Chapter 8

History and Distribution of Lynx in the Contiguous United States

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Abstract—Using written accounts, trapping records, and spatially referenced occurrence data, the authors reconstructed the history and distribution of lynx in the contiguous United States from the 1800s to the present. Records show lynx occurrence in 24 states. Data over broad scales of space and time show lynx distribution relative to topography and vegetation. For all three study regions (Northeastern states, Great Lakes and North-Central states, and Western Mountain states), high frequencies of occurrence were in cool, coniferous forests, with occurrences at primarily higher elevations in the West.

Introduction

Understanding the geographic distribution of an organism can provide important insights into its ecology. In this chapter we compile and analyze occurrence data for lynx in the contiguous United States. We've organized our analyses into three sections. In the first, we evaluate available information on the history of lynx occurrence. Because data were generally collected independently by each state, this analysis is presented state-by-state. In the second, we evaluate the extent to which population dynamics of lynx in the states adjacent to Canada are associated with Canadian population dynamics and investigate the nature of observed relationships. In the third section, we identify the broadly defined vegetation cover types and elevation zones that encompass the majority of lynx occurrence records and examine the spatial relationships of records occurring outside these core areas.

The Nature of the Data

The analyses and discussion presented in this chapter are based on a variety of data from many sources. We believe they represent most of what is known concerning where and when lynx have occurred within the contiguous United States. We divide these data into three types. The first type is written accounts describing the occurrence patterns of lynx. For many of these accounts, and particularly the older ones, data are not presented to support the written statements. Because of the paucity of other information, our understandings of the historical distribution of lynx prior to the 20th century rely heavily on these accounts.

The second type of data are state- and province-level trapping records. These data are recorded in Novak et al. (1987) for all states and Canadian provinces that maintained records. The strength of trapping data is that it has been collected annually for many years using similar methods. These data have been used to analyze time trends (Elton and Nicholson 1942; Ranta et al. 1997), but there are several problems associated with using these data in this manner. A general problem with trapping data is that they do not represent constant effort: More lynx trapped could be due to more trapper effort rather than more lynx. A particular problem associated with lynx is confusion with bobcats, especially large, pale bobcats that were often referred to as "lynx-cats" (Novak et al. 1987). For these reasons, we limit our analysis of trapping data to those states for which we could confirm that lynx and bobcat harvest records were tabulated separately.

Lastly we have spatially referenced occurrence data. These data come from many sources: the primary literature, unpublished reports, museum specimens, state survey efforts, and casual observations (See Appendix 8.1). These data, because of their sources and types, have varying reliability. Although these data carry a reliability index, the index is not constant across data sets. Even if it were, reliability at the level of the individual observation does not necessarily infer overall reliability for a data set. Reliability of the data set depends not only on the intrinsic reliability of each datum, but also on the rarity of the organism. That is, as an organism becomes more rare, the proportion of false positives increases. For example, we know that bobcats are sometimes misidentified as lynx. If lynx were correctly identified 100% of the time and bobcats correctly identified 99% of the time, we have very reliable identification at the level of the individual observation. However, if 1,000 bobcats are seen for every lynx, then for every 1,000 wildcat identifications 10 will be classified as lynx, but on average only one will actually be a lynx. Even if lynx were extirpated from the area in question, these data would still include 10 "lynx." While we note the number of "reliable" points by type for each state (Table 8.1), we do no formal analyses based on these designations. Rather, for analyses where high reliability for each occurrence is essential, we used a subset of these data we call "verified records." We considered a record to be verified only if it was represented by a museum specimen or a written account in which a lynx was either in someone's possession or observed closely, i.e., where a lynx was killed, photographed, trapped and released, or treed by dogs. Information obtained from snow-tracking surveys conducted by trained individuals are discussed where appropriate, but neither tracks nor sighting reports were considered to represent a verified record.

Data quantity and quality vary greatly from state to state (Table 8.1). Because none of these data, with the possible exception of trapping records, represent anything like a census, using numbers of occurrences to infer numbers of lynx in an area during a specific time period or to make comparisons between states is not appropriate. Assessing changes in occurrence at the state level can be attempted from the verified records, but we caution that inferences derived from those data are potentially unreliable. We know, for instance, that a lynx was killed in New Hampshire in 1992. This does not, however, lead to any conclusions concerning the current status of lynx populations in New Hampshire. Similarly, simply because we have no verified records for lynx in Michigan after 1985 does not mean that lynx are currently absent from Michigan.

In most states, the majority of the data consist of physical remains or track data collected by state agencies. In the West, however, Colorado and Oregon have a high proportion of visual data (Table 8.1), and the patterns in these states should be considered to be less reliable. In the Great Lakes states, Wisconsin has a high proportion of visual sightings, but the areas in which they occur also contain physical specimens and particularly tracks.

Table 8.1—Lynx occurrence data used in this chapter. R means reliable, U means of unknown reliability. See text for a discussion of data types and reliability. Unknown occurrences were often older records in existing databases where data other than the location were not retained. In the western states, many records of unknown reliability are associated with locations reported by Maj and Garton (1994) that are not duplicated in other databases.

	Spatially referenced occurrences[a]								Trapping[c]		Verified records[d]	
	Physical[b]		Tracks		Visual							
State	R	U	R	U	R	U	Unknown	Total	Time period	Number	Time period	Number
Colorado	33	0	25	25	26	45	42	196			1878-1974	17
Connecticut	0	0	0	0	0	0	0	0			1839	1
Idaho	96	0	74	1	58	4	1	234			1874-1991	74
Illinois	0	0	0	0	0	0	0	0			1842	1
Indiana	0	0	0	0	0	0	0	0			1832	1
Iowa	1	0	0	0	0	0	0	1			1869-1963	6
Maine	15	4	6	1	0	2	0	28			1862-1999	35
Massachusetts	0	0	0	0	0	0	0	0			1855-1918	5
Michigan	32	23	8	5	2	2	9	81			1842-1983	44
Minnesota	179	6	7	4	4	6	81	287	1930-1983	5,585	1892-1993	76
Montana	588	0	518	24	63	7	342	1,542	1950-1997	3,012	1887-1999	84
North Dakota	7	0	0	0	0	0	1	8			1850-1963	16
Nebraska	4	0	0	0	0	0	4	8			1890-1983	13
New Hampshire	40	1	7	5	3	6	0	62	1928-1964	139	1860-1992	5
Nevada	2	0	0	0	0	0	0	2			1916	2
New York	13	2	0	0	1	0	1	17			1877-1973	24
Oregon	15	5	0	1	9	27	15	72			1897-1993	12
Pennsylvania	1	1	0	0	0	0	0	2			1903-1926	4
South Dakota	3	0	0	0	0	0	3	6			1875-1973	10
Utah	11	1	2	0	4	4	5	27			1916-1991	10
Vermont	4	0	0	0	0	0	0	4			1928-1965	4
Washington	144	7	384	107	43	23	57	765	1960-1989	215	1896-1999	134
Wisconsin	12	32	7	42	4	65	0	162			1870-1992	29
Wyoming	83	5	92	7	113	18	43	361			1856-1999	30

[a]Only data spatially referenced to at least the county level are included in these totals.
[b]Physical remains data also include photographs, radiotelemetry collared animals, and recent hair samples. These other occurrence types generally make up a tiny proportion of the total.
[c]Trapping data are presented for those states where we confirmed the reliability of these data.
[d]Verified records are spatially referenced to the state and in some cases contain additional records not in the spatially referenced occurrence data.

