskeg.

Township 59 North, Range 14 West. No lynx sign was observed in this township. Mining operations have altered a substantial percentage of the land cover, and it was estimated that less lynx habitat was found in this township than in the other townships in the study area. Recent logging within the township has also reduced the amount of suitable lynx habitat for the short term. Lynx use of the southeast portion of the township is likely.

Township 60 North, Range 12 West. Lynx 1 and Lynx 2 were found in this township. Lynx use of this township also occurred in March 2004 and January 2005, based on scat collections and DNA analysis. Excluding mined lands, a large amount of suitable habitat for lynx occurs within the township. The greatest snowshoe hare densities were in the northeast quadrant, although lynx sign was not found in this quadrant during 2006 surveys.

Township 60 North, Range 13 West. No lynx sign was observed in this township during the survey, although lynx may have been sighted near the northern boundary of the township in January 2006. Recent, large scale logging in the central portion of the township has reduced the amount of suitable lynx habitat for the short term, but forest regeneration should provide suitable habitat for lynx in this area in the next decade. Land cover at the Northshore Mine is generally unsuitable for lynx, although habitats immediately adjacent the mine may be used by lynx.

Township 60 North, Range 14 West. No lynx sign was observed in this township. Recent logging in the northern portion of the township has reduced the amount of suitable habitat for lynx for the short term, but forest regeneration should provide suitable habitat for lynx in this area in the next decade. Habitat along the Embarrass River may become suitable for lynx if snowshoe hare densities increase.

4.8.2.2. Habitats Used by Lynx 2 and Lynx 3

Important habitat features used by Lynx 2 and Lynx 3 were identified during snow tracking. Lynx 2 hunted snowshoe hares in mature jack pine where balsam fir inclusions in the understory were prevalent and provided dense cover, and in pole jack pine forest, often near lowland edges where balsam fir and other sapling and small pole conifers provided relatively dense cover. This lynx also use lowland conifer habitats. Lynx 2 stalked three locations where deer had bedded and investigated one site where grouse activity had occurred. It used Section 27, where deer activity was high, and also followed deer trails and hunted snowshoe hare at this location. Two resting beds used by this lynx were found, one in mature jack pine and the other in a recent clearcut near a timbered edge.

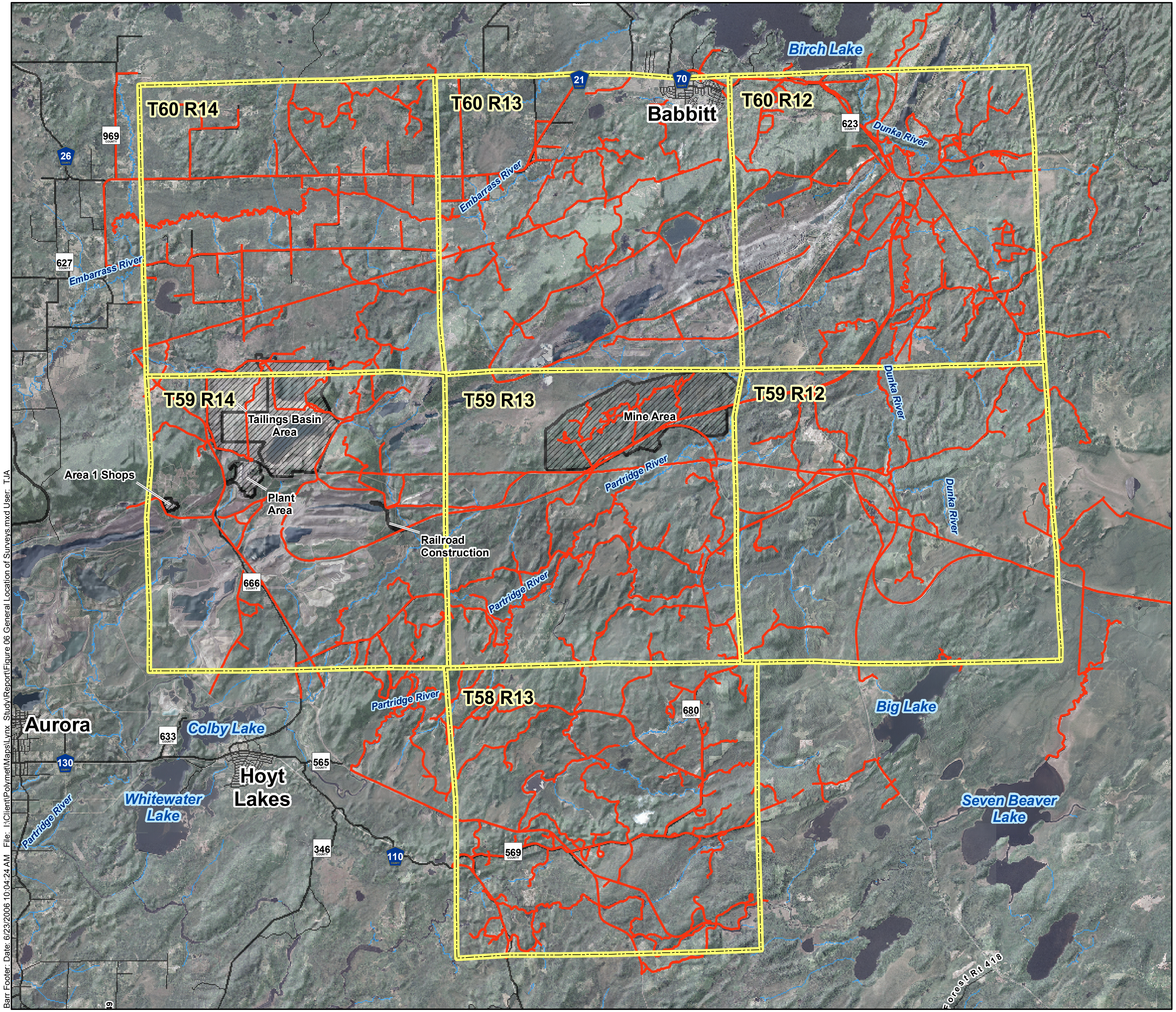
Lynx 3 used mature black spruce swamp and hunted primarily in sapling and pole jack pine forest regenerating on sites that had been clearcut within 25 years. Snowshoe hare densities were abundant in a small stand of jack pine/balsam fir where the lynx hunted. Two resting beds, within 325 feet (100 meters) of each other, were found in this stand. The lynx pursued a deer for a short distance and visited a site where humans had deposited venison trimmings. The lynx also investigated the empty snow roost of a grouse.

4.9. Other Observations

Residents near the survey area provided information on lynx and their habitat use to biologists during the survey period. Two Babbitt residents believed they observed a lynx on three occasions in mid-January 2006; two sightings were in Section 1 of Township 60 North, Range 13 West, and another approximately 2 miles (3 km) east in Township 60 North, Range 12 West. All three sightings were at the northern edge of the survey area. We did not observe lynx or their sign in this area during the 2006 lynx survey.

A Babbitt resident indicated that he had observed lynx sign in Township 60, North Range 12 West on several occasions in the past 8 years. He also mentioned that two lynx were taken by Babbitt trappers during the 2005-06 trapping season.

Two Babbitt residents observed trails of three lynx (believed to be an adult and two kittens) traveling together during winter 1996-97 near Slate Lake, Minnesota, which is approximately 7.5 miles (12 km) east of the study area. The lynx ate a beaver (*Castor canadensis*) carcass the trappers left for them.



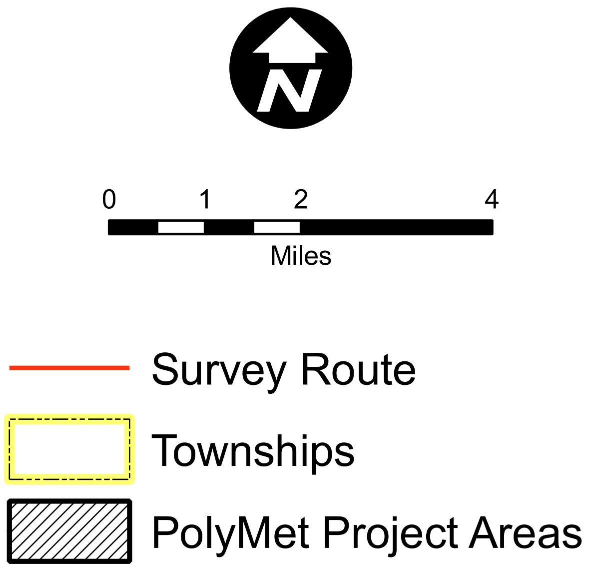
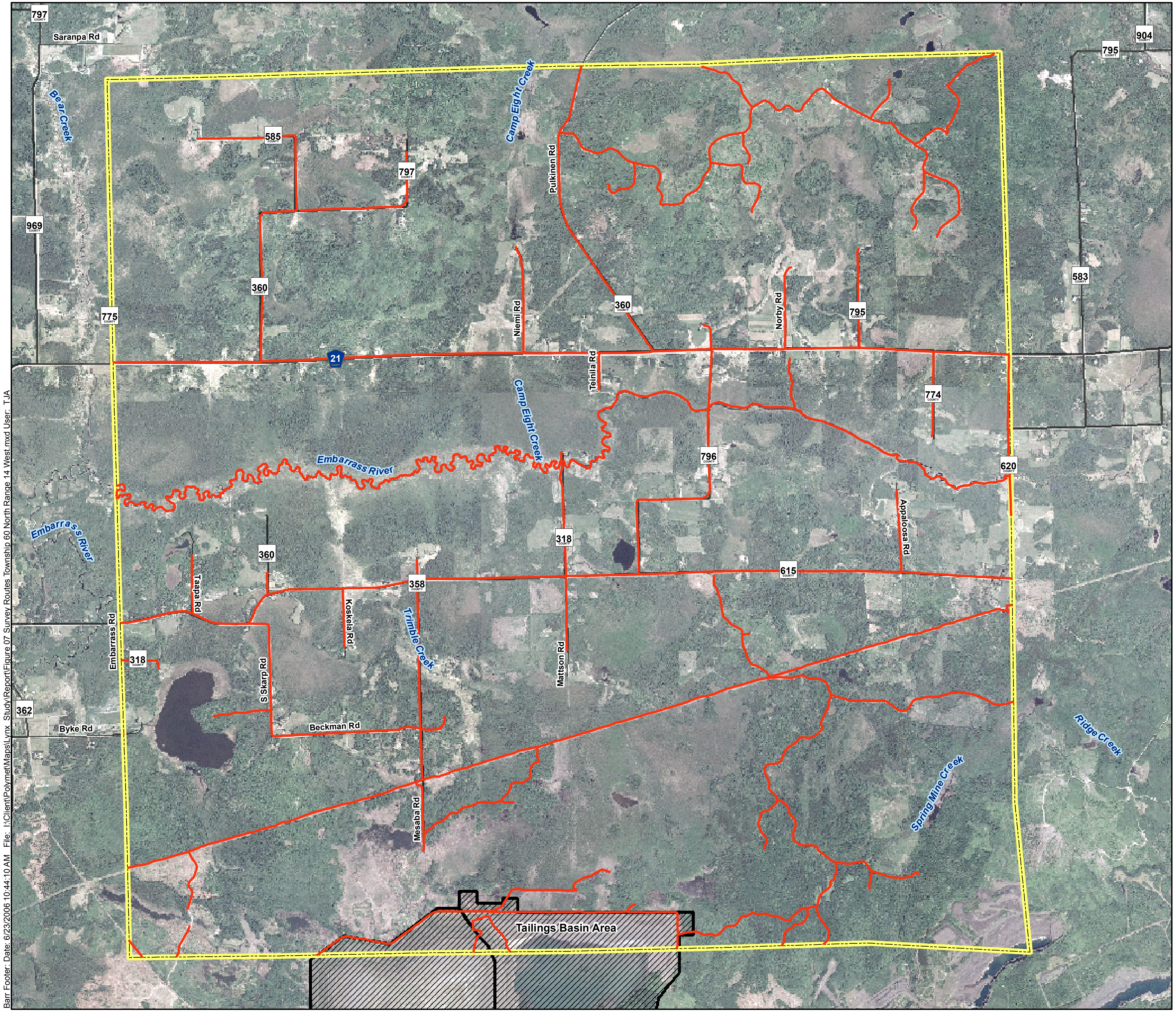