History of Lynx Occurrence in the Contiguous United States

In previously published distribution maps for lynx in North America, the lynx's range in the United States is depicted as marginal or peninsular extensions of the northern taiga into the western mountains, Great Lakes region, and Northeast (Burt 1946; Seton 1929; Hall 1981; McCord and Cardoza 1982). As explained in Chapter 3, these regions represent southern extensions of boreal forest in the United States, each of which has unique tree species composition, natural disturbance regimes, and histories of human-mediated changes in the composition, extent, and juxtaposition of available habitats. In the next section, we review the history of lynx occurrence and abundance in each of these three regions on a state-by-state basis. Although state boundaries generally do not correspond to ecological ones, lynx populations are managed by individual state wildlife or game agencies, and published literature is often limited to reporting or summarizing information from a particular state.

To evaluate the history of lynx occurrence in the contiguous United States, we compiled verified records from each state by obtaining data on museum specimens and reviewing published literature and unpublished state agency reports and harvest records. If there was a discrepancy between published tabulations of harvest data (Novak et al. 1987) and records obtained directly from state or provincial agencies, we assumed the latter to be more reliable and used those data in our analyses. To obtain museum specimen records of lynx in the contiguous United States, we contacted 88 museums or private collections in North America, including all mammal collections with >10,000 specimens, any museum from which lynx specimens had been reported, and at least one major museum from each state in which lynx have been reported to occur. We located 343 museum records of lynx in the contiguous United States from 41 museums or private collections, dating from 1842 to 1993.

Northeastern States

Maine—We located 35 museum specimens from Maine: 15 have no date associated with them and 12 were collected between 1862 and 1897. Only eight were obtained during this century: one in 1903, four in 1948, two in 1954, and one in 1993. Among these specimens, seven are kittens that either have no date of collection or were collected in the 1860s, verifying that a breeding population of lynx occurred in Maine during historical times. Reproduction of lynx in Maine during recent times was verified in 1964, when three kittens were presented to the state for bounty; additional verified records are known from 1966, 1973 (2 lynx), 1987, 1989, 1990, 1993, and 1998 (Hunt 1974; Jakubus 1997; Maine Dept. of Inland Fisheries and Wildlife, unpublished). Anecdotal evidence suggests that lynx were also breeding in the state during the 1970s; Chief Warden Alanson Noble reported seeing an adult lynx and kitten on the Southwest Branch of the St. John River in March 1976 (Jakubus 1997). Snow-tracking surveys have been conducted by the Maine Dept. of Inland Fisheries and Wildlife in areas with historical lynx records each winter since 1994-1995. Lynx tracks were found in all years to date except 1995-1996 and 1996-1997 (Jakubus 1997; C. McLaughlin, personal communication). Radiotelemetry research on lynx was initiated by the state in 1999; to date (September 1999), one female and one male lynx have been trapped and radio-collared. In June 1999, radiotelemetry monitoring of the female led researchers to a den with 2 kittens, verifying reproduction of lynx in Maine for the first time since 1964 (C. McLaughlin, personal communication).

Written records of Manly Hardy, a trapper and fur buyer in northern and eastern Maine during the late 1800s, indicate that during this time lynx occurred only in the northern portion of the state, and were not abundant; Manly also noted that lynx numbers varied greatly in different years, suggesting that population fluctuations may have occurred historically (Jakubus 1997, unpublished). According to Palmer (1937, unpublished), lynx had not been found in extreme southwestern Maine since the time of European colonization; by the 1930s, lynx only occurred in the northern half of the state. By the mid-1960s, lynx were reportedly absent from all but the north and northwestern portion of the state, where they were considered scarce (Hunt 1964). In 1967, the Maine legislature repealed the lynx bounty payment and gave the species complete protection from hunting or trapping.

New Hampshire—New Hampshire is the only state in the Northeast with a long and detailed history of commercial lynx harvest: From 1928 to 1964, 139 lynx were harvested in New Hampshire (Orff 1985, unpublished). In the 10-year period from 1928 to 1939, 114 lynx were harvested (mean = 10.4 per year, range 1-20), but the population appears to have declined significantly in the late 1930s; only 25 lynx were taken from 1940 to 1964 (mean = 1.0 per year, range 0-3), when trapping of lynx in the White Mountain National Forest was prohibited (Fig. 8.1). According to data compiled by Clark Stevens of the University of New Hampshire, 97% of lynx bountied from 1931 to 1954 were killed in the White Mountains of northern New Hampshire in Coos, Grafton, and Carroll Counties (Silver 1974). In 1965, the bounty was repealed by the State legislature but was reinstituted outside the

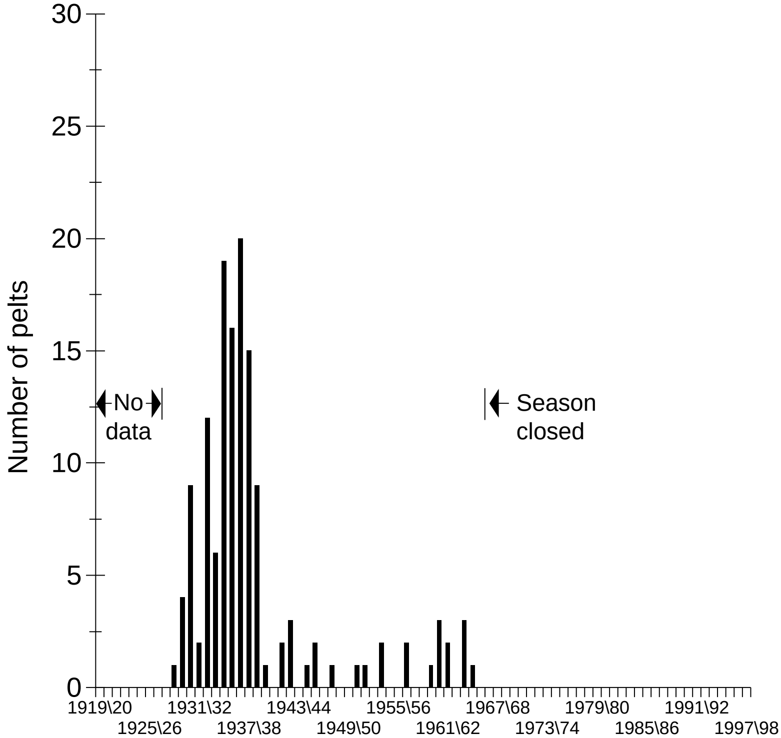

Figure 8.1—Lynx harvest data from New Hampshire, 1928-1964.

White Mountains in 1967 (Siegler 1971). In 1971, the lynx was protected from all harvest in New Hampshire; in 1980 it was listed as a state endangered species (Orff 1985, unpublished).

Except for harvest data, there are few verified records of lynx from New Hampshire; only four museum specimens are known: one undated and one each from 1860, 1947, and 1948. Only two recent verified records are known from New Hampshire; both were adult males that were road-killed in 1966 and 1992 (Litvaitis 1994; E. Orff, personal communication). From January to March 1986, Litvaitis et al. (1991) surveyed approximately 100 km^2 of the White Mountain National Forest on snowshoes (20 transects 2.5-10.0 km long) 24-96 hours after snowfall but found no lynx tracks. They concluded that their failure to find tracks and the scarcity of recent verified detections indicated that a viable population of lynx did not occur in New Hampshire at that time. We found no direct evidence of lynx breeding in New Hampshire in either historic or recent times.

The history of lynx in New Hampshire has been summarized in detail by several authors (Litvaitis et al. 1991; Siegler 1971; Silver 1974). Information on lynx occurrence and population status prior to the early 1900s is fragmentary and difficult to interpret because lynx and bobcat were typically considered together as "wildcat" in early records and reports (Silver 1974). From the late 1920s through the 1930s, lynx harvests in New Hampshire were relatively high (from 1934 to 1937, ≥15 lynx were trapped/year) and fluctuated strongly in number, reaching a peak in the mid-1930s that was coincident with a population peak recorded in Quebec (Figs. 8.1 and 8.2; Litvaitis et al. 1991). After 1940, lynx harvests remained low (0-3 trapped/year) until the trapping season was closed in 1965 (Fig. 8.1). Based on these records, Litvaitis et al. (1991) argued that historic populations of lynx in New Hampshire (and, probably, Maine) and Quebec were continuous at one time, and that immigrating lynx entered New Hampshire on a regular basis. They further speculated that large-scale timber harvesting for agricultural and residential development north of the Saint Lawrence Seaway in southern Quebec resulted in the isolation of lynx populations in New England, which were unable to remain viable without occasional immigrations of lynx from the north.

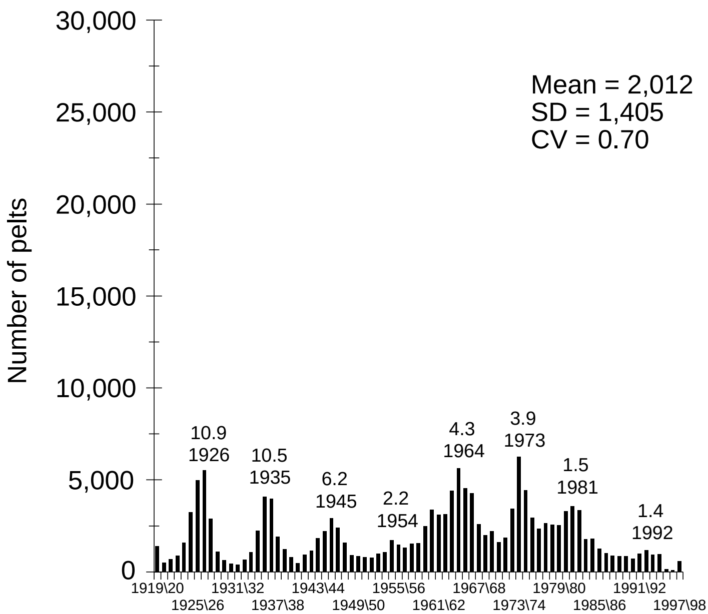

Figure 8.2—Lynx harvest data for Quebec, 1919-1997; peak years are indicated, as well as a measure of amplitude calculated by dividing the peak harvest value by the previous low harvest value.

Vermont—Published distribution maps for lynx in New England include Vermont within the range of lynx (Hamilton 1943; Godin 1977), but only four records verifying their occurrence at any time in the state could be found. Only one museum specimen is known from Vermont, a lynx collected in 1965 from Royalton in northern Windsor County. A lynx was reportedly killed in 1928 in Windam, Windam County (Osgood 1938); another was taken in Ripton, Addison County in 1937 (Hamilton and Whittaker 1979), and a third was trapped in the town of St. Albans, Franklin County in 1968 (Anonymous 1987, unpublished). In 1987, the Vermont Agency of Natural Resources classified the lynx as a state endangered species.

Massachusetts and Connecticut—No museum specimens of lynx could be found from Massachusetts or Connecticut, and verified records of lynx occurrence in these states are extremely rare. Parker (1939) describes a mounted specimen in the Worcester Museum of Natural History taken in Princeton in the winter of 1884-1885, but we were unable to locate this specimen. A lynx was reportedly killed in Concord, Middlesex County about 1855 (F.C.B. 1878), one was trapped about 1865 in Goshen, Hampshire County (Barrus 1881), one was killed in 1905 in Lanesborough, Berkshire County (Central 1905), and another was captured in 1918 near Mt. Greylock, also in Berkshire County (Eaton 1919). Crane (1931) considered the lynx to be “very rare” in western Massachusetts and quoted a report from 1840 that stated, “[The lynx] was once common in the State, but appears now only in the depth of winter, and as a straggler.” The lynx is now considered extirpated from Massachusetts (Cardoza, in press). Only one verified record of lynx in Connecticut was found: one was shot at Southington, Hartford County in 1839 (Goodwin 1935). Goodwin (1935) concluded that the “lynx is now a very rare animal in Connecticut, and it probably never was very common.”

New York—The history of lynx in New York was described in detail by Bergstrom (1977, unpublished) and Brocke (1982, unpublished), and much of the following account comes from these sources. Historical records suggest that the lynx was once relatively common in New York, but that its range retreated northeastward as early as the mid- to late-1800s. Rafinesque (1817) observed lynx in the Catskill, Allegheny, and Adirondack Mountains, and a lynx was killed near Rhineback on the Hudson River in the eastern foothills of the Catskill Mountains in southeastern New York during the winter of 1877-1878 (Mearns 1899). A report on the zoology of New York in 1842, however, failed to note the lynx’s presence in the southern portion of the state, describing its range as “not uncommon in the northern districts of the state [presumably the Adirondack Mountains]” (DeKay 1842). Anecdotal reports gathered by Harper (1929) indicated that the lynx was fairly common in the Adirondacks in the 1880s and 1890s, but a report on the mammals of the Adirondack region in 1884 described the lynx as rare and occurring mostly in the eastern portions of the region (Merriam 1884). By the turn of the century, Miller (1899) speculated that, although the lynx still occurred in the Adirondacks and may still occur in the Catskills, the species was rapidly approaching extinction in New York.

Verified evidence of the occurrence of lynx in New York after 1900 consists of 23 records scattered in time from 1907 to 1973 (Table 8.2). All but four of these records are from the Adirondack Mountains, an area of boreal forest adjacent to the Green Mountains of Vermont and the White Mountains of New Hampshire. These high-elevation boreal zones may have served as a corridor of suitable habitat, providing connectivity among areas occupied by lynx in the northeastern United States with those in southeastern Canada (see map in Bailey 1998). Until 1970, the lynx was an unprotected species in New York and bounty payments were made for their pelts. The bounty was removed in 1970, but the lynx remained unprotected until 1976, when it was declared a game animal with closed hunting and trapping seasons. The New York Department of Environmental Conservation considers the lynx to be extirpated as a breeding species in the State, and has recommended that it be listed as a state endangered species (Bergstrom 1977, unpublished).

In response to a lack of evidence for the continued presence of lynx in the State, a program to reintroduce lynx to the Adirondack Mountains was initiated in the late 1970s (Brocke et al. 1990). A feasibility study (Brocke 1982,

Table 8.2—Verified records of lynx in New York.

Date	Record	Reference
Unknown	1 specimen from Jefferson County (western Adirondacks)	Academy of Natural Sciences of Philadelphia
1877-88	1 killed near Rhinebeck on the Hudson River (southeastern New York)	Mearns 1899
1907	2 killed in Willseyville, Tioga County (south-central New York)	Seagers 1948
1908	1 killed in Nine Mile Swamp, near North Brookfield (Adirondacks)	Whish 1919
1908	3 killed in the Quaker Bridge region (Adirondacks)	Whish 1919
1909	5 killed near Lowville, Lewis County (western Adirondacks)	Whish 1919
1916	1 killed in Oneida County (southwestern Adirondacks)	Anonymous 1952
1918	1 trapped near Upper Jay, Essex County (northeastern Adirondacks)	Anonymous 1918
1928	1 killed on Hogback Mountain, Essex County (northeastern Adirondacks)	Anonymous 1952
1930	1 taken alive near Elizabethtown, Essex County (northeastern Adirondacks)	Seagers 1948
Late 1930s	1 killed near Azure Mountain, Waverly, Franklin County (northern Adirondacks)	Bergstrom 1977, unpublished
1951	1 shot on Battle Hill, Washington County (eastern New York)	Seagers 1951
1961	1 shot near Sherman Lake, Crown Point, Essex County (northeastern Adirondacks)	Bergstrom 1977, unpublished
1962	1 trapped on Black Cat Mountain in Arietta, Hamilton County (central Adirondacks)	Anonymous 1963
1964	1 killed near Croghan, Lewis County (western Adirondacks)	Fountain 1976
Winter 1965-66	1 trapped on Pine Mountain, near Wells, Hamilton County (central Adirondacks)	Anonymous 1966
1968	1 specimen from Catskill, Delaware County (southeastern New York)	American Museum of Natural History
1973	1 trapped in Altona, Clinton County (northeastern Adirondacks)	Bergstrom 1977, unpublished

unpublished) indicated that a suitable colonization area for lynx existed in the Adirondacks above 800 m where bobcats (a potential competitor) were rare and where snowshoe hare populations were dense enough to support lynx. Between 1989 and 1991, after about 10 years of planning and public input, 83 lynx ranging in age from <1 to 10.5 years were translocated from the Whitehorse area of the Yukon Territory in Canada, radio-collared, and released in the High Peaks area of the Adirondack Mountains (Brocke et al. 1991; K. Gustafson, personal communication). These animals were monitored for two years until the transmitter batteries failed; recorded mortality was high: 37 of 83 were known to have died, 16 of which were road-killed. Available evidence indicates that the reintroduction was unsuccessful; since the last radiotracking season in the winter of 1992-1993, there have been no verified records of lynx in the Adirondacks and no indication that any reintroduced lynx bred after they were released (K. Gustafson, personal communication).