Figure 6
General Location
of Surveys



0 1,750 3,500 7,000
Feet

Survey Route
Township 60N Range 14W
PolyMet Project Areas

Note:
No lynx trails or sign found in this township

Figure 7
Survey Routes
Township 60 North Range 14 West

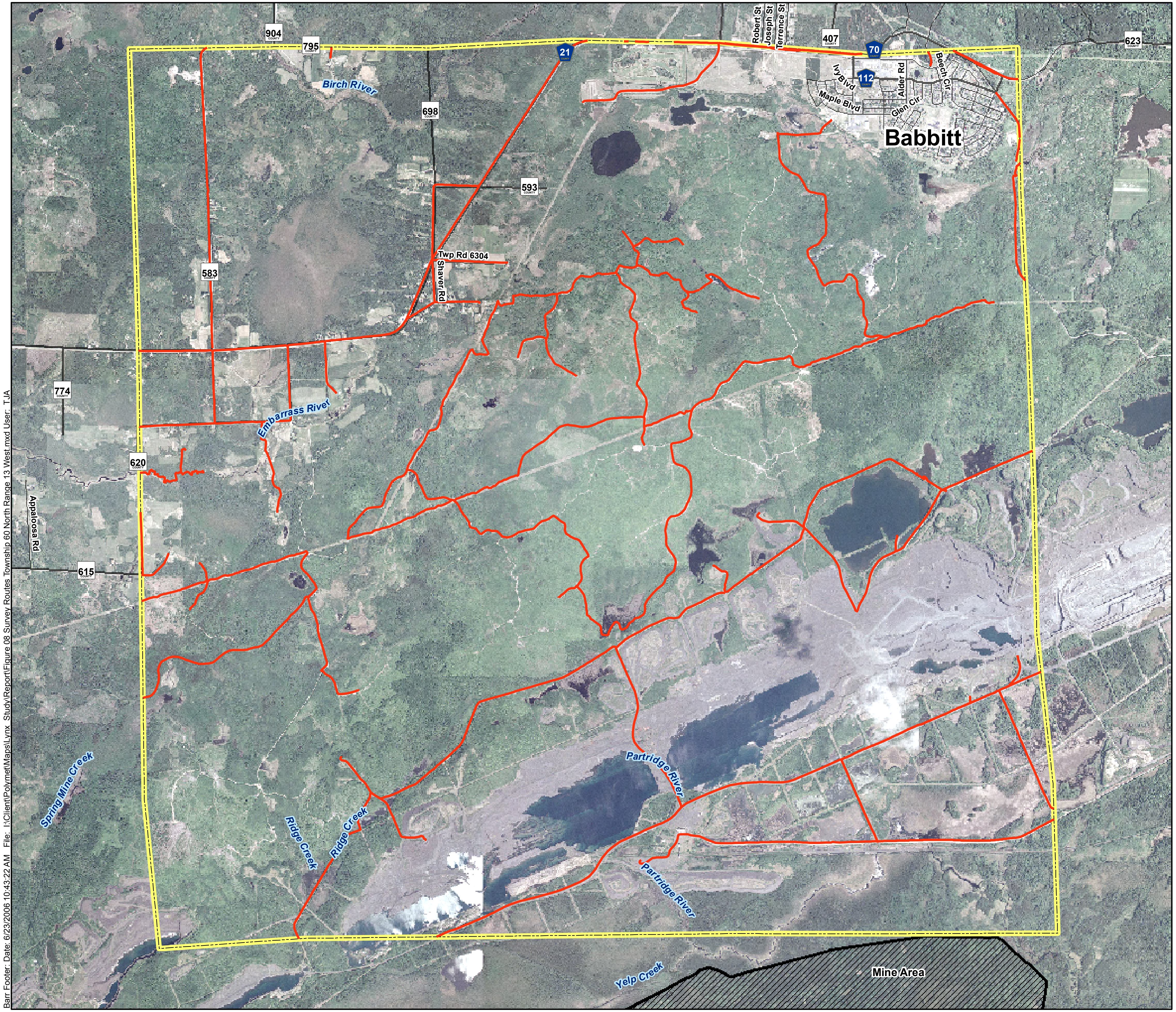
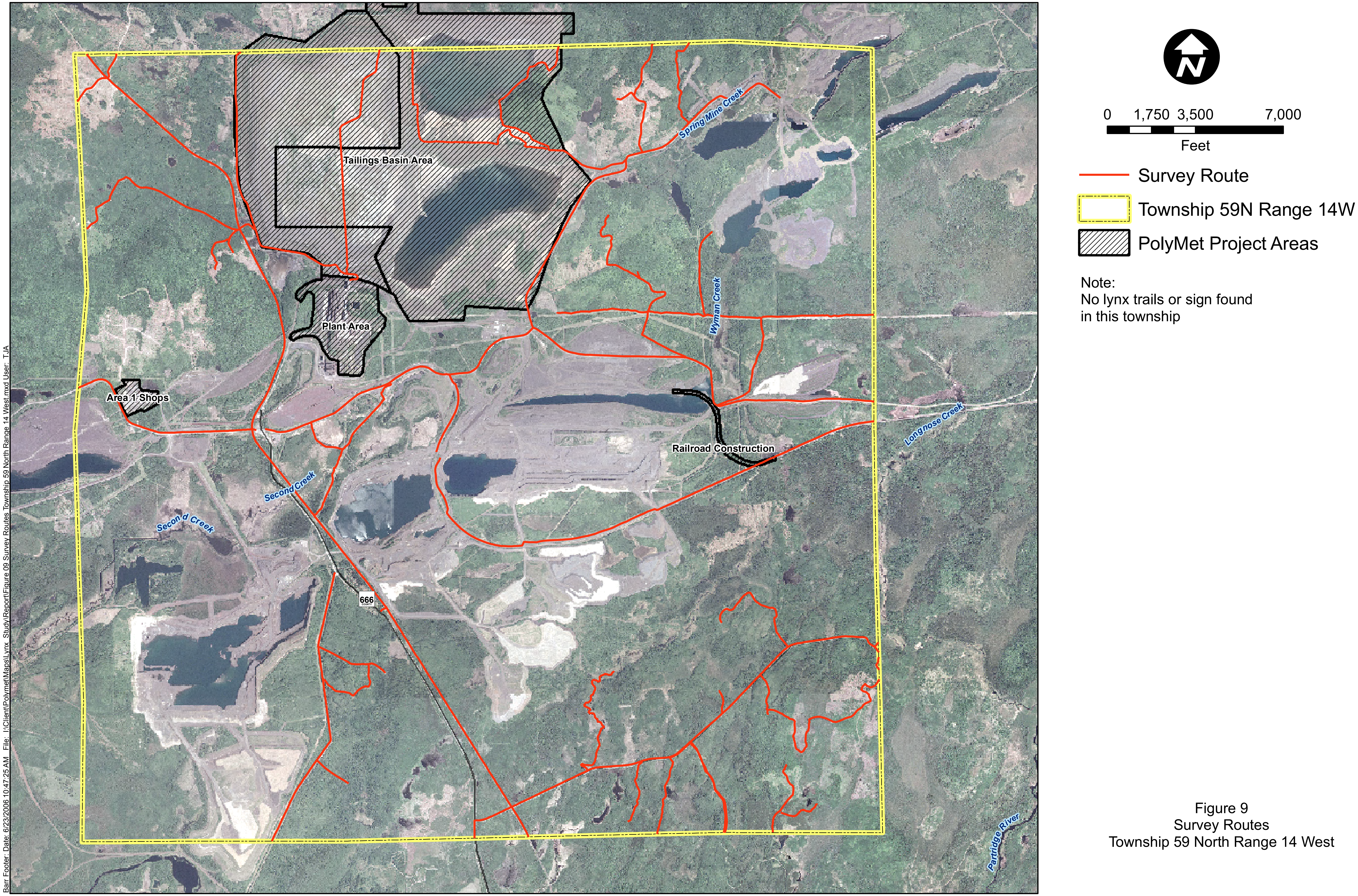
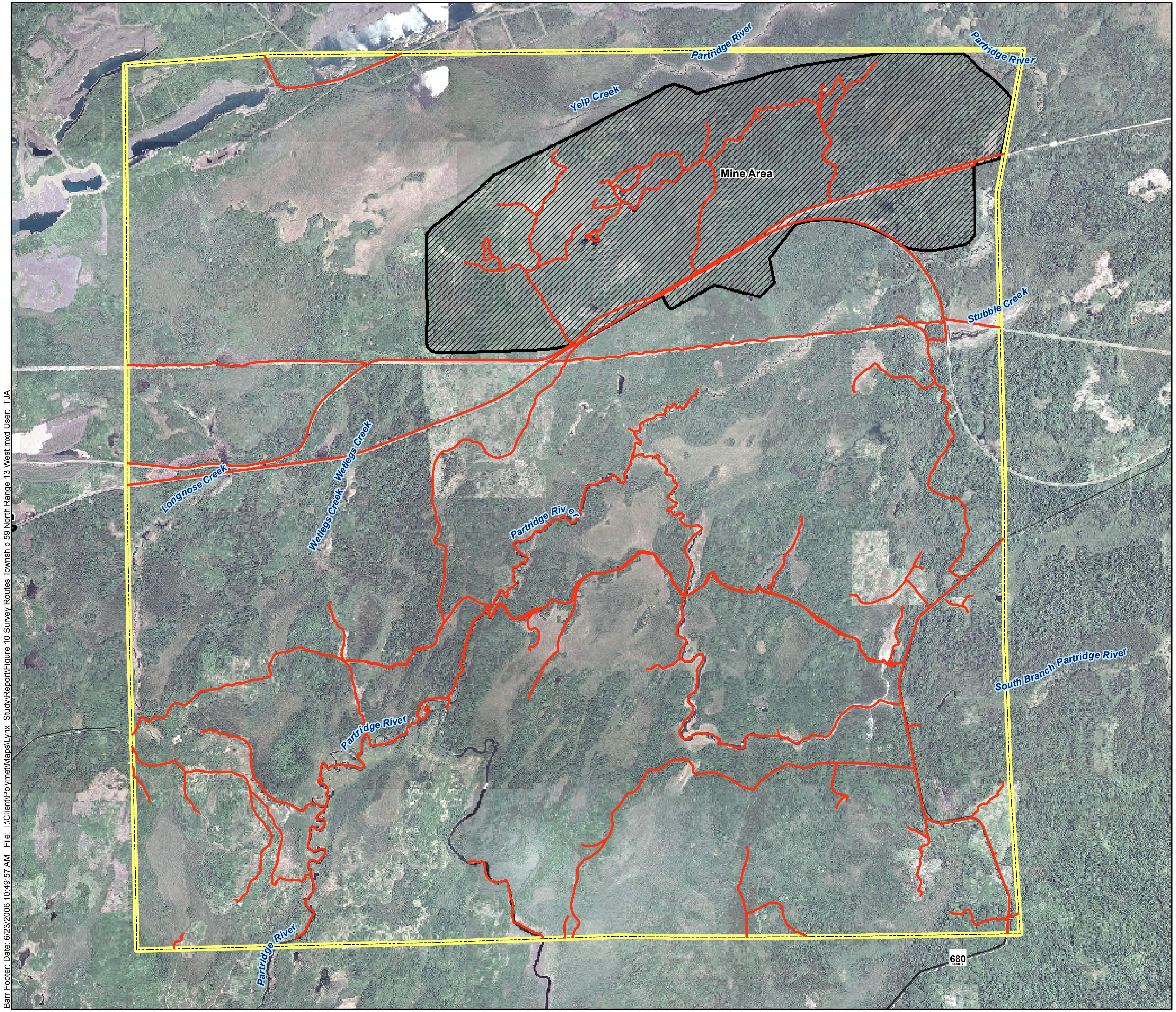