Pennsylvania—A comprehensive review of paleontological, historical, and specimen records of lynx in Pennsylvania was conducted by Williams et al. (1985). Surprisingly, they report 26 records of lynx being killed in Pennsylvania from 1790 to 1900. Bobcats and lynx were often confused in reports from the 18th and 19th centuries, however, so we view these records with caution. Recent records are extremely scarce: Only one museum specimen exists, a lynx collected near Antrium, Tioga County in 1923. A lynx was reportedly killed in 1903 in Clinton County and two others in 1926 in Monroe County (Shoemaker 1929; Grimm and Whitebread 1952, unpublished). The majority of records reported by Williams et al. (1985) are from the northern counties where unbroken, mature boreal forest existed prior to extensive logging of Pennsylvania forests in the latter half of the 19th century. This area also represents the southwestern-most extension of mixed deciduous-coniferous forest in the northeastern United States (Bailey 1998).

Great Lakes and North-Central States

Michigan—Historical accounts of varying reliability, summarized by Burt (1946) and Baker (1983), suggest that in the 1800s lynx may have been widely distributed in both the Lower and Upper Peninsulas of Michigan. However, six of seven verified records from the 1800s are from the Upper Peninsula near the Wisconsin border; a lynx killed in Washtenaw County in 1842 and five lynx trapped along the Au Sable River in Oscoda County in 1917 represent the only verified records of lynx from the Lower Peninsula (Table 8.3). Verified records of lynx occurrence in Michigan in the early 1900s are extremely scarce: five specimens were collected on Isle Royale in 1904

Table 8.3—Verified records of lynx in Michigan.

Date	Record	Reference
Unknown	1 specimen from Michigan.	Zoology Museum, University of Michigan
(1842)[a]	1 taken near Petersburg, Monroe County (LP)[b]	Wood and Dice 1924
1842	1 killed in Washtenaw County (LP)	Wood 1922
(1844)[a]	1 killed along the Au Sable River, Oscoda County (LP)	Wood and Dice 1924
Prior to 1874	3 specimens from Marquette, Marquette County (UP)[c]	Peabody Museum, Yale University
1874	1 specimen from Gogebic County (UP)	Milwaukee Public Museum
(1875)[a]	Several caught at headwaters of Manistique River, Schoolcraft County (UP)	Wood and Dice 1924
1889	1 specimen from Ishpening, Marquette County (UP)	Milwaukee Public Museum
1890-91	1 taken near Gogebic Lake, Gogebic County (UP)	Dice and Sherman 1922
(1894)[a]	1 taken 18 miles east of Cadillac, Wexford County (LP)	Wood and Dice 1924
(1894-95)[a]	34 killed in Mackinac County (UP)	Wood and Dice 1924
(1903)[a]	1 trapped at Big Creek, Oscoda County (LP)	Wood and Dice 1924
1904-05	5 collected on Isle Royale, Keneenaw County (UP)	Zoology Museum, University of Michigan
1910	1 taken at Rudyar, Chippewa County (UP)	Wood and Dice 1924
1912	1 taken near Sault Ste. Marie, Chippewa County (UP)	Wood and Dice 1924
1917	5 trapped along the Au Sable River near Luzerne, Oscoda County (LP)	Harger 1965
1923	1 specimen from Mackinac County (UP)	National Museum of Natural History
1928	1 trapped in Ontonagon County (UP)	Baker 1983
1940	1 trapped on Bois Blanc Island, Mackinac County (UP)	Harger 1965
1949	1 trapped at Engadine, Mackinac County (UP)	Harger 1965
1953	1 specimen from Dunbar, Marquette County (UP)	Erickson 1955; Zoology Museum, University of Michigan
1955	1 specimen from Marquette County (UP)	Grand Rapids Public Museum
1958	1 specimen from Rockview, Chippewa County (UP)	Michigan State University Museum
1960	1 shot near Rockview, Chippewa County (UP)	Harger 1965
1960	1 specimen from Trout Lake, Chippewa County (UP)	Michigan State University Museum
1961	1 specimen from Pickford, Chippewa County (UP)	Zoology Museum, University of Michigan
1961	1 shot near Dafter, Chippewa County (UP)	Harger 1965
1962	1 shot near Pickford, Chippewa County (UP)	Harger 1965
1962	1 shot near Nun's Creek, Mackinac County (UP)	Harger 1965
1962	1 trapped near Channing, Dickinson County (UP)	Harger 1965
1962	1 shot 7 mi. N of Iron Mountain, Dickinson County (UP)	Harger 1965
1962	1 specimen from Dunbar, Chippewa County (UP)	Michigan State University Museum
1962	1 shot in Ontonagon County (UP)	Harger 1965
1962	1 shot near Sagola, Dickinson County (UP)	Harger 1965
1962	1 shot near Trout Lake, Chippewa County (UP)	Harger 1965
1962	1 shot near Manistique, Schoolcraft County (UP)	Harger 1965
1962	1 shot between Topaz and Matchwood, Ontonagon County (UP)	Harger 1965
1962	1 specimen from Sault Ste. Marie, Chippewa County (UP)	Michigan State University Museum
1962	1 shot near Dafter, Chippewa County (UP)	Harger 1965
1966	1 specimen from Schoolcraft County (UP)	Michigan State University Museum
1983	1 killed in Mackinac County (UP)	Michigan Dept. of Natural Resources

[a]Wood and Dice (1924) caution that there is a strong possibility that some of these records may be of bobcats; we therefore consider these records to be probable, but not verified, records of lynx in Michigan.
[b]LP = Lower Peninsula.
[c]UP = Upper Peninsula.

and 1905, and mortality records from the Upper Peninsula are known only from 1910, 1912, 1923, and 1928 (Table 8.3). By 1928, the Michigan Department of Conservation reported the lynx to be extirpated from the Lower Peninsula and nearly so from the Upper Peninsula; by 1938, the lynx was declared on the verge of extinction throughout Michigan and, in later reports, was not even mentioned (Harger 1965).

By the mid-1940s, Burt (1946) considered the lynx to be "probably gone from the fauna of Michigan," but there are verified records from 1940, 1949, 1953, 1955, and 1958 (Table 8.3). From 1960 to 1962, 16 lynx were killed on the Upper Peninsula, including 12 in 1962, following an unusually large irruption of lynx in south-central Canada during the early 1960s (Adams 1963; Gunderson 1978). Harvest records from Ontario, Manitoba, and Saskatchewan clearly depict the irruption of lynx during this time and its unusually high amplitude (Fig. 8.3), which was several times greater than during previous peaks recorded this century. Since the early 1960s, however, only two verified records of lynx in Michigan could be found: one in 1966 and another in 1983 (Table 8.3). The lynx has been fully protected in Michigan since 1983, when it was classified as a threatened species; it was reclassified as a state endangered species in 1987.

Wisconsin—The history of lynx in Wisconsin was reviewed in detail by Thiel (1987), including a comprehensive compilation of specimen and mortality records. Only 11 verified records of lynx in Wisconsin prior to

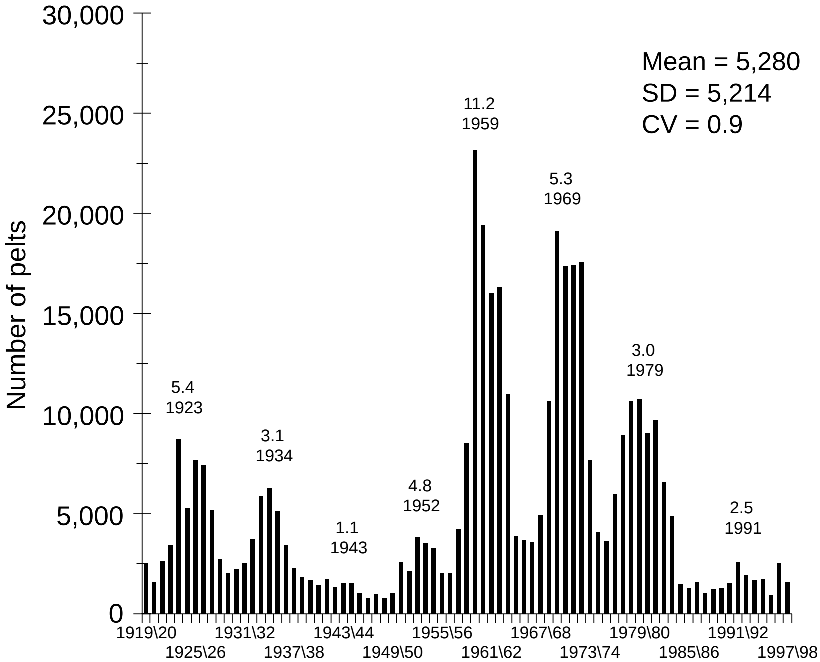

Figure 8.3—Lynx harvest data for Saskatchewan, Manitoba, and Ontario combined, 1919-1997; peak years are indicated, as well as a measure of amplitude calculated by dividing the peak harvest value by the previous low harvest value.

1962 are known, including eight records dating from 1870 to 1926 and three specimens collected in 1946, 1954, and 1955 (Table 8.4). The lynx is reported to have always occurred most frequently in the northern portion of Wisconsin (Jackson 1961), and the distribution of verified records supports this assertion. Only three records are known from the southernmost counties near the Illinois border; the last of these was in 1946. The last known occurrence of the lynx in central Wisconsin was in 1972, and all but a few records since 1965 are from counties located near the borders of northern Minnesota and the Upper Peninsula of Michigan (Table 8.4). An unusual increase in lynx mortalities occurred in Wisconsin during the 1960s and early 1970s (Table 8.4; Thiel 1987). The number of verified records of lynx being killed (16) in Wisconsin during this time period exceeded those from the previous 100 years (Table 8.4). Similar increases in lynx mortalities during these same time periods have been reported for Minnesota, North Dakota, and Montana (Adams 1963; Gunderson 1978; Mech 1973, 1980).

Table 8.4—Verified records of lynx in Wisconsin.

Date	Record	Reference
1870	1 specimen from Jefferson County	Zoological Museum, University of Wisconsin, Madison
1899	2 specimens from Iron County	Zoological Museum, University of Wisconsin, Madison
1901	1 specimen from Gordon, Douglas County	Zoological Museum, University of Wisconsin, Madison
1907	1 killed in Middleton, Dane County	Schorger 1947
1908	1 specimen from Edson, Chippewa County	Museum of Natural History, Wisconsin State University, Stevens Point
1917	1 trapped in La Crosse, La Crosse County	Milwaukee Public Museum
1926	1 shot in Shell Lake, Washburn County	Stouffer 1961 (cited in Thiel 1987)
1946	1 specimen from Spring Green, Sauk County	Zoological Museum, University of Wisconsin, Madison
1954	1 specimen from Hurley, Iron County	Zoological Museum, University of Wisconsin, Madison
1955	1 specimen from Richland, Rusk County	Zoological Museum, University of Wisconsin, Madison
1962	1 shot in Rusk County	Thiel 1987
1963	1 shot in Douglas County	Thiel 1987
1964	1 killed in Jackson County	Thiel 1987
1965 or 1968	1 killed in Pierce County	Thiel 1987
1965	1 killed in Green Lake County	Thiel 1987
1965	1 killed by a train near Viroqua, Pierce County	Thiel 1987
1965	1 specimen shot while swimming at the mouth of the St. Louis River, Douglas County	University of Wisconsin, Superior
1971	1 shot in Trempealeau County	Thiel 1987
1972	1 shot in Trempealeau County	Thiel 1987
1972	1 specimen from Woodruff, Vilas County	Zoological Museum, University of Wisconsin, Madison
1972	1 killed by car in Oneida County	Thiel 1987
1972	1 trapped in Price County	Thiel 1987
1972	1 specimen from Lake Noquebay, Marinette County	Technical Center, University of Wisconsin, Marinette
1972	1 shot in Tomahawk, Lincoln County	Thiel 1987
1973	1 trapped in Iron County	Thiel 1987
Winter 1972-1973	1 specimen from Oneida or Vilas County	Zoological Museum, University of Wisconsin, Madison
1992	1 specimen from Burnette County	Museum of Natural History, Wisconsin State University, Stevens Point
1992	1 specimen from St. Croix County	Museum of Natural History, Wisconsin State University, Stevens Point

Since that time, only two records of lynx being killed in Wisconsin are known; both were in 1992. Lynx tracks were detected by the Wisconsin Department of Natural Resources during wolf surveys from 1993 to 1997, but all were within six to seven miles of each other, suggesting that they may represent the same individual (Wydeven 1998, unpublished). Lynx have been completely protected in Wisconsin since 1957, when harvest seasons and bounty payments were eliminated; in 1972, the lynx was placed on the state endangered species list.

Indiana, Illinois, Ohio, and Iowa—Lyon (1936) reviewed published reports of lynx from Indiana in the 1800s and concluded that none could be considered verified records, given the confusion over terms used for cougar, bobcat, and lynx in these sources. Mumford (1969) believed that some of these records might be authentic, however, and cited a report of a lynx being killed at Bicknell, Knox County in southwestern Indiana in 1832. Records from Illinois are similarly scanty; Kennicott (1855) included the lynx in his list of mammals occurring in Cook County (now metropolitan Chicago), and specimen records of the Academy of Natural Sciences of Philadelphia include a lynx collected in Illinois that was obtained by the museum in June 1842 (this specimen is now missing from the collection). No verified records of lynx from Ohio could be found, but Smith et al. (1973) included the species in a list of mammals that once bred in Ohio but which have now been extirpated. Historical records of lynx in Iowa are more prevalent; Spurrell (1917) reported that three lynx were trapped in Sac County in northwestern Iowa in 1869 and one in 1875; another lynx was apparently killed in Iowa in 1906 (Gunderson 1978). In July 1963, a lynx was shot in Shelby County in west-central Iowa (Rasmussen 1969); none has been reported since that time.

Minnesota—Published historical information on lynx in Minnesota is virtually nonexistent. In an early monograph on the mammals of Minnesota, Herrick (1892) was uncertain if the lynx was even a member of the state's fauna at that time. Hunters consistently told him that two species of wildcats occupied the state but all specimens he examined, including those presented to him as "lynx," proved to be bobcats. Although lynx were apparently not common at that time, their presence in Minnesota during the late 1800s is confirmed by the existence of eight museum specimens dating from 1892 to 1900. Two of these specimens are from Sherbourne County in south-central Minnesota and the remainder are from Itaska County in the north-central portion of the state. Verified records prior to the south-central Canadian population peak of 1959 are scarce: a lynx was collected in Sherbourne County in 1927, one in Morrison County in 1928, one in St. Louis County in 1951, one in Aitkin County in 1953, and one in Lake of the Woods County in 1955.