Figure 8
Survey Routes
Township 60 North Range 13 West



Note:
No lynx trails or sign found in this township

Figure 9
Survey Routes
Township 59 North Range 14 West



0 1,750 3,500 7,000
Feet

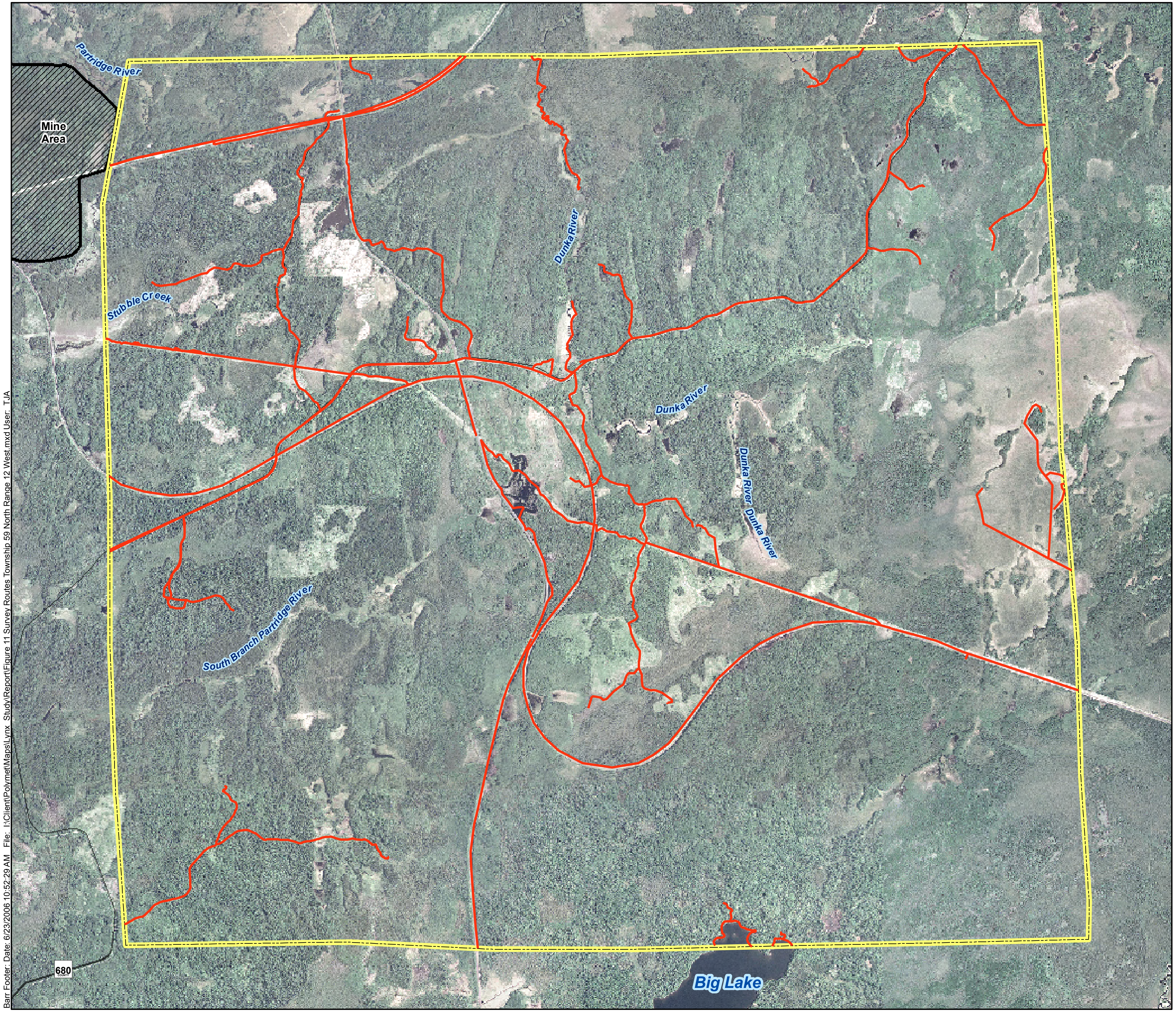
Survey Route

Township 59N Range 13W

PolyMet Project Areas

Note:
No lynx trails or sign found
in this township

Figure 10
Survey Routes
Township 59 North Range 13 West

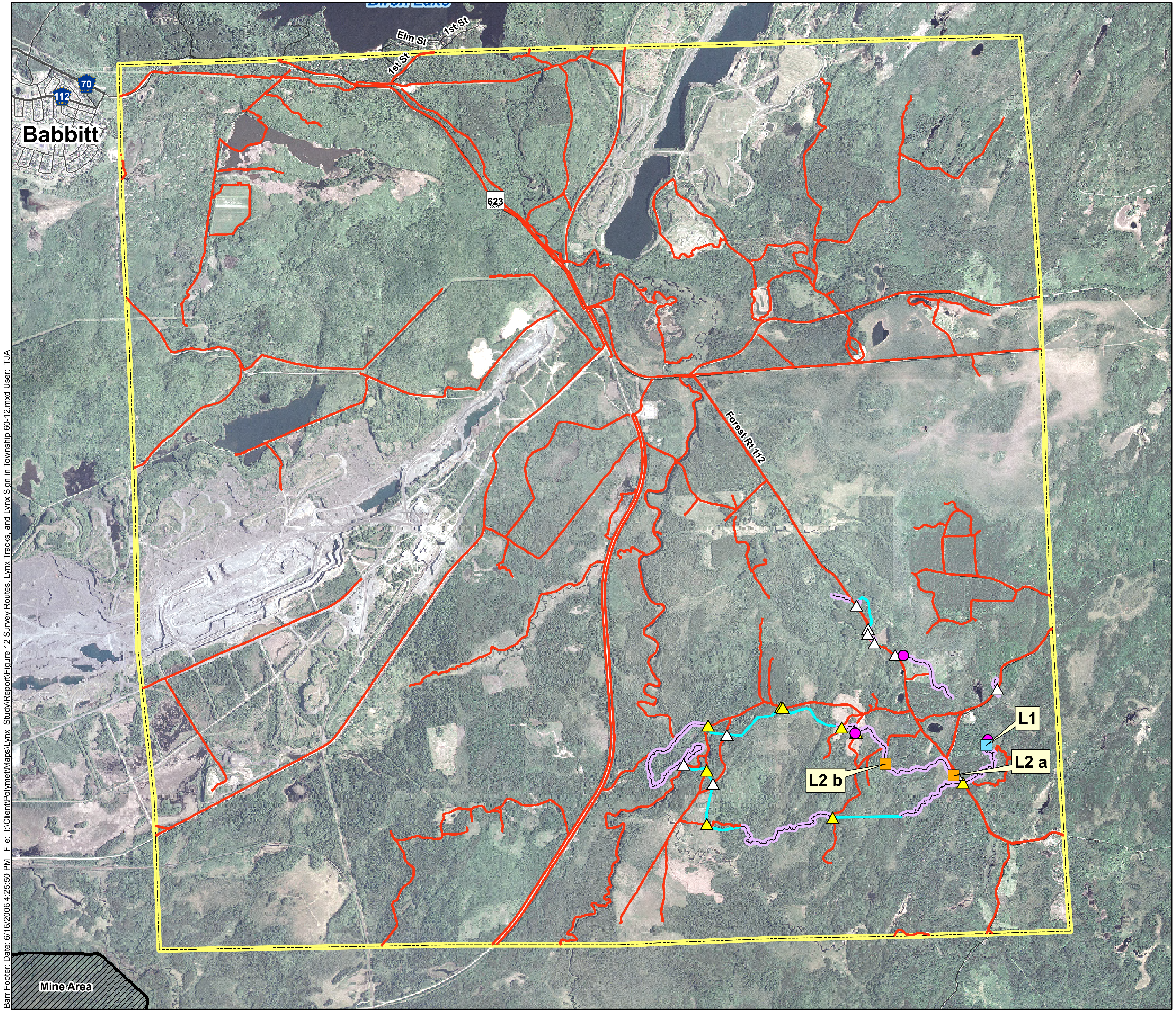


0 1,750 3,500 7,000
Feet

Survey Route
Township 59N Range 12W
PolyMet Project Areas

Note:
No lynx trails or sign found
in this township

Figure 11
Survey Routes
Township 59 North Range 12 West

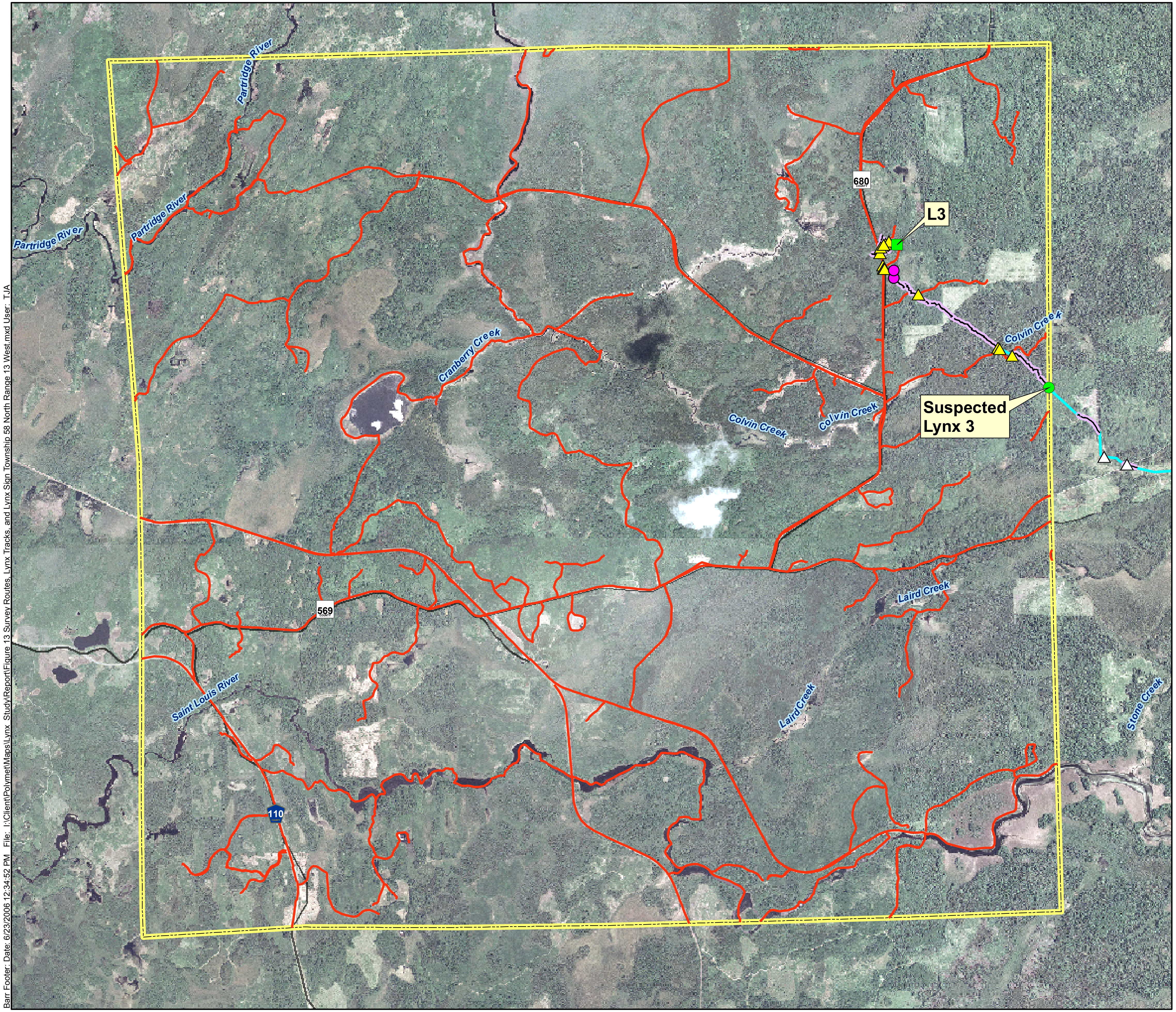


0 1,750 3,500 7,000
Feet

Lynx 1 Scat Collection Site
Lynx 2 Scat Collection Site
Lynx Resting Bed
Lynx Trail Intercept on Transect*
Incidental Lynx Trail Intercept**
Lynx Trail
Estimated Lynx Trail
Survey Route
PolyMet Project Areas
Township 60N Range 12W

*Detected while searching a survey transect
**Detected while traveling

Figure 12
Survey Routes, Lynx Tracks, and Lynx Sign
Township 60 North Range 12 West



0 1,750 3,500 7,000
Feet

- Lynx 3 Scat Collection Site
- Suspected Lynx 3 Scat Collection Site
- Lynx Resting Bed
- Lynx Trail Intercept on Transect*
- Incidental Lynx Trail Intercept**
- Lynx Trail
- Estimated Lynx Trail
- Survey Route
- Township 58N Range 13W

*Detected while searching a survey transect
**Detected while traveling

Figure 13
Survey Routes, Lynx Tracks, and
Lynx Sign
Township 58 North Range 13 West

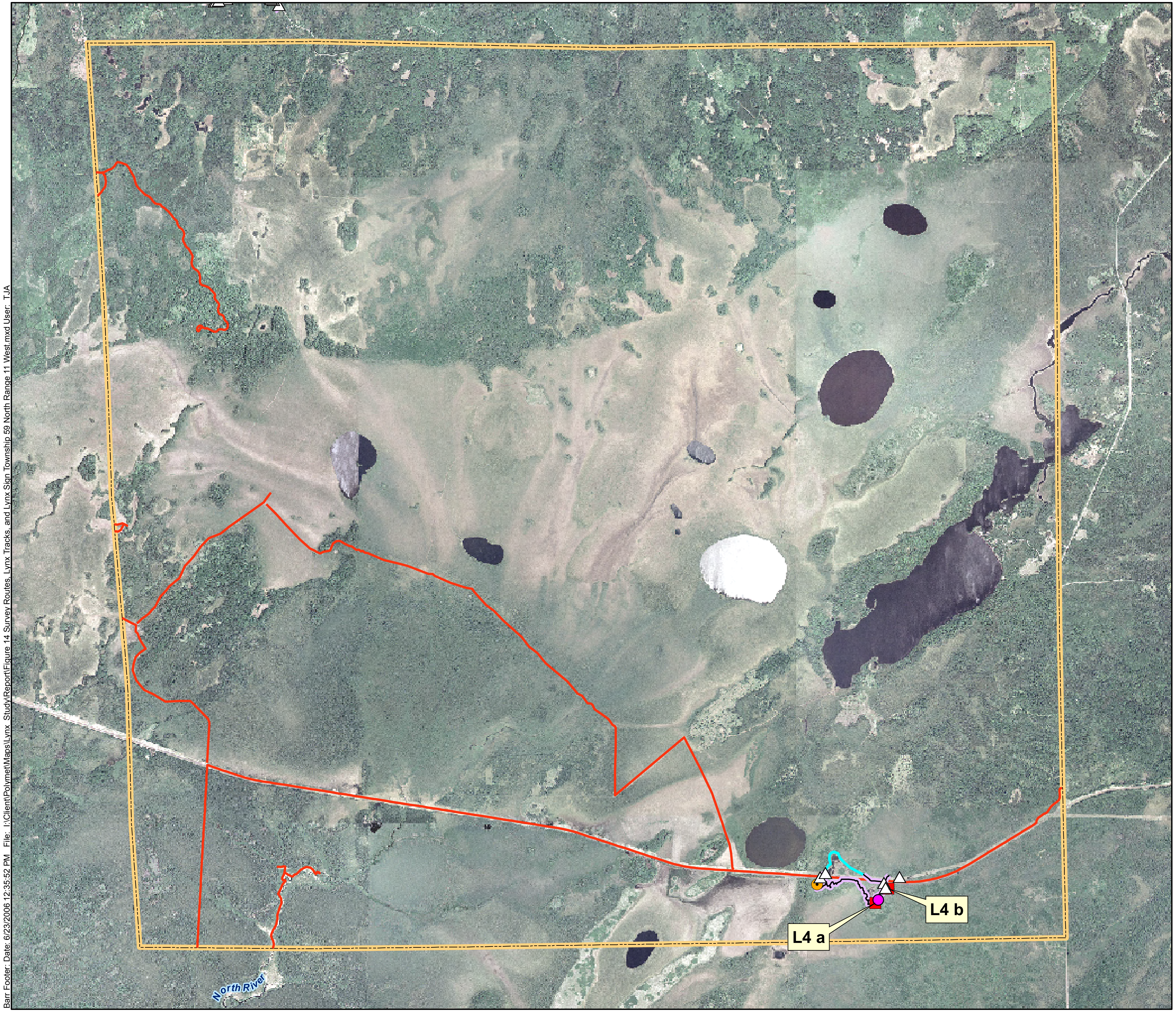


Figure 14
Survey Routes, Lynx Tracks, and Lynx Sign
Township 59 North Range 11 West

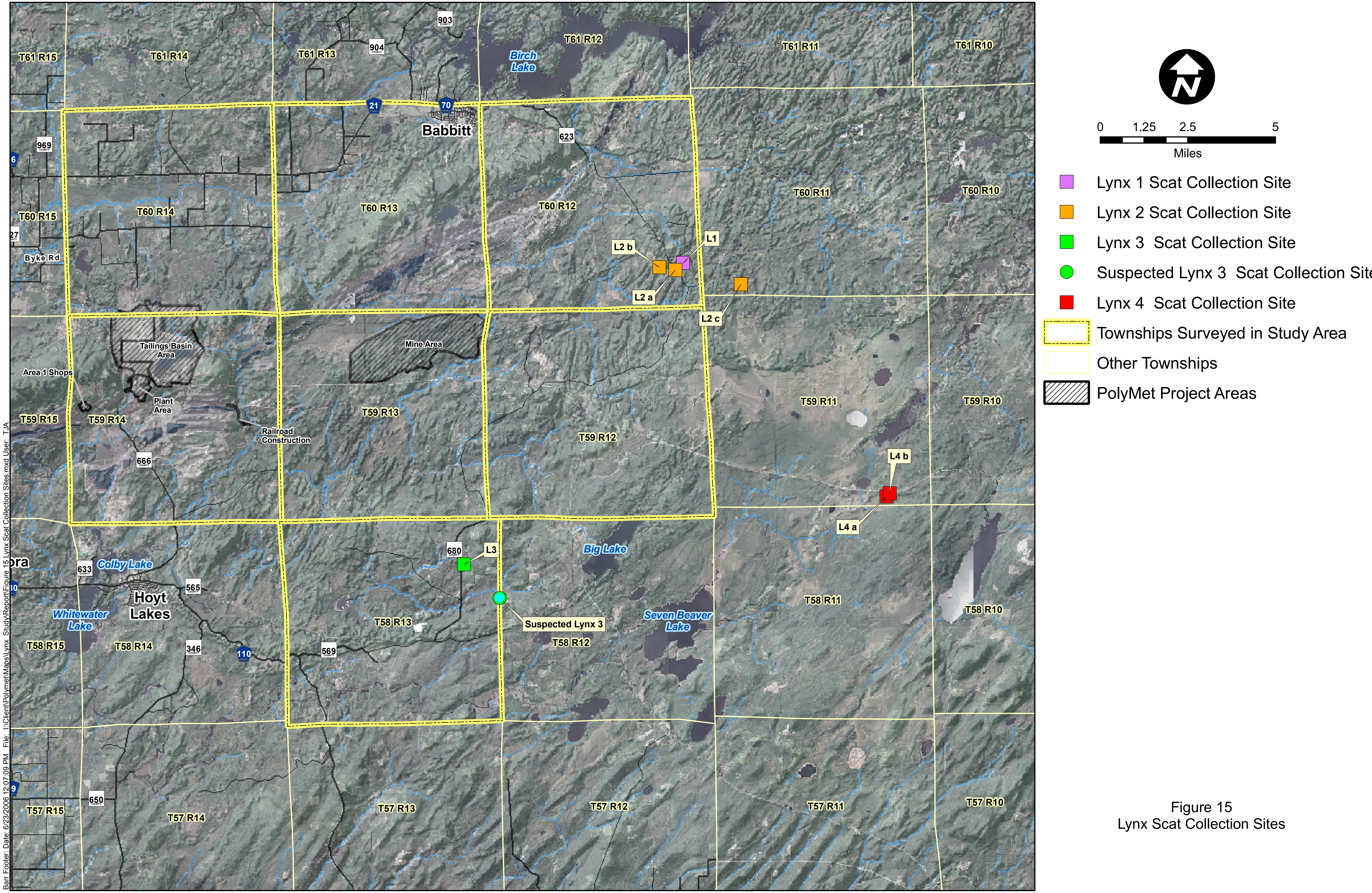
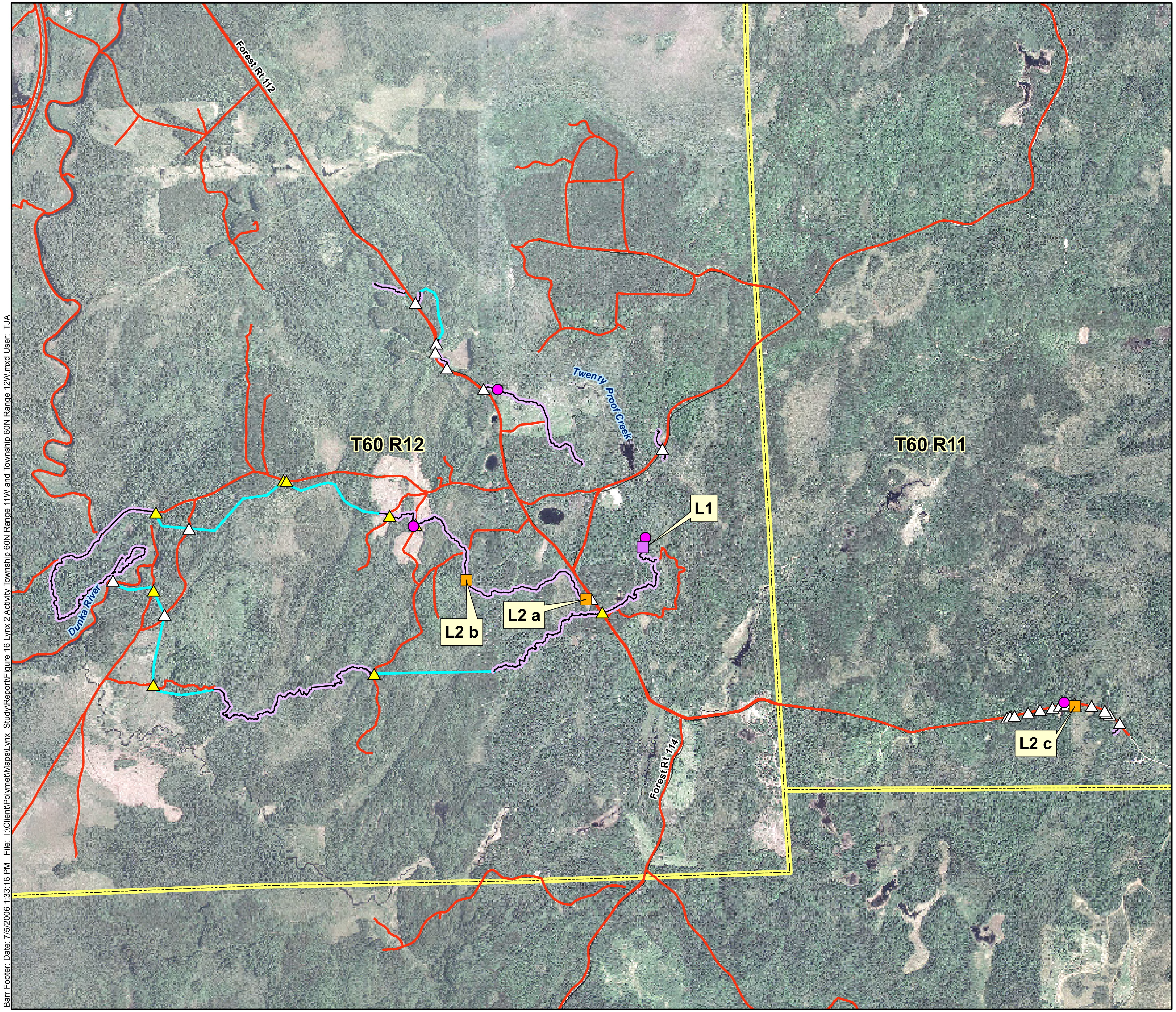