The only other documented information on lynx in Minnesota prior to 1960 are harvest records published by the state Department of Natural Resources (Fig. 8.4; Henderson 1978). However, these records should be considered with caution; data from 1930 to 1976 do not represent reports of catch or carcass records obtained during the year of harvest but, rather, are estimates of harvest obtained in later years by mail survey. These records indicate, however, that lynx have been harvested in relatively high numbers in Minnesota in most years since 1930 (mean = 103 per year, range = 0-400). Peaks in the harvest record that occurred in 1962 and 1973 are also reflected in museum specimen records. All other specimens from Minnesota are from the early 1960s and early 1970s: one from 1960, one from 1961, four from 1962, 14 from 1963, one from 1964, 25 from 1972, and one from 1973. During this time, Mech (1980) trapped 14 lynx in northeastern Minnesota: five in 1972, three in 1973, four in 1974, and two in 1975.

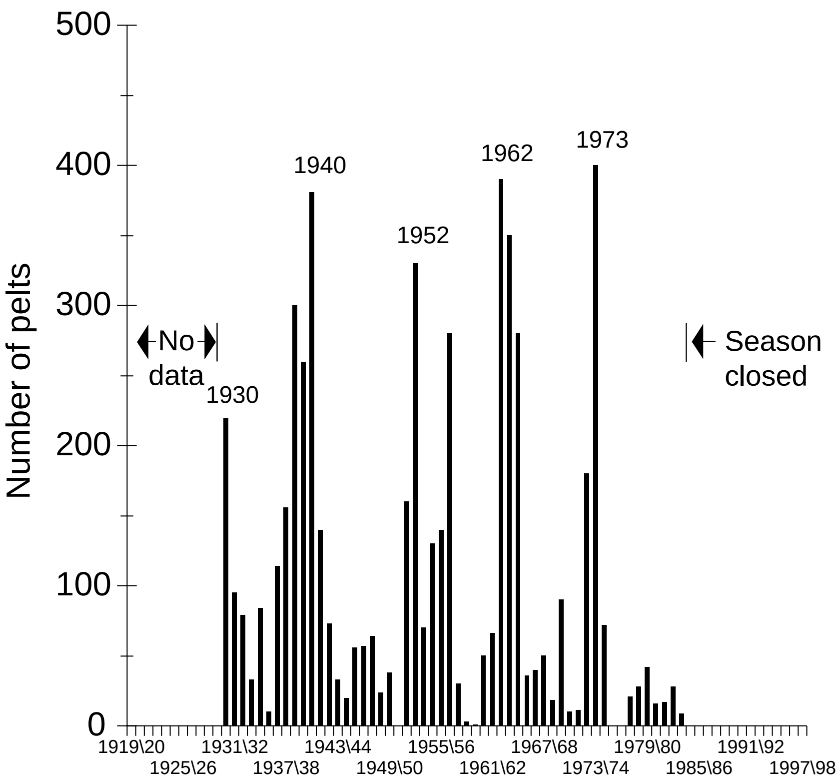

Figure 8.4—Lynx harvest data from Minnesota, 1930-1983; years of peak harvest values are indicated.

The continued occurrence of lynx in Minnesota in the late 1970s and early 1980s is verified by state records dating from 1977 to 1983, which represent reports of catch from hunters and trappers at the close of each trapping season. Altogether, 161 lynx were harvested in Minnesota during this period (mean = 23, range = 9-42). When expected increases in lynx numbers failed to occur in the early 1980s, the state closed the harvest season for lynx; it has not been reopened. Since the closure of lynx harvests, only three verified lynx records are known: one trapped in Cook County in 1992, and one illegal possession in Anoka County and one road-kill in St. Louis County in 1993 (DonCarlos 1994, unpublished). The only documented records of lynx breeding in Minnesota are two females that gave birth to kittens in the spring of 1972 (Mech 1973).

North Dakota—The northern Great Plains are generally not included in the range of lynx (Burt 1946; McCord and Cardoza 1982; Quinn and Parker 1987; Seton 1929), yet there are a surprising number of historical specimen records from this region. Bailey (1926) reports numerous anecdotal accounts of lynx being trapped in North Dakota in the 1800s and lists three specimen records: one collected at Fort Union (now Buford, North Dakota, on the Montana border) in 1850, one at Arrowhead Lake in east-central North Dakota in 1907, and one at Cannonball near the south-central border in 1915. Other reports include several lynx that were killed in the northeastern portion of the state, including one at Lakota in 1915 and two near Grafton in 1909 and 1911. Bailey (1926) makes several references to periodic increases in lynx numbers in this region, noting that "in some years, the lynx is common over the northern portion of North Dakota," and that many lynx were captured in north-central North Dakota and brought into taxidermists' shops in 1908 and 1909, when they were apparently "wandering in search of new hunting fields." Two lynx were bountied during the winter of 1954-1955 in the northeastern corner of North Dakota (Adams 1963; Gunderson 1978). In addition, many lynx apparently were killed in North Dakota during the lynx irruptions of the 1960s and 1970s (Adams 1963). According to records of the North Dakota Game and Fish Department, 53 lynx were harvested from 1962 to 1965 and another 24 from 1972 to 1973. With the exception of eight museum specimens collected in 1962 and 1963, no other verified lynx records from North Dakota could be found.

South Dakota and Nebraska—The earliest records of lynx in South Dakota are both from the southeastern corner of the state, near the borders of Minnesota and Iowa: One lynx was taken above Sioux City in 1875 and a museum specimen was collected at Bullhead, Corson County in 1925. Other reports include one killed in Meade County and two in Pennington County in 1944; one near Briton, Chamberlain County in 1962; one near Marindahl, Yankton County in 1962; one near Chamberlain, Brule County in 1963 (Gunderson 1978; Turner 1974); a museum specimen collected in northeastern South Dakota in 1965; and, according to federal Animal Damage Control records, one killed in 1973 on the Cheyenne River in Pennington County. Records from Nebraska are of a similar nature: a museum specimen was collected in 1890 near Norfolk in Madison County, and Jones (1964) reports that a lynx was killed in 1915 near Bassett in north-central Nebraska, another along the North Platte River near Keystone in 1917, and a third near Ewing in 1958. All other verified records are associated with mid-continent lynx irruptions in the early 1960s, 1970s, and 1980s: five from 1963 to 1964; three from 1972 to 1974; and a specimen collected near Herman, Washington County in 1983 (Nebraska Game and Parks records).

Western Mountain States

Montana—Available information on the history of lynx in Montana in the late 1800s and early 1900s consists of 12 museum specimens collected between 1887 and 1921; published information on the recent or historical status of Montana mammals is limited (Hoffmann et al. 1969). Four specimens were collected in Rosebud and Musselshell Counties in southeastern Montana in 1887, one in 1895 at upper St. Mary Lake in Glacier National Park, three in the Bitterroot Mountains in 1910 (two at Bass Creek and one at Elk Lake), two in 1916 (one without a specific collecting locality and another at Deer Lodge, Powell County in west-central Montana), one in 1918 at Kintla Lake in Glacier National Park, and one in 1921 in northwestern Montana near Plains, Sanders County. The status of lynx in the Glacier Park area of northwestern Montana during the early 1900s was reviewed by Bailey (1918), who considered the lynx “more or less common throughout the Glacier Park region.” He noted, however, that “during years when rabbits are abundant, [lynx] too, become abundant, and when there are few rabbits, they are correspondingly scarce.” Five specimens were collected in northwestern Montana in the 1940s and 1950s: one in Lincoln County in 1941, two in Flathead County in 1954 and 1956, one in Missoula County in 1958, and one from an unknown locality in the late 1950s.

As in the Great Lakes and north-central States, most later specimen records are associated with lynx irruptions in the early 1960s and 1970s. The remaining 19 specimens include 14 obtained from 1962 to 1966 and five from 1971 to 1976. Data on lynx harvests in the state have been kept since 1950, however, and show continuous presence of lynx in the state (Fig. 8.5); since 1977, over 475 lynx were harvested in Montana. Smith (1984, unpublished) and Brainerd (1985, unpublished) captured 10 lynx during radiotelemetry studies in western Montana in the 1980s, and an ongoing

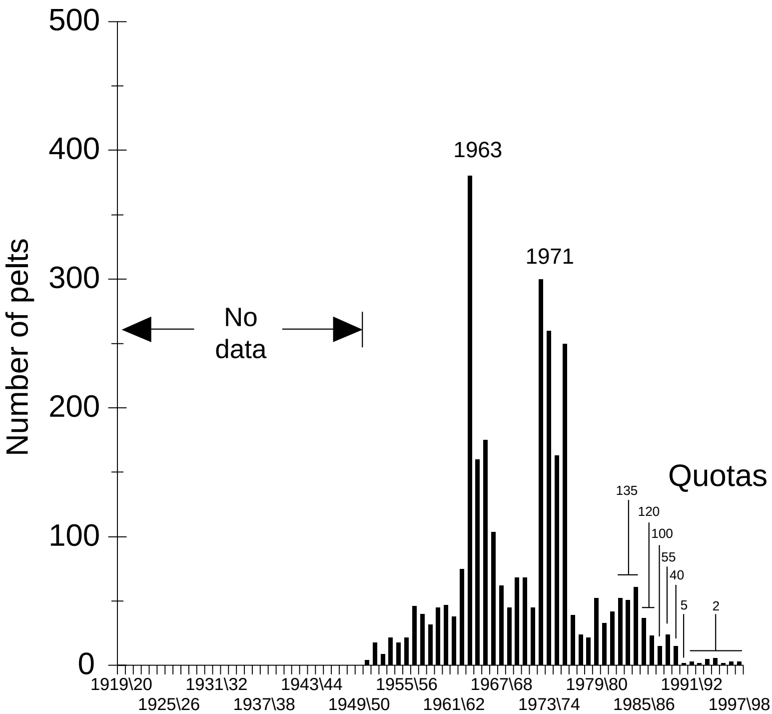

Figure 8.5—Lynx harvest data from Montana, 1950-1997; years of peak harvest values are indicated.

study begun in 1998 in the area around Seeley Lake (Chapter 11) has captured 18 lynx to date (June 1999). Although reliable data on lynx reproduction in Montana are scarce, Brainerd (1985, unpublished) examined 20 trapper-killed lynx carcasses, including several kittens, and found a pregnancy rate for all ages of 70.6%. As was noted for New Hampshire, lynx harvest data from Montana is cyclic in nature, with peaks corresponding closely in time and magnitude with those occurring in western Canada, especially for 1963 and 1971 (Figs. 8.5 and 8.6).

Idaho—Specimen records of lynx in Idaho during the early 1900s are relatively common; there are 22 museum specimens dating from 1874 to 1917, all of which were collected in the northern and central montane regions of Idaho north of the Snake River Plain. Specimens were later collected in central Idaho in 1939 on the Payette National Forest in Valley County and in 1940 in Idaho County. The only other museum records are both from the northern panhandle region: one from Bonner County in 1954 and one from

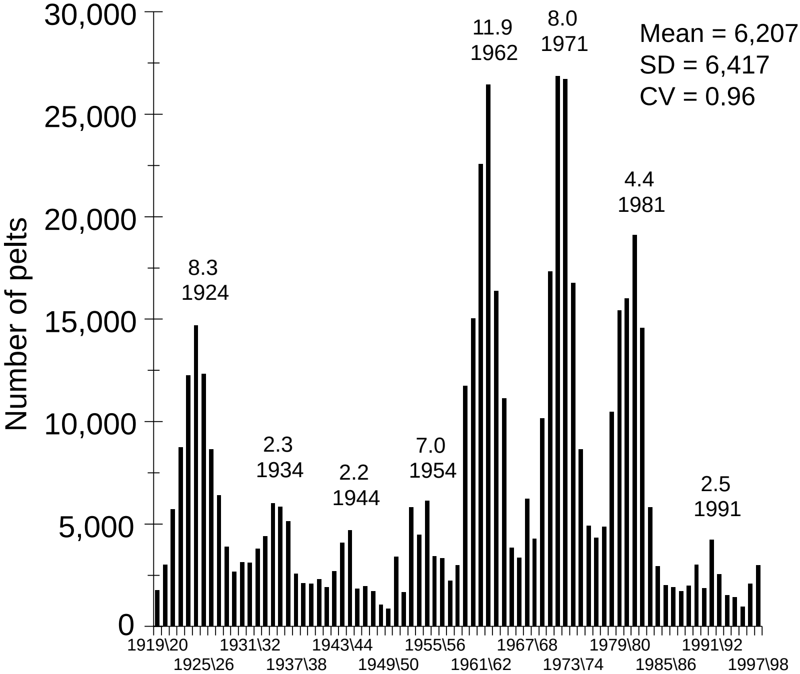

Figure 8.6—Lynx harvest data for British Columbia and Alberta combined, 1919-1997; peak years are indicated, as well as a measure of amplitude calculated by dividing the peak harvest value by the previous low harvest value.

Shoshone County in 1955. Other verified records prior to 1960 include one from Shoshone County in 1901, one from Boundary County in 1919, one from Idaho County in 1936, one from northwest Idaho in 1939, one from Clearwater County in 1942, five from Caribou County in 1947, two from Bonneville County in 1955, and one from Idaho County in 1947 (Anonymous 1999, unpublished; Dalquest 1948). With the exception of Caribou and Bonneville Counties, which are located along the Wyoming border, all of these records are from the north-central and northern regions of the state.

In an early account of the mammals of Idaho, Davis (1939) described lynx occurring "in the mountainous regions north and east of the Snake River Plain." Rust's (1946) assessment of the status of lynx in northern Idaho is similar: "While nowhere abundant in northern Idaho, the Canadian lynx is fairly well distributed throughout the wooded areas of eight of the 10 northern counties, largely in the Canadian and Hudsonian zones." He noted that 25-30 lynx are usually taken by local trappers in addition to those killed by predator control agents.

There are 35 verified records from 1960 to 1991: four from 1962 to 1969, 18 from 1970 to 1979, 10 from 1982 to 1989, and three from 1990 to 1991; there are no verified records of lynx in Idaho since 1991 (Anonymous 1999, unpublished). Although most of these records are from the northern and central regions of Idaho where lynx occurred historically, six are from counties in the Snake River Plain, in areas where forest types occupied by lynx are absent or very fragmentary in extent (see "Lynx Associations with Broad Cover Types"). These include records from Blaine, Butte, Jerome, and Twin Falls Counties in 1972; one from Blaine County in 1984; and one from Power County in 1990. As in other western and midwestern states, there are a number of anecdotal accounts of lynx being killed or captured in anomalous, low-elevation habitats during lynx irruptions in the 1960s and 1970s (Lewis and Wenger 1998). These accounts are derived from interviews initiated in 1997, however, and the lack of similar reports from the 1980s or 1990s suggests that these records represent transient lynx.

Lynx harvest records for Idaho from 1934 to 1981 are available (Novak et al. 1987), but state biologists consider these data to be unreliable prior to the late 1980s due to the inclusion of large, pale bobcats in these totals. This concern appears to be valid; after 1981, when a mandatory pelt-tagging program was instituted, no lynx was harvested for the next seven trapping seasons (Anonymous 1999, unpublished). The lynx was unprotected in Idaho before 1977, when it was classified as a furbearer and harvest was restricted to a one-month trapping season and a three-month pursuit season. In 1990, a state-wide quota of three lynx per year was imposed; the season was closed in 1996.