Figure 15
Lynx Scat Collection Sites

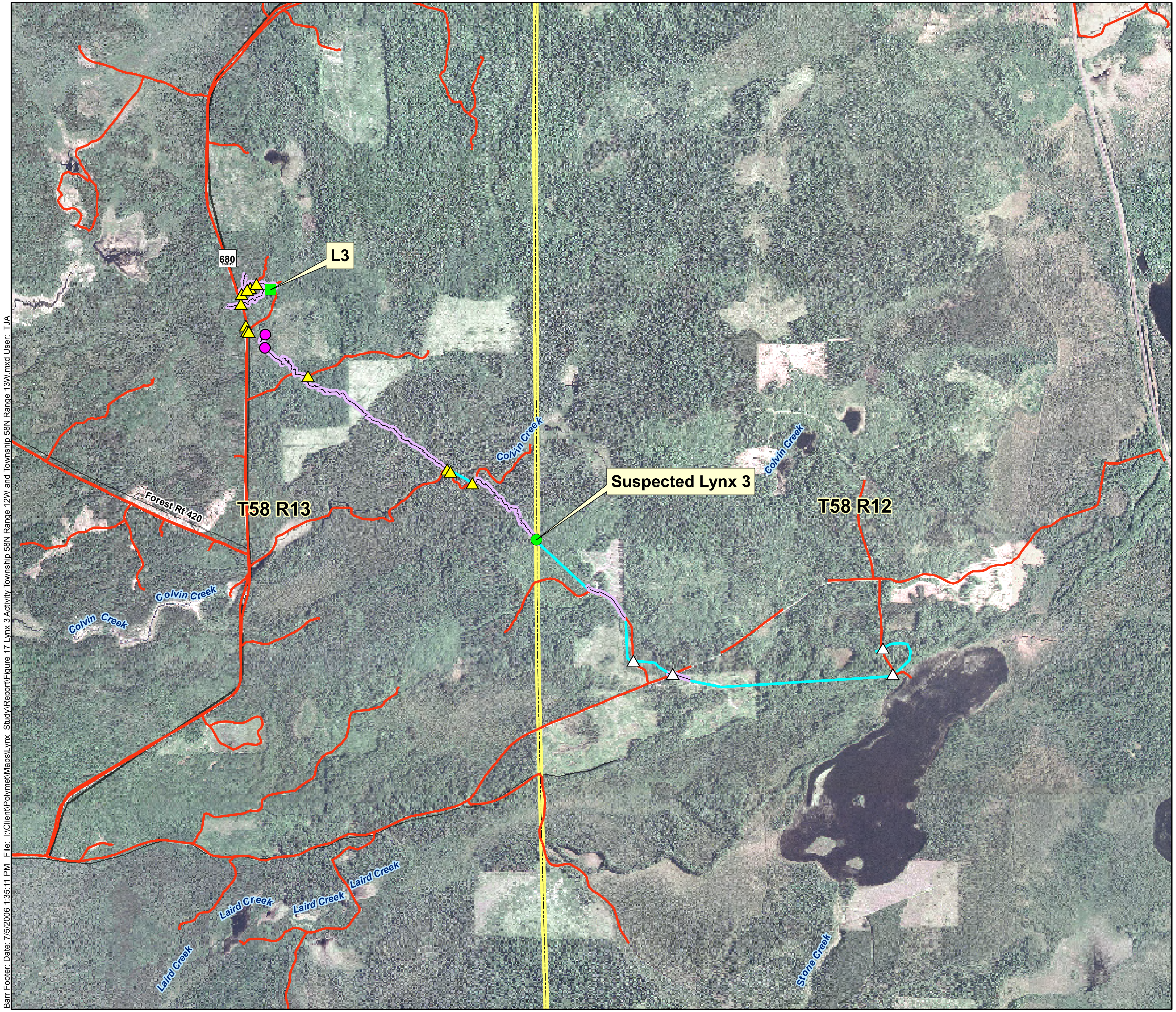


0 1,000 2,000 4,000
Feet

- Lynx 1 Scat Collection Site
- Lynx 2 Scat Collection Site
- Lynx Resting Bed
- Lynx Trail Intercept on Transect*
- Incidental Lynx Trail Intercept**
- Lynx Trail
- Estimated Lynx Trail
- Survey Route
- Township 60 North Range 11 West and Township 60 North Range 12West

*Detected while searching a survey transect
**Detected while traveling

Figure 16
Lynx 2 Activity
Township 60 North Range 11 West
and Township 60 North Range 12 West



0 1,000 2,000 4,000
Feet

- Lynx 3 Scat Collection Site
- Suspected Lynx 3 Scat Collection Site
- Lynx Resting Bed
- Lynx Trail Intercept on Transect*
- Incidental Lynx Trail Intercept**
- Lynx Trail
- Estimated Lynx Trail
- Survey Route
- Township 58 North Range 12 West and Township 58 North Range 13 West

*Detected while searching a survey transect
**Detected while traveling

Figure 17
Lynx 3 Activity
Township 58 North Range 12 West
and Township 58 North Range 13 West

5.0 FACTORS AFFECTING CANADA LYNX AND THEIR HABITATS WITHIN THE STUDY AREA

5.3. Factors Identified in Final Rule

The USFWS concluded that the single biggest factor threatening the lynx in the contiguous U.S. is the inadequacy of existing regulatory mechanisms, specifically the lack of guidance for conservation of the lynx in National Forest and other resource management plans (Federal Register 2000). In addition, the USFWS noted that timber harvest and fire suppression impact lynx in the Great Lakes Geographic Area.

Lands under federal management are necessary for lynx conservation regionally and nationally. Large tracts of Superior National Forest lands are found in and adjacent to the study area. Most of the lands not associated with Mesabi Iron Range mining and related activities are forests. These forestlands provide important habitat for lynx within the study area, and for movement of lynx between the study area and areas with higher densities of lynx to the east.

5.4. Other Lynx Risk Factors

The *Lynx Conservation Assessment and Strategy* (Ruediger et al. 2000) identified several other risk factors for lynx in the contiguous U.S., which could also apply to lynx in the study area. These factors will be considered in the following section on the effects of the proposed action, and the cumulative effects of the project and other projects within the study area, on lynx. These include the following (**bolded items** considered important in the study area):

1. Factors Affecting Lynx Productivity
   - **a. Timber management**
   - **b. Wildland fire management**
   - **c. Recreation**
   - **d. Forest/backcountry roads and trails**
   - e. Livestock grazing
   - **f. Other human developments (mining, power generation, etc.)**

2. Factors Affecting Lynx Mortality
   - **a. Trapping**
   - b. Predator control
   - **c. Incidental or illegal shooting**
   - **d. Competition and predation as influenced by human activities**
   - **e. Highways (vehicular collisions)**

3. Factors Affecting Lynx Movements
   - **a. Highways, roads, and ROWs**
   - **b. Land ownership patterns**
   - c. Ski areas and large resorts

4. Other Large-scale Risk Factors
   - **a. Fragmentation and degradation of lynx refugia**
   - b. Lynx movement and dispersal across shrub-steppe habitats
   - c. Habitat degradation by non-native invasive plant species

5.5. Current Non-federal Regulatory and Conservation Mechanisms within the Study Area

Within the Great Lakes Geographic Area, lynx are state listed as endangered in Michigan, protected as a wild animal in Wisconsin, and protected from harvest in Minnesota. Protection from legal harvest represents an important conservation benefit to lynx. Because most conservation actions are voluntary under these designations, no assurance of habitat protection can be attributed to state species designations.

6.0 LIKELY EFFECTS TO CANADA LYNX FROM THE MINE PROJECT

The proposed project could have adverse impacts to lynx, although most impacts would be limited to lynx found in the vicinity of the mine site. The assessment of impacts is based on our knowledge of lynx use of the area (as discussed in Chapter 3), and assumes that based on sightings and habitat availability, lynx may reside in the study area and travel through the area, and it is reasonably foreseeable that mine activities could impact lynx traveling in the area. Proposed mitigation measures would eventually restore some wildlife habitat to the site, but it would not be the same quantity or quality as the pre-disturbance condition. The following describes the likely effects of the project on lynx and their habitat, followed by conservation measures that could be undertaken by PolyMet and conservation agencies and organizations to reduce effects to lynx.

6.3. Determination of Effects

6.3.1. Types of Effects

Potential beneficial, direct, indirect, interdependent, and interrelated threats to the species that are unrelated to the proposed action, and that may result in cumulative effects as a result of the proposed action, are presented in this chapter (for a more detailed discussion of types of effects, see USFWS and National Marine Fisheries Service 1998). These effects are defined as follows:

- Beneficial – Effects of an action that are wholly positive, without any adverse effects, on a listed species or designated critical habitat.
- Direct – The direct or immediate effects of the project on the species or its habitat. Direct effects result from the proposed action, including the effects of interrelated actions and interdependent actions.
- Indirect – Effects caused by or resulting from the proposed action that are later in time, and are reasonably certain to occur. Indirect effects may occur outside of the area directly affected by the action.
- Interdependent – Effects that result from an activity that has no independent utility apart from the action under consideration.
- Interrelated – Effects that result from an activity that is part of the proposed action and depends on the proposed action for its justification (e.g., mine supply traffic; increased housing for workers).
- Cumulative – The effects of future federal, state, tribal, local, or private actions that are reasonably certain to occur in the study area considered in this assessment.

The effects assessment is based on the risk factors identified in Chapter 4 and on the following factors:

- the dependency of the species on specific habitat components;
- habitat abundance;
- population levels of the species;
- the degree of habitat impact; and
- the potential to mitigate for the adverse effect.

6.3.2. Factors Affecting Lynx Productivity

6.3.2.1. Mine and Other Developments and Related Human Activity

Loss of habitat and disturbance would be the primary effects on lynx associated with the project. Based on GIS analysis, the project could directly impact approximately 3,015 acres of lynx habitat, including approximately 1,305 acres (528 ha) of wetland and 1,710 acres (692 ha) of upland habitat. Of this habitat, approximately 835 acres (338 ha) of sapling/pole/young mature forested wetland, and 1,049 (425 ha) of upland sapling/pole/young mature habitat could be lost from the mine project, the type of habitat that is most likely to be used by lynx. Loss of this habitat would reduce the amount of prey and cover available to lynx traveling through the study area, and impacts would be short term. Loss of habitat would also make it less likely that lynx would establish a territory within the study area, especially in areas directly impacted by the mine project. Portions of the site would be reclaimed and reforested at mine closure, but potential lynx habitat would be lost for a period of 20 years, and it would likely be 20 or more years after mine closure before suitable lynx habitat would again occur in mine disturbance areas. However, after reclamation, habitat could improve such that lynx could establish territories within the project area.

Light and glare, roads, and noise associated with the project could impact lynx. The mine would operate 24 hours a day, 365 days per year, for up to 20 years. Light and glare would primarily be associated with plant buildings and structures, active stockpiles, and mine pits. Light and glare can affect the behaviors of lynx and make some species more susceptible to predation at night. Lynx traveling through the study area would likely avoid areas of the mine site that are active and well lit.

To date, most investigations of lynx have not shown human presence to influence how lynx use the landscape (Aubry et al. 2000). A possible exception is activity around a den site that may cause abandonment of the site, possibly affecting kitten survival (Ruggiero et al. 2000). Anecdotal information (Roe et al.1999) suggests that individual lynx behave differently in response to the presence of humans and their associated activities, depending on the environmental setting in which the interaction occurs. Intuitively, some threshold exists where human disturbance becomes so intense that it precludes use of an area by lynx.

A variety of factors may influence the effects of mine and other developments and human activity on lynx. The following list helps evaluate how an activity might influence lynx.

1. *Type and quality of lynx habitat in which an activity occurs.* For instance, human activity in denning or diurnal security habitats may have a greater effect on lynx than activity in other habitat components.

2. *Time of year the activity occurs.* For example, fall hunting in lynx denning habitat may have far less effect than spring alpine skiing, cross-country skiing, or snowboarding in such habitat. Recreational facilities designed for summertime use, such as developed campgrounds or amphitheaters, most likely have very little effect on lynx.

3. *Time of day the activity occurs.* At developed facilities that receive high, concentrated human use during the day (e.g., commercial developments and industrial facilities), lynx may rest during the day in secure habitats while people use the remainder of the landscape. Lynx could emerge after dark to use the landscape when human activity has ceased or receded to acceptable levels. If extensive activities occur at night in lynx habitat, they may diminish or preclude habitat use by lynx.

4. *Type of Activity.* The type of activity, pattern of human use, associated habitat impacts, and area of influence can affect the suitability of the landscape for lynx.

5. *Pattern of Activity.* Some animals can adapt to predictable human activities. That is, if the activity generally occurs at predictable time periods at the same places or along the same routes, animals may become habituated to the activity. Response of the animal depends on the context within which a human/animal encounter takes place, the behavioral state of the animal, the type of human activity, and the time and location of the recreational activity (Bowles 1995; Gutzwiller 1995; Gabrielson and Smith 1995; Knight and Cole 1995a, b).

6. *Intensity and Frequency of Activity.* How often the activity occurs and the number of people involved in the activity may influence the way lynx respond and use the surrounding environment. Encounters with a limited number of users might elicit a different behavioral response than frequent encounters with large groups of users.

Mining and processing are obviously heavy industrial operations and the source of various levels of noise and other disturbances. These activities have driven much of the economy for northeastern Minnesota communities for many decades. Local wildlife are likely to be accustomed to the sound from normal mine activities in the area. Noise impacts from the mine site and mill would be expected to be similar to impacts experienced from the neighboring Northshore Mine.

Mine construction, mine and mill operations, and ore transport are sources of noise. Noise from these sources would be relatively low-toned and constant, consistent with industrial fans, so it should present less annoyance than higher-pitched or variable tones of changing loudness.

Other sources of noise from the project site would include:

- chain saws and skidders used in clearing the project site
- blasting
- excavators and drills
- large trucks hauling and dumping rock
- backup alarms on mine excavators and trucks
- mine site warning sirens
- over-the-road diesel trucks
- trains hauling ore
- train whistles

In general, noise levels would not exceed 90 A-weighted decibels at the project boundary. The impacts of noise on lynx and other wildlife are largely unknown, and the assessment of impacts remains subjective. Wildlife are receptive to different sound frequency spectrums, many of which may be inaudible to humans. Wildlife also are known to habituate to noise, especially noises that are steady or continuous, such as noises that would occur at the mill. Wildlife are less likely to habituate to sudden, infrequent impulse noises. It is likely that noise would cause lynx to avoid areas near the mine project during their travels through the study area.

Although some workers currently reside near the mine, other workers will move to the area. New housing and other infrastructure would be required to support these new workers. Other industrial facilities proposed for development within the study area. The mine project, along with normal population growth, would result in conversion of wooded/forested habitats more suitable for lynx to developed uses that provide few habitat values for lynx. It is likely that ongoing and future development and disturbances within the study area would reduce the suitability of the study area to provide habitat and travel corridors for lynx. Federal forestlands on and near the study area would continue to provide a refuge for lynx, and it is likely the lynx would favor these areas over those within the study area.

6.3.2.2. Timber Management

Nearly all forestlands on the mine site would be removed. Forest management practices such as thinning, commercial harvest, and post harvest treatments would continue to occur at irregular intervals on non-project lands within the study area and would influence habitats for lynx and prey. As described previously, snowshoe hares may reach highest densities in young, dense coniferous or coniferous-deciduous forests, or mature forests with a dense understory of shrubs, aspen, and/or conifers. Red squirrels appear to be most abundant in mature cone-bearing forests. Lynx natal dens, described by Berrie (1974), Kesterson (1988), and Koehler (1990) are generally located in areas with large quantities of coarse woody debris, such as blowdown and root wads, which may occur in mature forests or in regenerating stands.

Timber harvest is not an exact ecological substitute for natural disturbance processes. For example, timber harvest may result in the following:

- removal of most standing biomass, especially larger size classes of trees, from the site;

- a decrease in the amount of coarse woody debris available for cover and denning;
- smaller, more dispersed patch sizes and concentrated harvest, resulting in a greater degree of habitat fragmentation;
- selective removal of particular tree species;
- soil disturbance and compaction by heavy equipment, which may result in increases of exotic plants that can compete with native vegetation;
- harvest, planting, and thinning treatments that may give a competitive advantage to certain tree species; and
- construction of roads that may be used during winter as designated or groomed travel routes for snowmobiles or cross-country skiers.

Loss of forestlands and associated overstory and understory vegetation and cover from mine construction and development would make these areas unsuitable for use by lynx. However, forest management practices outside of the mine footprint that improve habitat for snowshoe hare and other lynx prey species would benefit lynx traveling through the study area.

6.3.2.3. Wildland Fire Management

Fire, wind, insects, and disease historically played an important role in maintaining the mosaic of forest successional stages that provide habitat for both snowshoe hare and lynx (Fox 1978; Bailey et al. 1986; Quinn and Thompson 1987; Koehler and Brittell 1990; Poole et al. 1996; Slough and Mowat 1996). For the first few years after a burn, there appears to be a negative correlation between lynx use and the amount of area burned (Fox 1978). This short-term effect is likely the result of reduced snowshoe hare populations, removal of cover, and possibly increased competition from coyotes in open habitats (Stephenson 1984, Koehler and Brittell 1990). The lag time until the peak of hare population increase is generally about 15 to 30 years (this varies depending on tree species, habitat type and severity of disturbance). Re-sprouting of broadleaf species occurs more quickly, in 3 to 12 years. Hare populations again decrease as the forest canopy develops and shades out the understory. Forest gap processes, such as large blowdowns, insect infestations, and outbreaks of disease, produce effects similar to those associated with fire (Agee 2000).

Areas with suitable lynx habitat in the Great Lakes Geographic Area boreal forests historically tended to have relatively short fire return intervals of 50 to 150 years. Disturbance intervals and fire severity varied by cover type, with xeric pine types such as jack pine typically experiencing more frequent and more severe fires than mixed conifer types and spruce/fir.

Because much of the study area has been developed, or is in timber production, the likelihood of wildland fires being allowed to burn over large acreages is unlikely, although some prescribed burning would likely occur in the Superior National Forest. Over time, continued fire exclusion alters vegetative mosaics and species composition, and may reduce the quality and quantity of habitat for snowshoe hares. In jack pine forests of the Great Lakes region, including the study area, fire exclusion has changed stand composition and successional pathways, possibly permanently (Agee 2000).

Salvage logging following wildfires and other disturbances, such as windstorms and insect outbreaks, may negatively affect habitat for lynx and lynx prey if most large-diameter trees are removed. After they fall to the ground, large dead trees are important in providing cover for foraging in the short term and potentially for denning habitat in the long term, depending on post-fire stand conditions.

The mine project would have some influence over forest and fire management activities in the study area. Wildfires and prescribed fires would be contained before they reached the mine or mill site. Even after mine reclamation, it is unlikely that fires would be allowed to burn uncontrolled on the project site, although prescribed burning could possibly be used on inactive portions of the site to improve habitat for lynx and other wildlife.

6.3.3. Recreation

Recreational activities are becoming increasingly more widespread across the landscape, but their effects on lynx are little known. Very few studies have investigated the complex interactions between humans and wildlife. Some anecdotal information suggests that lynx are quite tolerant of humans and that a wide variety of behavioral responses to human presence can be expected (Staples 1995; Roe et al. 1999; Mowat et al. 2000).

Nonconsumptive recreational activities are growing in popularity over the more traditional consumptive recreation uses of hunting and fishing (Duffus and Dearden 1990). Trends indicate that land-based activities occurring within developed recreation sites or near roads involve the greatest number of people. However, there have been vast improvements in bicycle and off-road vehicle technology, as well as a growing popularity in motorized off-road activities, including snowmobiling. Although the project would not be used for recreational purposes, natural population growth, along with an influx of workers to support the mine, would further increase the growth of recreational activity in the study area and could possibly impact lynx movements within the study area.

Lynx and carnivore biologists (Bider 1962; Ozoga and Harger 1966; Murray and Boutin 1991; Koehler and Aubry 1994; Murray et al. 1995; Lewis and Wenger 1998; Buskirk et al. 2000) have suggested that packed trails created by snowmobiles, cross-country skiers, snowshoe hares, and predators may serve as travel routes for potential competitors and predators of lynx, especially coyotes. Buskirk et al. (2000) hypothesized that the usual spatial segregation of lynx and coyotes "may break down where human modifications to the environment increase access by coyotes to deep snow areas. Such modifications include expanded forest openings throughout the range of the lynx in which snow may be drifted..."

Fuller and Kittredge (1996) noted that the distribution and numbers of coyotes have dramatically expanded in recent decades. Geir (1975) and Nowak (1979) suggested that coyotes are thought to have originated in areas where snow cover was minimal, and it is only within the last century that they have colonized the boreal forests. Coyotes were seen near the mill during 2000 winter studies (ENSR 2000).

Buskirk et al. (2000) hypothesized that coyotes may be locally or regionally important competitors for lynx food resources, possibly exerting interference competition pressures on lynx as well. O'Donoghue et al. (1998b) suggested coyotes exert potentially important exploitation competition pressures on lynx. Predation rates by coyotes on snowshoe hares exceeded those by lynx in the Yukon Territories during hare highs. Coyotes then shifted their prey preference from snowshoe hares to carrion because of intolerance to deep snow conditions (Todd et al. 1981). Coyotes have been shown to increase their use of open habitats between November and March due to the increase in packed snow conditions and the load-bearing strength of snow in openings. It is this strong prey- and habitat-switching ability of the coyote that may contribute to its success as a competitor with lynx (Buskirk et al. 2000).

Murray and Boutin (1991) reported that both lynx and coyotes used travel routes with shallow snow, but that coyotes traveled on harder snow more frequently. They also reported that the use of trails in the snow not only reduced the depth to which an animal sinks into the snow, but aided coyotes and lynx in obtaining additional food. Keith et al. (1977) suggested that during peak highs of hares, the density of trails in snow facilitates coyote movement. Murray and Boutin (1991) reported similar results with their study where hare densities were high.

Recreational snowmobile use has expanded dramatically over the past 25 years, and is a common recreational activity in northern Minnesota. Numerous snowmobile trails are found to the northeast of the mine site, near Babbitt, and the Dunka Road, Forest Service roads, and power transmission and railroad rights-of-way near the mine site were used by snowmobilers. The growth of snowmobile use and an expanded trail system over the past 2 to 3 decades has increased human presence in lynx habitat in northern Minnesota and elsewhere in the U.S.

6.3.4. Forest/Backcountry Roads and Trails

A well-established road system is associated with mining activity along the Mesabi Iron Range, and to serve nearby towns, recreational areas, private residences, and forestlands within the study area. The number of miles of roads within the study area is not expected to increase during the life of the mine, and some roads, especially those used for timber harvest, could be taken out of service or reclaimed during the life of the project.

There is little information available on the effects of roads and trails on lynx or its prey (Apps 2000; McKelvey et al. 2000d). Construction of roads may reduce lynx habitat by removing forest cover. On the other hand, in some instances, along less-traveled roads where vegetation provides good snowshoe hare habitat, lynx may use the roadbed for travel and foraging (Koehler and Brittell 1990).

Roads and trails may facilitate snowmobile, cross-country skiing, and other human uses in the winter. As described previously in the recreation section, snow compaction on roads or trails may allow competing carnivores, such as coyotes and mountain lions, access into lynx habitat (Buskirk et al. 2000). In the absence of roads and trails, snow depths and snow conditions normally limit the mobility of these other predators during midwinter.

Recreational, administrative, and commercial uses of roads are known to disturb many species of wildlife (Ruediger 1996). However, preliminary information suggests that lynx do not avoid roads (Ruggiero et al. 2000a), except at high traffic volumes (Apps 2000). Lynx were seen crossing roads near the mine site during this study. It is possible that summer use of roads and trails through denning habitat may have negative effects if lynx are forced to move kittens because of associated human disturbance (Ruggiero et al. 2000b).

At this time, there is no compelling evidence to suggest management of road density is necessary to conserve lynx, and any increase in road density associated with future growth in the study area should have little effect on lynx movements in the Area.

6.3.5. Factors Affecting Lynx Mortality

6.3.5.1. Trapping

Lynx, like most felids, are vulnerable to trapping and easily overexploited (Mech 1980, Carbyn and Patriquin 1983, Parker et al. 1983, Ward and Krebs 1985, Bailey et al. 1986, Quinn and Thompson 1987, Slough and Mowat 1996). Lynx populations may be even more susceptible to overexploitation as a result of expanding or abandoning their home ranges during years of low prey availability (Ward and Krebs 1985). At low population levels, or in situations where reproduction or recruitment are low, trapping mortality can be additive and lead to population declines (Brand and Keith 1979, Poole 1994, Mowat et al. 1996, Slough and Mowat 1996). Road access may increase the vulnerability of lynx to trappers (Bailey et al. 1986).

Lynx trapping is prohibited in Minnesota, however incidental trapping of lynx occurs in areas where regulated trapping for other species, such as wolverine, coyote, fox, and wolf, overlaps with lynx habitats.

6.3.5.2. Incidental or Illegal Shooting

Lynx could be shot mistakenly by hunters or illegally by poachers. The actual magnitude of shooting in northern Minnesota is unknown. Of the 412 records in the MNDNR lynx database for 2000-2006, only one record lists that the animal was shot. However, it is likely that lynx shootings are generally not reported. It is unlikely that lynx would be shot within the study area due to limited numbers of lynx in the general vicinity of the mine and because hunting and target shooting would not be allowed within the mine site or near the mill.

6.3.5.3. Competition and Predation as Influenced by Human Activities

Lynx interact with other carnivores throughout their range. Competition with or predation by coyotes, gray wolves, mountain lions, bobcats, and birds of prey have been inferred or documented throughout the range of the lynx. Some human activities, particularly those related to timber harvest and over-the-snow access routes, have the potential to alter natural relationships between lynx and other predators.

Gray wolves were extirpated from the continental U.S., except Minnesota, by 1960 (Thiel and Ream 1995). Much of this effort was carried out through government control programs to protect ungulates and halt the spread of rabies (Paradiso and Nowak 1982). Recently, wolf populations have rebounded in Minnesota, Wisconsin, the Upper Peninsula of Michigan and Montana, and have been reintroduced into central Idaho and the Yellowstone ecosystem.

Coyotes have expanded their range in recent decades (Fuller and Kittredge 1996), and coyotes may have expanded their range and increased in numbers as wolves were reduced in range and number. Crabtree and Sheldon (1999) also reported that in some areas of the contiguous U.S., wolves are increasing in numbers and distribution, while coyotes are decreasing in response.

Certain timber harvest practices increase edges and openings within forest stands, which may improve foraging conditions for generalist predators such as coyotes, bobcats, and great horned owls (*Bulbus virginianus*). This in turn increases the potential for both exploitation and interference competition with lynx to occur.

As described previously (in the Recreation section), snow compaction due to resource management or recreation activities may facilitate movement of coyotes and other potential competitors and predators into lynx habitat, making it likely that lynx in the study area would compete with these competitors and predators for primary lynx prey (Buskirk et al. 2000). Both coyote and wolf are regular visitors to the mine and mill sites.

6.3.5.4. Highways (Vehicular Collisions)

There are few records of lynx being killed on highways, but direct mortality from vehicular collisions may be detrimental to small lynx populations in the lower 48 states. Of the 408 verified, potential, and unverified lynx observations in the MNDNR database for 2000 to 2006, there are five records of lynx being killed by a vehicle (four verified and one potential lynx), and one record of a lynx being killed by a train (verified) in St. Louis County.

Traffic volumes that affect lynx mortality and dispersal have not been studied. However, a study of carnivores on highways in Canada suggest that highway traffic volumes of 2,000 to 3,000 vehicles per day are thought to be problematic. Traffic volumes of 4,000 vehicles or more per day are considered to be serious impacts in terms of both mortality and habitat fragmentation. Railroads, especially when paralleling major highways, increase both the mortality risks and habitat fragmentation (Gibeau and Heuer 1996, Woods and Munro 1996).

Attempts to mitigate highway losses by signing, reducing speed limits, and public education have had little or no effect on decreasing the losses of large ungulates and carnivores in Banff National Park, Canada, or of the Florida panther (*Felis concolor*). One measure that appears to reduce highway mortality is the construction of wildlife fencing and associated underpasses or overpasses. Lynx use of highway underpasses constructed in Banff National Park has been documented (Heuer 1995). No wildlife underpasses or overpasses have been constructed within the southern portion of lynx range with the objective of facilitating movement of carnivores.

Lynx injury and death could occur from increased traffic volume on the roads associated with the project. Most traffic would occur during shift changes on roads leading from the mine site and mill and Hoyt Lakes and Babbitt. However, the risks of lynx injury and death are low because of the few lynx likely to be found near the mine and mill sites. As traffic, in general, increases in the study area over time, and if lynx populations continue to expand in the region, it is likely there would be future lynx-vehicle collisions.

Ore would be shipped from the mine site to the mill. As noted above, lynx have been killed by trains and increased rail traffic in the study area would increase the potential for train-lynx collisions, though it would still be very low.

The risks to wildlife of a spill during the transport of materials used for maintenance and operation of the project site, and during storage and use of the materials at the mine, would depend on the location of the spill and types and amounts of materials spilled. Potentially toxic compounds used in mine operations include lime, ammonium nitrate, gasoline, and diesel fuel; water draining from reactive waste rock piles could contain acidic water and metals, although it is unlikely that lynx would access ponds where this water would be stored.

6.3.6. Factors Affecting Lynx Movements

6.3.6.1. Highways, Roads, and Rights-of-way

Highways can alter landscapes by fragmenting large tracts of land, some of which were previously homogenous habitats. Highways typically follow natural features such as lakes, rivers, and valleys that may have high habitat value for lynx. As the standard of road increases from gravel to 2-lane highways, traffic volumes increase. Lynx and other carnivores may avoid using adjacent habitat or become intimidated by highway traffic and may not cross (Gibeau and Heuer 1996). The degree of impact increases as highways are upgraded from 2 lanes to 4 lanes. Four-lane highways, such as the Interstate Highway System, commonly have fences on both sides, service roads, paralleling railroads and impediments like "Jersey Barriers" that make successful crossing more difficult, or impossible. Highways can also directly affect the amount of feeding and denning habitat available to lynx by converting natural forests into road surface, rights-of-way, or associated facilities such as maintenance areas or gravel pits.

Utility corridors can have impacts to lynx habitats, depending on location, type (e.g., gas pipelines, power lines), vegetation clearing requirements, and maintenance access. The primary effect is to disrupt connectivity of lynx habitat. When located adjacent to highways and railroads, utility corridors can further widen the rights-of-way, thus increasing the likelihood of impeding lynx movement. Remote, narrow utility corridors may have little or no effect on lynx, or could even enhance habitat in certain vegetation types and conditions.

Of 102 lynx records for St. Louis County, nearly half were made by observers traveling roads or other rights-of-way, including Highway 2, a well-traveled road. As noted earlier, lynx do cross roads, and lynx tracks were often seen crossing roads during surveys at the NorthMet Mine Project near Babbitt, Minnesota. However, lynx tracks usually went in a nearly straight line from one side of the road to the other.

Utility corridors would be constructed for the project, although their impact on lynx should be minimal, given the other habitat loss and disturbance associated with the project. Public roads constructed in the study area have the potential to disrupt habitat homogeneity, although much of the study area consists of fragmented habitat due to historic land disturbances, including mining and logging activity. Thus, it is likely that these activities would impact lynx traveling in the study area, but effects on lynx movements and habitat use would be minor.

6.3.6.2. Land Ownership Patterns

Lynx exemplify the need for landscape level ecosystem management. Land and population management must cross international, federal, state, county, and private land boundaries, as lynx are wide ranging. Coordination within and between agencies and other landowners has often been difficult. In situations where habitat connectivity is needed to maintain adequate populations, private land development may preclude use by lynx, and may interrupt the connectivity of habitat and populations. Habitat fragmentation also may impede lynx movements, which in turn could isolate lynx and/or prey populations, or retard movements to other areas.

Contiguous tracts of land in public ownership (e.g., national and state forests and parks) provide an opportunity for management that can maintain lynx habitat connectivity. Throughout most of the lynx range in the lower 48 states, connectivity with habitats and source populations in Canada is critical for conserving populations. The size, amount, and spatial distribution of federal land vary considerably from west to east across the U.S.

In both the Great Lakes and the Northeast geographic areas, the ability to provide necessary connectivity is made more difficult by current land ownership and land use patterns between tracts of lynx habitat occurring on National Forests. In both areas, dispersing animals from Canada often must traverse significant areas of non-federal lands to access lynx habitat occurring on National Forest lands.

Because of past mining activity, much of the land associated with the Mesabi Iron Range is heavily disturbed. Large areas nearly devoid of vegetation, including tailing facilities and waste rock piles, are readily observed immediately north of the mine site, in the vicinity of the mill, and adjacent to the road leading from the mill to the mine site. Although disturbed areas that are no longer mined have become revegetated, natural revegetation can take decades on tailings and waste rock sites. Most non-mine development and associated land development in the region is also associated with the east-west trending Mesabi Iron Range. Although lynx travel across this disturbance area to reach habitats to the north and south, mine and other development in the region may force lynx to move in a more east-west pattern.

Lynx would be able to move to the north and south relatively easily, as much of this land is in the Superior National Forest. Land in the vicinity of the study area is primarily second growth forest, shrublands, and wetlands. It is anticipated that most of this land will remain forested for decades. Based on the pattern of lynx sighting (Figure 5), it appears that if lynx found near the project site left the area, they would likely move in an easterly direction where lynx sightings are greater and more suitable habitat may be found.

6.3.7. Other Large-scale Risk Factors

6.3.7.1. Habitat Fragmentation and Travel Routes

The proposed project would increase the amount of habitat fragmentation in the area, changing wooded/forested and other vegetated habitats to disturbed/developed areas with little or no habitat value. As noted above, development of iron mines along the Iron Range has made much of this area of limited value to lynx, especially areas with pits, tailings, and waste rock piles. Historic waste rock piles and tailings have begun to revegetate and provide some habitat for lynx and their prey, but their value is greatly reduced compared to habitat that existed in the area prior to mining. Because much of the project would occur in areas of old workings or tailings, the amount of new habitat loss and fragmentation associated with the project would be small in the context of available habitat regionally and effects to lynx would be minor.

A common strategy to avoid excessive habitat loss and overexploitation of wildlife populations has been to provide “refugia.” Weaver et al. (1996) suggested that large carnivores (grizzly bears *[Ursus arctos],* gray wolves, mountain lions, and wolverines) require some form of refugia. The characteristics, size, and distribution of refugia that are needed vary depending on the species. In general, refugia are defined as large, contiguous areas encompassing the full array of seasonal habitats that are connected to each other across landscapes.

McKelvey et al. (2000d) argued that a system of reserves embedded in a fragmented and non-natural landscape would not be sufficient to sustain lynx populations. Rather, a strategy that encompasses the entire landscape may be necessary.

Refugia have been recommended for lynx to avoid over-harvest by trapping (Ward and Krebs 1985; Bailey et al. 1986). Refugia must be large enough to protect a proportion of the local population (Poole 1994). Although the minimum size is unknown, evidence from Alaska and Manitoba indicate that areas as large as 1,170 mi^2 (3,000 km^2) may not be large enough for cyclic and heavily exploited populations (Carbyn and Patriquin 1983, Bailey et al. 1986). In northcentral Washington, a population of about 25 lynx has persisted in an area of about 700 mi^2 (1,800 km^2); this area is connected to additional lynx habitat and populations in Canada.

Given its susceptibility to human-caused mortality (e.g., trapping) and relatively specialized foraging strategy, refugia were identified as a possible element in a long-term conservation strategy for the lynx. The identification of refugia will undoubtedly require the coordination and cooperation of a variety of landowners, both public and private.

As noted above, the number of lynx seen in the study area is small compared to areas east of the project, probably reflecting the high level of disturbance found in the study area due to past and ongoing mining activities. Although forestland dominates most of the study area, portions of these forests are logged each year and it may be a decade or more before these lands are again suitable for lynx. The Superior National

Forests provides a refugia for lynx, but it is uncertain whether or not other lands, including the mine site, would ever be included within a lynx refugia.

6.4. Conservation Measures

The following conservation measures are intended to conserve the lynx, and to reduce adverse effects from the proposed mine project. These measures are based, in part, on conservation measures identified in the *Lynx Conservation Assessment and Strategy* (Ruediger et al. 2000) that are applicable to lynx populations throughout the contiguous U.S. and could therefore apply to lynx in the study area.

Six measures are recommended as mitigation measures for potential impacts to lynx from the project. Because little research has been conducted on lynx in the contiguous U.S., the first conservation measure that would be part of mitigation if the proposed mine project is approved would be to continue to follow studies of lynx conducted by the Forest Service, NRRI, MNDNR, and other conservation agencies and groups to better understand lynx use of the study area during mine construction and operation, and to identify specific reclamation measures that could be implemented to restore lynx habitat to the area after mining ceases. Additional mitigation measures that are recommended if the project is approved include: 2) reclaiming the project site to habitats favored by lynx and other wildlife; 3) maintaining vegetated buffers around the project site to reduce impacts to lynx from light and noise, where feasible; 4) closing the site to recreation during development, operation, and reclamation; 5) minimizing the number of roads constructed and reclaiming roads upon mine closure; and 6) educating workers on the need to observe speed limit and other mine regulations and to take measures to protect lynx and other wildlife. These measures are discussed in more detail below.

The remaining measures discussed below could be implemented to potentially benefit lynx and their habitats if it is determined through future studies (including the study proposed in the preceding paragraph) that the study area is important to lynx. These conservation measures are written to support management of lynx and their habitat. However, in the absence of specific knowledge about lynx, many of the recommendations were drawn from knowledge about their primary prey (snowshoe hares) and important alternate prey (red squirrels), other forest carnivores, and basic principles for maintaining or restoring native ecological processes and patterns. A benefit of this approach is that it should enhance compatibility with the needs of other species that inhabit the same ecosystems.

6.4.1. Factors Affecting Lynx Productivity

6.4.1.1. Mine and Other Developments and Related Human Activity

The project would eliminate habitat, increase the amount of disturbance, and increase the amount of vehicle travel within the study area, Although most habitat associated with the mine footprint is of marginal value, it could become of greater value over time in the absence of new disturbance.

The primary goal of reclamation would be to restore portions of the mine to productive uses for lynx and other wildlife. As discussed in the Environmental Assessment Worksheet for the NorthMet Mine Project, a mine plan will be submitted that includes information about reclamation within the mine footprint. Reclamation of the site must comply with specific requirements identified in Minnesota Rule Chapter 6130. This rule requires that landforms be designed and constructed to complement nearby natural terrain, minimize adverse water quality and quantity effects on receiving waters, enhance the survival and propagation of vegetation, be structurally sound, control erosion, promote early completion and progressive reclamation, and encourage the prompt conversion from mining to an approved subsequent use. At least 2 years prior to deactivation of any portion of the mining area, proposed subsequent uses shall be presented to the MNDNR commissioner for approval. The proposed uses shall be selected based on:

- compatibility of adjacent uses;
- the needs of the area;
- the productivity of the site;

- projected land use trends;
- public health and safety;
- preventing pollution of air and water; and
- compatibility with local land use plans and plans of the surface owners.

The purpose of mineland reclamation is to control adverse environmental impacts, plan for future land use, and promote orderly mining that will encourage good mining practices and recognize the beneficial aspects of mining.

Where feasible, the mine facility would be designed to minimize impacts to lynx by minimizing the disturbance area and sequentially reclaiming areas as mine activities cease. Where feasible, a vegetative buffer would be retained around the perimeter of the mine to reduce light and noise effects on nearby lynx. In addition, existing and newly constructed roads (built to access project site) would be reclaimed or obliterated after mine closure, where feasible.

6.4.1.2. Timber Management

Upon mine closure, much of the site would likely be reclaimed to wooded/forested habitat. Although it could take decades for reclaimed areas to provide suitable habitat for lynx and their prey, timber management practices conducted on the site after mine closure that maintain or enhance habitat for snowshoe hare and alternate prey such as red squirrel would be beneficial. In addition to reclaiming sites using deciduous tree species, providing conifer trees can also create good cover for snowshoe hare. Reclamation of the site would be enhanced if PolyMet evaluates historical and current conditions and landscape patterns to develop vegetation mosaics within the reclaimed area that are beneficial to lynx and other wildlife and are conducive to promoting movement of wildlife throughout the study area and region. Given that past (and proposed) mining has led to fragmentation of habitat within and near the study area, management activities that produce forest composition, structure, and patterns similar to those that would have occurred under historical disturbance regimes would benefit lynx and their prey. PolyMet could cooperate with the Superior National Forest to manage their forest stands to benefit lynx and other wildlife, and to help maintain habitat connectivity between the study area and nearby national forests to provide future habitat for lynx and allow for the movement of lynx between private and federal lands.

6.4.1.3. Wildland Fire Management

Wildland fire and insects have historically played the dominant role in maintaining a mosaic of forest successional stages in lynx habitat. Periodic vegetation disturbances maintain the snowshoe hare prey base for lynx. In the period immediately following large stand-replacing fires, snowshoe hare and lynx densities are low. Populations increase as the vegetation grows back and provides dense horizontal cover, until the vegetation grows out of the reach of hares. Low to moderate intensity fires may also stimulate understory development in older stands.

Although it is unlikely that large-scale prescribed fire treatments would be conducted within the study area, due to the interspersion of private development and forestlands, it may be possible to conduct small (10 to 50 acres; 4 to 20 ha) prescribed burns, or to conduct timber management activities to mimic natural/prescribed fire (e.g., thinnings, patchy mosaic of clearcuts). Treatments that promote mixed forest stands with a good shrub understory may contribute to the quality of lynx foraging habitat.

6.4.1.4. Recreation

Lynx have evolved a competitive advantage in environments with deep soft snow that tends to exclude other predators during the middle of winter, a time when prey is most limiting (Murray and Boutin 1991; Livaitis 1992; Buskirk et al. 2000). Widespread human activity (snowshoeing, cross-country skiing, snowmobiling, all-terrain vehicles) may lead to patterns of snow compaction that make it possible for competing predators such as coyotes and bobcats to occupy lynx habitat through the winter, reducing its value to and even possibly excluding lynx (Bider 1962; Ozoga and Harger 1966; Murray et al. 1995; O'Donoghue et al. 1998b). In order to maintain a competitive advantage for lynx, it may be necessary to minimize or even preclude snow compacting activities in and around quality snowshoe hare habitat.

The project site would be closed to recreation during development, operation, and reclamation. If public access was allowed after closure and reclamation, activities that compact snow should be discouraged in areas that have been identified/managed as potential lynx habitat. In addition, PolyMet should work with St. Louis County, the towns of Hoyt Lakes and Babbitt, and other private and public landowners within the study area to encourage them to minimize or preclude snow compacting activities on little-used roads and other rights-of-way, where feasible.

6.4.1.5. Forest/Backcountry Roads and Trails

As noted above, plowed roads and groomed over-the-snow routes may allow competing carnivores such as coyotes and mountain lions to access lynx habitat in the winter, increasing competition for prey (Buskirk et al. 2000). However, plowed or created snow roads would be necessary to access mine facilities during construction and operation, and may be necessary to accomplish winter logging on other lands within the study area, which may be desirable to meet a variety of resource management objectives.

Preliminary information suggests that lynx may not avoid roads, except at high traffic volumes. Therefore, at this time, there is no compelling evidence to recommend management of road density to conserve lynx. However, the number of new roads constructed in support of the project, and for other activities within the study area, should be minimized and roads reclaimed/obliterated where feasible.

6.4.2. Factors Affecting Lynx Mortality

6.4.2.1. Trapping

Lynx may be mistakenly trapped by legal trappers, as indicated by MNDNR (2006) lynx reports and information obtained from local residents for this study. To reduce or eliminate the incidence of illegal shooting of lynx, PolyMet could work with the MNDNR and local conservation groups to initiate information and education efforts to protect the lynx.

6.4.2.2. Incidental or Illegal Shooting

Lynx may be mistakenly shot by legal predator hunters seeking bobcats, or illegally by poachers. Prey species, such as snowshoe hares and ground squirrels, may also be affected by legal shooting. To reduce or eliminate the incidence of illegal shooting of lynx, PolyMet could work with the MNDNR and local conservation groups to initiate information and education efforts to protect the lynx. Trailhead posters, magazine articles, and news releases could be used to inform the public of the possible presence of lynx within the study area, field identification, and their status, and to encourage the public to notify the MNDNR when they observe lynx in the area.

6.4.2.3. Competition and Predation as Influenced by Human Activities

Habitat changes that benefit competitor/ predator species, including some vegetation management practices and providing packed snow travel ways, may lead to increased starvation or direct mortality of lynx. Measures described earlier to reduce road density and snow compacting would help to reduce habitat changes that benefit lynx competitor/predator species.

6.4.2.4. Highways (Vehicular Collisions)

Direct mortality from vehicular collisions has been detrimental to lynx in northern Minnesota. It is unlikely that lynx would travel close to the project due to disturbance and lack of habitat, but individual lynx could be hit by vehicles in other portions of the study area. To benefit lynx and other wildlife, speed limits would be enforced along mine access roads to reduce the risk of wildlife-vehicle collisions. Mine workers would be given training to make them aware of the importance of the area to wildlife, to request that employees report sick or dying wildlife along roads or at facilities, to ensure that employees do not dump wastes or other harmful materials off the site, and to make employees aware of other actions that could be harmful to wildlife or their habitats.

6.5. Factors Affecting Lynx Movements

6.5.1.1. Highways, Roads, and Rights-of-way

Highways impact lynx and other carnivores by fragmenting habitat and impeding movements. As traffic lanes, volume, speeds, and rights-of-way width increase, the effects on lynx and other carnivores are magnified. As human demographics change, highways tend to increase in size and traffic density. Special concern must be given to the development of new highways (gravel roads being paved), and changes in highway design, such as additions in the number of traffic lanes, widening of rights-of-way, or other modifications to increase highway capacity or speed.

Where feasible, dirt and gravel roads traversing lynx habitat (particularly those that could become highways) should not be paved or otherwise upgraded (e.g., straightening of curves, widening of roadway, etc.) in a manner that is likely to lead to significant increases in traffic volumes, traffic speeds, increased width of the cleared rights-of-way, or would foreseeably contribute to development or increases in human activity in lynx habitat within the study area. Such projects may increase habitat fragmentation, create a barrier to movements, increase mortality risks due to vehicle collisions, and generate secondary adverse effects by inducing, facilitating, or exacerbating development and human activity in lynx habitat. Whenever rural dirt and gravel roads traversing lynx habitat are proposed for such upgrades, a thorough analysis should be conducted on the potential direct and indirect effects to lynx and lynx habitat.

6.5.1.2. Land Ownership Patterns

Lynx exemplify the need for landscape-level ecosystem management. Contiguous tracts of land in public ownership (e.g., national and state forests) provide an opportunity for management that can maintain lynx habitat connectivity. Throughout most of the lynx range in the lower 48 states, connectivity with habitats and populations in Canada is critical for maintaining populations in the U.S.

As discussed earlier, the study area is used by lynx. Lynx may breed in the study area, and the area provides a travel corridor for lynx movement within the Superior National Forest and to Canada. The study area contains lynx habitat, and the area’s importance would increase if lynx populations continue to grow and expand within northern Minnesota. PolyMet should work with federal, state, and local resource management agencies and private landowners to help protect lynx habitat within the study area and to develop and implement a mine reclamation plan that provides for lynx habitat in the future on the project site.

6.6. Other Large-scale Risk Factors

6.6.1.1. Habitat Fragmentation and Travel Routes

Connected forested habitats allow lynx, and other large and medium size carnivores, to easily move long distances in search of food, cover, and mates. Highways and private lands that are subdivided for commercial or residential developments or have high human use patterns, can interrupt existing habitat connectivity and further fragment lynx habitat, reducing the potential for population interchange. Efforts undertaken by PolyMet to minimize habitat disturbance during mine development, and to reclaim disturbed lands to wooded/forested habitat, would help ensure that habitat fragmentation is minimized and large blocks of lynx habitat remain within the study area. Portions (primarily the Superior National Forest) of the study area likely serve as refugia for lynx, and the area can continue to serve as an important travel corridor for lynx moving between privately-owned lands and national forests and to help ensure that genetic interchange within and between geographic areas occurs in northern Minnesota.

7.0 REFERENCES

Adams, A.W. 1963. The Lynx Explosion. North Dakota Outdoors 26:20-24.

Agee, J.K. 2000. Disturbance Ecology of North American Boreal Forests and Associated Northern/mixed Subalpine Forests. Chapter 3 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Apps, C.D. 2000. Space-use, Demographics, and Topographic Associations of Lynx in the Southern Canadian Rocky Mountains: A Study. Pages 351-371 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Aubry, K.B., G.M. Koehler, and J.R. Squires. 2000. Ecology of Canada Lynx in Southern Boreal Forests. Pages 373-396 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Bailey, T. N., E. E. Bangs, M. F. Portner, J. C. Malloy, and R. J. McAvinchey. 1986. An Apparent Overexploited Lynx Population on the Kenai Peninsula, Alaska. Journal of Wildlife Management 50:279-290.

Berrie, P. M. 1974. Ecology and Status of the Lynx in Interior Alaska. Pages 4-41 *in* R. L. Eaton (ed.).The World's Cats. Volume 1. World Wildlife Safari. Winston, Oregon.

Bider, J. R. 1962. Dynamics and the Tempero-spatial Relations of a Vertebrate Community. Ecology 43:634-646.

Bowles, A. E. 1995. Responses of Wildlife to Noise. Pages 109-156 *in* R. L. Knight and K. J. Gutzwiller (eds.). Wildlife and Recreationists: Coexistence Through Management and Research. Island Press. Washington, D.C.

Brainerd, S. M. 1985. Reproductive Ecology of Bobcats and Lynx in Western Montana. M.S. Thesis, University of Montana. Missoula, Montana.

Brand, C. J., and L. B. Keith. 1979. Lynx Demography During a Snowshoe Hare Decline in Alberta. Journal of Wildlife Management 43(4):827-849.

________, ________, and C. A. Fischer. 1976. Lynx Responses to Changing Snowshoe Hare Densities in Alberta. Journal of Wildlife Management 40:416-428.

Brocke, R.H. 1982. Restoration of the Lynx (*Lynx canadensis*) in Adirondack Park: A Problem Analysis and Recommendations. Federal Aid Project E-1-3 and W-105-R, Study XII, Job 5, Final Report. New York Department of Environmental Conservation, Albany.

Buehler, D.A., and L.B. Keith. 1982. Snowshoe Hare Distribution and Habitat Use in Wisconsin. Canadian Field Naturalist 96:19-29.

Burke, P. 2006. Personal Communication with Stuart Paulus, ENSR, Redmond, Washington, Regarding Size of Lynx Action Area. U.S. Fish and Wildlife Service. St. Paul, Minnesota.

Burt, W.H. 1954. The Mammals of Michigan. University of Michigan Press. Ann Arbor, Michigan.

Buskirk, S. W., L. F. Ruggiero, K. B. Aubry, D. E. Pearson, J. R. Squires, and K. S. McKelvey. 2000. Comparative Ecology of Lynx in North America. Pages 397-417 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Carbyn, L. N., and D. Patriquin. 1983. Observations on Home Range Sizes, Movement, and Social Organization of Lynx, *Lynx canadensis* in Riding Mountain National Park, Manitoba. Canadian Field Naturalist 97:262-267.

Crabtree, R.L., and J.W. Sheldon. 1999. The Ecological Role of Coyotes on Yellowstone's Northern Range. Yellowstone Science 7:15-23.

Dolbeer, R. A., and W. C. Clark. 1975. Population Ecology of Snowshoe Hares in the Central Colorado Rocky Mountains. Journal of Wildlife Management 39:535-549.

DonCarlos, M.W. 1994. Fact Sheet: Management of Lynx (*Felis lynx*) in Minnesota. Minnesota Department of Natural Resources. St. Paul, Minnesota.

Duffus, D. A., and P. Dearden. 1990. Non-consumptive Wildlife-oriented Recreation: A Conceptual Framework. Biological Conservation 53:213-231.

Elliot-Fisk, D. L. 1988. The Boreal Forest. Pages 33-62 *in* M. G. Barbour and W. D. Billings (eds.). North American Terrestrial Vegetation. Cambridge University Press, Cambridge, United Kingdom.

Elton, C., and M. Nicholson. 1942. The Ten-year Cycle in Numbers of the Lynx in Canada. Journal of Animal Ecology 11:215-244.

ENSR. 2000. Winter 2000 Wildlife Survey Plan for the Proposed NorthMet Mine Site, St. Louis County, Minnesota. Report Prepared for PolyMet Mining Corporation, Hoyt Lakes, Minnesota. Redmond, Washington.

________. NorthMet Mine Summer Fish and Wildlife Study. Report Prepared for PolyMet Mining Corporation, Hoyt Lakes, Minnesota. Redmond, Washington.

Federal Register. 2000. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Contiguous U.S. District Population Segment of the Canada Lynx and Related Rule. Department of the Interior, Fish and Wildlife Service. March 24, 2000. Washington, D.C., U.S.A.

________. 2003. Endangered and Threatened Wildlife and Plants: Notice of Remanded Determination of Status for the Contiguous U.S. Distinct Population Segment of the Canada Lynx; Clarification of Findings; Final Rule.

Foth and Van Dyke. 1999. Supplemental Site Specific Resource Information PolyMet Mining Corporation NorthMet 1999 Exploration Project. Report Prepared for PolyMet Mining Corporation, Golden, Colorado.

Fox, J. F. 1978. Forest Fires and the Snowshoe hare - Canada lynx cycle. Oecologia 31:349-74.

Fuller, A.K. 1999. Influence of Partial Timber Harvesting on American Marten and Their Primary Prey in northcentral Maine. Master’s Thesis, University of Maine, Orono, Maine, U.S.A.

Fuller, T. K., and D. B. Kittredge, Jr. 1996. Conservation of Large Forest Carnivores. Pages 137-164 *In* R. M. DeGraaf and R. I. Miller (eds.). Conservation of Faunal Diversity in Forested Landscapes. Chapman and Hall, London, United Kingdom.

Gabrielson, G. W., and E. N. Smith. 1995. Physiological Responses of Wildlife to Disturbance. Pages 95-107 *in* R. L. Knight and K. J. Gutzwiller (eds.). Wildlife and Recreationists: Coexistence Through Management and Research. Island Press. Washington, D.C.

Gibeau, M., and K. Heuer. 1996. Effects of Transportation Corridors on Large Carnivores in the Bow River Valley, Alberta. Pages 67-79 *in* Proceedings of the Florida Department of Transportation/Federal Highway Administration Transportation-Related Wildlife Mortality Seminar. Orlando, Florida.

Geir, H. 1975. Ecology and Behavior of Coyote *(Canis latrans).* Pages 247-262 *in* M. Fox (ed.). The Wild Canids. R.E. Krieger Publishing Company Inc. Malabar, Florida.

Gunderson, H. L.. 1978. A Midcontinent Irruption of Canada Lynx, 1962-63. Prairie Naturalist 10:71-80.

Gutzwiller, K. J. 1995. Recreational Disturbance and Wildlife Communities. Pages 169-181 *in* R. L. Knight and K. J. Gutzwiller (eds.). Wildlife and Recreationists: Coexistence Through Management and Research. Island Press. Washington, D.C.

Hall, E. R. and K. R. Kelson. 1959. The Mammals of North America, 2 vols. The Ronald Press Co. New York, N.Y.

Harger, E. M. 1965. The Status of the Canada Lynx in Michigan. The Jack-Pine Warbler 43:150-153.

Hatler, D.F. 1988. A Lynx Management Strategy for British Columbia. Prepared for British Columbia Ministry of Environment. Victoria, British Columbia, Canada.

Henderson, C. 1978. Minnesota Canada Lynx Report, 1977. Minnesota Wildlife Research Quarterly 38:221-242.

Heuer, K. E. 1995. Wildlife Corridors Around Developed Areas of Banff National Park. Progress Report for Parks Canada. Alberta, Canada.

Hodges, K. E. 2000a. The Ecology of Snowshoe Hares in Northern Boreal Forests. Chapter 6 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

________. 2000b. The Ecology of Snowshoe Hares in Southern Boreal and Montane Forests. Chapter 7 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Hoving, C.L. 2001. Historical Occurrence and Habitat Ecology of Canada Lynx (*Lynx canadensis*) in Eastern North America. M.S. Thesis, University of Maine, Orono, Maine, U.S.A.

Johnson, M.D., and G.A. Lieberman. 1979. Aquatic Biology Resources. Volume 4, Chapter 1, Minnesota Environmental Quality Board Regional Copper-Nickel Study. Minneapolis, Minnesota.

Jones, J.K., D.C. Carter, H.H. Genoways, R.S. Hoffman, D.W. Rice, C. Jones. 1986. Revised checklist of North American Mammals North of Mexico, 1986. Occasional Paper of the Museum of Texas Tech University No. 107. Texas Tech University, Lubbock, Texas. U.S.A.

__________, R.S. Hoffman, D.W. Rice, C. Jones, R.J. Baker, M.D. Engstrom. 1992. Revised checklist of North American Mammals North of Mexico, 1991. Occasional Paper of the Museum of Texas Tech University No.146. Texas Tech University, Lubbock, Texas. U.S.A.

Keith, L.. B., A.. W. Todd, C. J. Brand, R. S. Adamcik, and D. H. Rusch. 1977. An Analysis of Predation During Cyclic Fluxation of Snowshoe Hares. Proceedings of the XIII International Congress of Game Biologists. Pages 151-175.

Kesterson, M. B. 1988. Lynx Home Range and Spatial Organization in Relation to Population Density and Prey Abundance. M.S. Thesis, University of Alaska, Fairbanks.

Knight, R. L., and D. N. Cole. 1995a. Wildlife Responses to Recreationists. Pages 51-70 *in* R. L. Knight and K. J. Gutzwiller (eds.). Wildlife and Recreationists: Coexistence Through Management and Research. Island Press. Washington, D.C.

_________, and D. N. Cole. 1995b. Factors that Influence Wildlife Responses to Recreationists. Pages 71-79 *in* R. L. Knight and K. J. Gutzwiller (eds.). Wildlife and Recreationists: Coexistence Through Management and Research. Island Press. Washington, D.C.

Koehler, G. M. 1990. Population and Habitat Characteristics of Lynx and Snowshoe Hares in North Central Washington. Canadian Journal of Zoology 68: 845-851.

__________, M. G. Hornocker, and H. S. Hash. 1979. Lynx Movements and Habitat Use in Montana. Canadian Field-Naturalist 93(4):441-442.

__________, and J. D. Brittell. 1990. Managing Spruce-Fir habitat for Lynx and Snowshoe Hares. Journal of Forestry 88:10-14.

__________, and M.G. Hornocker.1991. Seasonal Resource Use Among Mountain Lions, Bobcats, and Coyotes. Journal of Mammalogy 72:391-396.

__________, and K. B. Aubry. 1994. Pages 74-98 *in* Ruggiero et al. (eds.). The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx and Wolverine in the Western United States. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-254. Fort Collins, Colorado.

Krebs, C. J., S. Boutin, R. Boonstra, A. R. E. Sinclair, J. N. M. Smith, M. R. T. Dale, K. Martin, and R. Turkington. 1995. Impact of Food and Predation on the Snowshoe Hare Cycle. Science 269:1112-1115.

Lewis, L., and C. R. Wenger. 1998. Idaho's Canada Lynx: Pieces of the Puzzle. Idaho Bureau of Land Management, Technical Bulletin No. 98-11.

Litvaitis, J. A. 1992. Niche Relations between Coyotes and Sympatric Carnivora. Pages 73-85 *In* Ecology and Management of the Eastern Coyote (A. H. Boer, ed.). University of New Brunswick Wildlife Research Unit. Fredericton, New Brunswick.

Major, A.R. 1989. Lynx, *Lynx canadensis canadensis* (Kerr) Predation Patterns and Habitat Use in the Yukon Territory, Canada. M.S. Thesis, State University of New York, Syracuse, N.Y.

McCord, C.M., and J.E. Cardoza. 1982. Bobcat and Lynx. *In* J.A. Chapman and G.A. Feldhamer (eds.). Wild Mammals of North America Biology, Management and Economics Johns Hopkins University Press. Baltimore, Maryland.

McKelvey, K. S., K. B. Aubry, and Y. K. Ortega. 2000a. History and Distribution of Lynx in the Contiguous United States. Pages 207-264 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

_________, S. W. Buskirk, and C. J. Krebs. 2000b. Theoretical Insights Into the Population Viability of Lynx. Pages 21-37 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

_________, Y. K. Ortega, G. M. Koehler, K. B. Aubry, and J. D. Brittell. 2000c. Canada Lynx Habitat and Topographic use Patterns in North Central Washington: A Reanalysis. Pages 307-336 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

_________, K. B. Aubry, J. K. Agee, S. W. Buskirk, L. F. Ruggiero, and G. M. Koehler. 2000d. Lynx Conservation in an Ecosystem Management Context. Pages 419-441 McKelvey, K. S., S. W. Buskirk, and C. J. Krebs. 2000b. Theoretical Insights Into the Population Viability of Lynx. Pages 21-37 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Mech, L.D. 1973. Canadian Lynx Invasion of Minnesota. Biological Conservation 5:151-152.

_________. 1980. Age, Sex, Reproduction, and Spatial Organization of Lynxes Colonizing Northeastern Minnesota. Journal of Mammalogy 61:261-267.

Mills, L. S., K. L. Pilgrim, M. K. Schwartz, and K. S. McKelvey. 2000. Identifying lynx and other North American cat species based on MtDNA analysis. Conservation Genetics 1:285-288.

Minnesota Department of Natural Resources (MNDNR). 2006. Canada Lynx Sightings in Minnesota 2000-2006. St. Paul, Minnesota. Available at: http://www.dnr.state.mn.us/ecological_services/nhnrp/research/lynx_sightings.html.

Moen, R., G. Niemi, C.L. Burdett, and L.D. Mech. 2004. Canada Lynx in the Great Lakes Region 2003 Annual Report to U.S. Department of Agriculture Forest Service and Minnesota Cooperative Fish and Wildlife Research Unit. Natural Resources Research Institute. University of Minnesota, Duluth, Minnesota.

Monthey, R. W. 1986. Responses of Snowshoe Hares, *Lepus americanus,* to Timber Harvesting in Northern Maine. Canadian Field Naturalist 100:568-570.

Mowat, G., K. G. Poole, and M. O'Donoghue. 2000. Ecology of Lynx in Northern Canada and Alaska. Chapter 9 McKelvey, K. S., S. W. Buskirk, and C. J. Krebs. 2000b. Theoretical Insights Into the Population Viability of Lynx. Pages 21-37 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Murray, D. L. and S. Boutin. 1991. The Influence of Snow on Lynx and Coyote Movements: Does Morphology Affect Behavior? Oecologia. 88:463-469.

_________, _________, and M. O'Donoghue. 1994. Winter Habitat Selection by Lynx and Coyotes in Relation to Snowshoe Hare Abundance. Canadian Journal of Zoology 72:1444-1451.

_________, _________, _________, and V. O. Nams. 1995. Hunting Behavior of Sympatric Felid and Canid in Relation to Vegetative Cover. Animal Behavior 50:1203-1210.

Natural Resources Research Institute (NRRI). 2006. Canada Lynx in the Great Lakes Region. Center for Water and Environment, University of Minnesota. Duluth, Minnesota. Available at: http://www.nrri.umn.edu/lynx/index.html.

Nellis, C. H., S. P. Wetmore, and L. B. Keith. 1972. Lynx-prey Interactions in Central Alberta. Journal of Wildlife Management 36(2):320-329.

Nowak, R. M. 1979. North American Quaternary *Canis.* Monograph No. 6, Museum of Natural History, University of Kansas. Lawrence, Kansas.

O'Donoghue, M., S. Boutin, C. J. Krebs, and E. J. Hofer. 1997. Numerical Responses of Coyotes and Lynx to the Snowshoe Hare Cycle. Oikos 74:115-121.

________, ________, ________, G. Zuleta, D. L. Murray, and E. J. Hofer. 1998a. Behavioral Responses of Coyotes and Lynx to the Snowshoe Hare Cycle. Oikos 82:169-183.

________, ________, ________, ________, ________, and ________. 1998b. Functional Responses of Coyotes and Lynx to the Snowshoe Hare Cycle. Ecology 79(4):1193-1208.

Ozoga, J. J. and E. M. Harger. 1966. Winter Activities and Feeding Habits of Northern Michigan Coyotes. Journal of Wildlife Management 30 (4):809-818.

Paradiso, J. L., and R. M. Nowak. 1982. Wolves. Pages 460-474 *In* Wild Mammals of North America (J. A. Chapman and G. A. Feldhamer, Eds.). Johns Hopkins University Press. Baltimore, Maryland.

Parker, G.R. 1981. Winter Habitat Use and Hunting Activities of Lynx (*Lynx canadensis*) on Cape Breton Island, Nova Scotia. *In* J.A. Chapman and D. Pursley (eds.) Proceedings from the Worldwide Furbearers Conference, Frostburg, Maryland, U.S.A.

________, J. W. Maxwell, L. D. Morton, and G. E. J. Smith. 1983. The Ecology of the Lynx *(Lynx canadensis)* on Cape Breton Island. Canadian Journal of Zoology 61:770-786.

Phillips, S. 1999. Draft Biological Evaluation Reservoir Analysis Area Laurentian Ranger District Superior National Forest. USDA Forest Service, Aurora, Minnesota.

Poole, K. G. 1994. Characteristics of an Unharvested Lynx Population During a Snowshoe Hare Decline. Journal of Wildlife Management 58:608-618.

________, L. A. Wakelyn, and P. N. Nicklen. 1996. Habitat selection by lynx in the Northwest Territories. Canadian Journal of Zoology 74:845-850.

________. 1997. Dispersal Patterns of Lynx in the Northwest Territories. Journal of Wildlife Management 61(2): 497-505.

Quinn, N.W.S., and G. Parker. 1987. Lynx. *In* M. Novak, J.A. Barber, M.E. Obbard, and B. Malloch (eds.). Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Ottawa, Canada.

________, and J. E. Thompson. 1987. Dynamics of an exploited Canada lynx population in Ontario. Journal of Wildlife Management 51:297-305.

Roe, A. N., K. G. Poole, and D. L. May. 1999. A Review of Lynx Behavior and Ecology and its Relation to Ski Area Planning and Management. Unpublished Report, IRIS Environmental Systems. Calgary, Alberta, Canada.

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Naney, G. Patton, T. Rinaldi, J. Trick, A. Vandehey, F. Wahl, N. Warren, D. Wenger, and A. Williamson. 2000. Canada Lynx Conservation Assessment and Strategy. U.S. Department of Agriculture Forest Service, U.S. Department of the

Interior Fish and Wildlife Service, U.S. Department of the Interior Bureau of Land Management, and U.S. Department of the Interior National Park Service. Missoula, Montana.

Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, G. M. Koehler, C. J. Krebs, K. S. McKelvey, and J. R. Squires. (Tech. Eds.) 2000*a*. Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, G. M. Koehler, C. J. Krebs, K. S. McKelvey, and J. R. Squires. 2000*b*. The Scientific Basis for Lynx Conservation: Qualified Insights. Pages 443-454 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Ryan, D. 2006. Forest Service Superior National Forest District Biologist. Personal Communication with Steve Loch. Aurora, Minnesota.

Sather, N., G.A. Lieberman, and W.A. Patterson. 1979. Terrestrial Ecosystems. Volume 4, Chapter 2, Minnesota Environmental Quality Board Regional Copper-Nickel Study. Minneapolis, Minnesota.

Saunders, J. K., Jr. 1963a. Food Habits of the Lynx in Newfoundland. Journal of Wildlife Management 27(3):384-390.

________. 1963b. Movements and Activities of the Lynx in Newfoundland. Journal of Wildlife Management 27(3):390-400.

Schwartz, M.K., K.L. Pilgrim, K.S. McKelvey, E.L. Lindquist, J.J. Claar, S. Loch, L.F. Ruggiero. 2004 Hybridization between Canada lynx and bobcats: Genetic results and management implications. Conservation Genetics 5: 349-355.

Slough, B. G., and G. Mowat. 1996. Lynx Population Dynamics in an Untrapped Refugium. Journal of Wildlife Management 60:946-961.

Squires, J. R. and T. Laurion. 2000. Lynx Home Range and Movements in Montana and Wyoming: Preliminary Results. Pages 337-349 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (eds.). Ecology and Conservation of Lynx in the United States. University Press of Colorado. Boulder, Colorado.

Staples, W. R. 1995. Lynx and Coyote Diet and Habitat Relationships During a Low Hare Population on the Kenai Peninsula, Alaska. M.S. Thesis. University of Alaska, Fairbanks.

Stephenson, R. O. 1984. The Relationship of Fire History to Furbearer Populations and Harvest. Final Report, Federal Aid in Wildlife Restoration, Project W-22-2, Job 7.13R Alaska Department. of Fish and Game, Juneau, Alaska.

Thiel, R.P. 1987. The Status of Canada Lynx in Wisconsin, 1865-1980. Wisconsin Academy of Sciences, Arts, and Letters 75:90-96.

________, and R. R. Ream. 1995. Status of Gray Wolf in the Lower 48 United States to 1992. *In* L.N. Carbyn, S. H. Fritts, and D. R. Seip (eds.). Ecology and Conservation of Wolves in a Changing World. Canadian Circumpolar Institute, Occasional Publication No. 35.

Todd, A. W., L. B. Keith, and C. A. Fischer. 1981. Population Ecology of Coyotes During a Fluctuation of Snowshoe Hares. Journal of Wildlife Management 45:629-640.

Tumlison, R. 1987. *Felis Lynx*. Mammalian Species 269:1-8.

U.S. Fish and Wildlife Service (USFWS). 2000. Biological Opinion of the Effects of National Forest Land and Resource Management Plans and Bureau of Land Management Land Use Plans on Canada Lynx (*Lynx canadensis*) in the Contiguous United States. Memorandum to Kathleen A. McAllister, U.S. Forest Service, from Ralph Morgenweck, USFWS. Denver, Colorado.

________. 2006. Canada Lynx Critical Habitat. Mountain-Prairie Region Endangered Species Program. Helena, Montana. Available a: http://mountain-prairie.fws.gov/species/mammals/lynx/criticalhabitat.htm.

________, and NMFS. 1998. Consultation Handbook: Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act, U.S. Government Printing Office. Washington, D.C.

U.S. Department of Agriculture Forest Service. 1999. Environmental Assessment for the Reservoir Analysis Area. Superior National Forest Laurentian Ranger District, Aurora, Minnesota.

_________, and Bureau of Land Management 1999. Biological Assessment of the Effects of National Forest Land and Resource Management Plans and Bureau of Land Management Land Use Plans on Canada Lynx. Unpublished Draft (December 1999).

Van Zyll de Jong, C. G. 1966. Food Habits of the Lynx in Alberta and the Mackenzie District, Northwest Territories. Canadian Field-Naturalist 80:18-23.

Ward, R. P. M., and C. J. Krebs. 1985. Behavioural Responses of Lynx to Declining Snowshoe Hare Abundance. Canadian Journal of Zoology 63:2817-2824.

Washington Department of Wildlife. 1993. Status of the North American Lynx *(Lynx canadensis)* in Washington. Unpublished Report. Olympia, Washington.

Weaver, J. L., P. C. Paquet, and L. F. Ruggiero. 1996. Resilience and Conservation of Large Carnivores in the Rocky Mountains. Conservation Biology 10(4):964-976.

Wilson, D.E., and D.M. Reeder. 1993. Mammal Species of the World. Smithsonian Institution Press, Washington, D.C., U.S.A.

Wolfe, M. L., N. V. Debyle, C. S. Winchell, and T. R. McCabe. 1982. Snowshoe Hare Cover Relationships in Northern Utah. Journal of Wildlife Management 46:662-670.

Wolff, J. O. 1980. The Role of Habitat Patchiness in the Population Dynamics of Snowshoe Hares. Ecological Monographs 50:111-130.

Woods, J. and R. Munro. 1996. Roads, Railroads and the Environment. Pages 39-45 *In* Proceedings of the Florida Department of Transportation/Federal Highway Administration Transportation-Related Wildlife Mortality Seminar. Orlando, Florida.

Appendix A

Scat Lab Analysis Summary

United States Department of Agriculture | Forest Service | Rocky Mountain Research Station | P.O. Box 8089
Missoula, MT 59807

Date: June 9, 2006

Steve Loch
1676 Highway 2
Two Harbors MN 55616

Dear Steve,

On May 16, 2006 we received seventeen scats (8 from PolyMet, 9 from the Superior National Forest), one hair and ten tissues samples. The scat and hair samples were suspected to be from lynx (*Lynx canadensis*), and species and individual identification using DNA methods was requested. We also received nine bobcat (*Lynx rufus*) tissues, and one lynx-bobcat hybrid (T-10) previously identified from Polk County, WI. These tissues were sent to add to our DNA database of lynx, bobcats and hybrids and won't be discussed in this report.

DNA was extracted from the scat and hair samples, and these were tested for species (Mills et al. 2000). Samples identified as lynx using mitochondrial DNA were further analyzed to individual using six, variable microsatellite loci (Carmichael et al. 2001). These samples were further tested for lynx-bobcat hybridization (see Schwartz et al. 2004) and sex (see Pilgrim et al. 2005).

PolyMet Samples

All eight scats were identified as being from lynx. Seven of the eight scats contained quality DNA for individual and sex identification (we re-extracted DNA from scat 13/P but could not successfully genotype this sample). We identified four, female lynx in these scat. One of these females matches scat GLNR-S-199 collected March 9, 2006 by Dan Ryan at intersection of Hwy and Hwy 15.

Results for these samples are summarized below:

Sample	Collection Date	Species	Sex	Individual
Loch-S-03/P	02-FEB-06 16:34	Lynx	F	F1
Loch-S-04/P	02-FEB-06 16:58	Lynx	F	F1
Loch-S-06/P	04-FEB-06 16:41	Lynx	F	F2
Loch-S-08/P	07-FEB-06 13:53	Lynx	F	F3
Loch-S-09/P	08-FEB-06 12:48	Lynx	F	F3
Loch-S-12/P	28-FEB-06 12:53	Lynx	F	F3
Loch-S-13/P	11-MAR-06 16:11	Lynx	poor DNA	poor DNA
Loch-S-14/P	13-MAR-06 12:14	Lynx	F	F4*

*matches female identified from Superior NF scat S-199

Superior National Forest Samples

All nine scats and one hair sample were identified as being from lynx. Seven of the nine scats contained quality DNA for individual and sex identification (we re-extracted DNA from scat 23 but could not successfully genotype this sample). Sample 26A was a duplicate sample and was not re-extracted. The hair sample did not successfully genotype.

Six individual lynx were identified. Scat S-01 matched the female detected in the PolyMet scats 3/P and 4/P. Five other lynx were identified that match known lynx in this study area. Scat 2 is a recapture of male L38 (a kitten of L13 from 2005). Scats 5 and 7 matched one another and were scats from female L17. Scat 10 was a recapture of individual K04 (also matches scat GLNR-S-161). Scat S26 was from female L07, while scat 25 was from female L40 (a kitten of L07 from 2005).

Sample	Collection Date	Species	Sex	Individual	Location	Notes
Loch-S-01	02-FEB-06 15:31	Lynx	F	unique= PolyMet F1	59-11, Sand Lake	Lynx Scat, same trail as Loch-S-03/P
Loch-S-02	18-JAN-06 16:25	Lynx	M	L38	55-12, Brimson	Lynx Scat, one of 2 lynx.
Loch-S-05	03-FEB-06 08:02	Lynx	F	L17	56-11, Kane Lake	Lynx Scat, deer carcass in vicinity
Loch-S-07	06-FEB-06 09:29	Lynx	F	L17	56-11, Kane Lake	Lynx Scat, deer carcass in vicinity
Loch-S-10	19-FEB-06 17:08	Lynx	M	K04	61-11, Harris Lake	Lynx Scat, old trail.
Loch-S-23	21-MAR-06 12:43	Lynx	poor DNA	poor DNA	57-11, Sullivan Lake	Unknown Scat, suspect 1 of 4, possibly 5, lynx - Sullivan Lake (L07 family).
Loch-S-25	21-MAR-06 13:13	Lynx	F	L40	57-11, Sullivan Lake	Unknown Scat, suspect 1 of 4, possibly 5, lynx - Sullivan Lake (L07 family).
Loch-S-26	21-MAR-06 13:16	Lynx	F	L07	57-11, Sullivan Lake	Unknown Scat, suspect 1 of 4, possibly 5, lynx - Sullivan Lake (L07 family).
Loch-S-26 A	21-MAR-06 13:16	Lynx	poor DNA	poor DNA	57-11, Sullivan Lake	Duplicate sample of S-26
Loch-H-01	14-Mar-06	Lynx	poor DNA	poor DNA	58-13, Colvin Creek	

Addendum

All lynx reported here produced genotypes that were lynx (not F1 lynx-bobcat hybrids). We are pursuing the ability to detect F_2 backcrosses, and at this time can not rule out the possibility of such an individual in these samples.

As per your request, these samples were compared to scats collected in the Superior National Forest during the winter of 2005-2006. None of the scats matched GLNR-S-195 or GLNR-S-196. As reported above, PolyMet scat 14/P matches GLNR-S-199.

Sincerely,

Kristy Pilgrim
Lab Supervisor
USFS / RMRS
Wildlife Ecology Research Unit’s
Wildlife Genetics Laboratory