Washington—Verified records of lynx in Washington are numerous and well-distributed since the late 1800s. There are 78 museum specimens of lynx from Washington—more than any other state in the contiguous United States. The earliest records are represented by 10 specimens collected in 1896 and 1897 on Mt. Adams in the southern Cascade Range near the border of Oregon. All but a few subsequent specimen records, however, are from the north-central and northeastern portions of the state near the Canadian border, including 32 from 1916 to 1920, three from 1928 to 1930, four from 1939 to 1940, eight from 1951 to 1959, one in 1965, and 17 from 1976 to 1983. In addition, there are three specimens from southeastern Washington: one from the Blue Mountains in 1931 and two from arid grassland habitats in 1962 and 1963. A lynx was reportedly trapped near the southern boundary of Mt. Rainier National Park "some years" prior to 1927 (Taylor and Shaw 1927) and nine lynx were trapped west of Oroville in Okanogan County in 1938 (photo in Dalquest 1948). According to Dalquest (1948), each of several trappers regularly took a dozen or more lynx from remote areas of northeastern Washington each year. No verified records of lynx are known from coastal areas west of the Cascade Range. Lynx populations in Washington have been studied in the field more than anywhere else in the contiguous United States, and most of what is known of lynx ecology in southern boreal forests comes from these studies (Chapter 13; Koehler and Aubry 1994). Thirty lynx were studied with radiotelemetry in north-central Washington from 1981 to 1988 (Brittell et al. 1989, unpublished; Koehler 1990), including two radio-collared females that each gave birth to kittens in 1986 and 1987; snow-tracking indicated that a third, uncollared female also had a litter of kittens in 1986 (Koehler 1990). From 1995 to 1999, 16 remote-camera photographs of lynx were taken at bait stations in north-central Washington (J. Rohrer and M. Skatrud, personal communication).

Management of lynx in Washington began in 1933, when the Washington Department of Game was established and the lynx was classified as a furbearer that could only be harvested by trapping; the first lynx trapping season was in the winter of 1934-1935. Monitoring of the lynx harvest did not begin until 1961, however, at which time trappers were required to submit reports of catch to the Department of Game. In 1978, the state initiated mandatory tagging of lynx pelts within 10 days of the close of each trapping season (Brittell et al. 1989, unpublished). Washington harvest data from 1961 to 1984 (Fig. 8.7) suggests that Washington lynx populations may also exhibit cyclic patterns of abundance. During the peak harvest of 1969, 26 of the 31 lynx taken were from the Kettle Range in Ferry County. Only a few were harvested in this area from 1970 to 1974, but 14 of 19 lynx taken in Washington in 1975 and 17 of 39 taken in 1976 came from this area. Of the 25 lynx harvested since that time, only two were from Ferry County. Although trapper effort and pelt prices undoubtedly influence these data, the lynx population in the Kettle Range appears to have undergone several dramatic increases and decreases in number from 1961 to 1977. Snow-tracking surveys conducted from 1992 to 1996 in the Kettle Range resulted in only two sets of tracks: one in 1991-1992 and one in 1995-1996 (Washington Dept. of Fish and Wildlife, unpublished data). Trapping seasons lasted 2-2.5 months from 1961 to 1977 but were shortened to about one month beginning in 1978; in 1987, a restricted permit system was implemented. Thus, harvest data after 1977 are not directly comparable to previous data. A statewide closure of the lynx trapping season was implemented in 1990, and the lynx was classified as a threatened species in Washington in 1993.

Oregon—The presence of lynx in Oregon in the late 1800s and early 1900s is documented by nine museum specimens collected from 1897 to 1927. Verified records after that time, however, are extremely rare. Only three

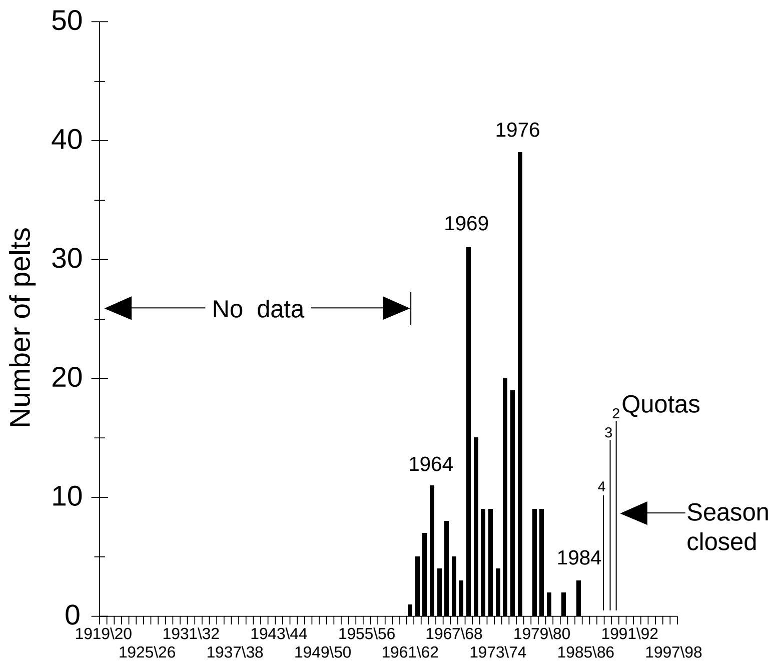

Figure 8.7—Lynx harvest data from Washington, 1960-1989; years of peak harvest values are indicated.

recent specimens are known, and all were collected in anomalous habitats within several years of lynx population peaks in western Canada (see "Lynx Associations With Broad Cover Types"): one in bunchgrass-rimrock habitat in Wallowa County in 1964, one in a suburban residential area in Benton County in 1974 (Verts and Carraway 1998), and a third in Harney County in southeastern Oregon in 1993, where there are only small fragments of forest types associated with lynx occurrence (see "Lynx Associations With Broad Cover Types"). Although Bailey (1936) describes early anecdotal reports of lynx in western Oregon, the 1974 specimen is the only verified record of lynx west of the Cascade Crest in Oregon.

Wyoming—Reeve et al. (1986, unpublished) conducted a thorough and comprehensive review of existing information on lynx in Wyoming, including verified records and information obtained through a mail and telephone survey of knowledgeable individuals in the state. The only verified record not located by these authors was a museum specimen obtained at Fort Frederick Steele in Carbon County in southeastern Wyoming sometime prior to 1872. There are three specimen records from the 1800s, including another from southeastern Wyoming in 1856 and one collected near the headwaters of the Wind River in northwestern Wyoming in 1893. All other early specimens were from the northwestern portion of the state: one from the Big Horn Mountains in 1919, two from the Wind River Range in 1908 and 1919, and seven collected from 1904 to 1920 in the area in and around Yellowstone National Park in what is now referred to as the "Greater Yellowstone Ecosystem" (GYE). In an early monograph on the animal life of Yellowstone Park, Bailey (1930) wrote that lynx "were said to be common and generally distributed throughout the timbered region." There are no recent verified records from the GYE.

Verified records of lynx in Wyoming after 1920 are rare; there are nine verified records from 1940 to 1957, and all were lynx killed near the west-central border of the state. A lynx was collected in 1940 at Hoback Rim in northwestern Sublette County and another in 1949 near Afton, Lincoln County. The remaining seven records are described by Halloran and Blanchard (1959) and include five lynx trapped by state predator control agents in northern Lincoln County from 1952 to 1955, a specimen collected in northwestern Sublette County in 1954, and a kitten collected in southwestern Teton County in 1957. The only other verified records are a lynx taken in Albany County in the Laramie Range of southeastern Wyoming in 1963 (Long 1965), and one from an anomalous locality near Douglas, Converse County in east-central Wyoming in 1983 (Reeve et al. 1986). A radiotelemetry study was initiated in western Wyoming in 1996, resulting in the capture of two lynx: a male in December 1996 and a female in March 1997; the female produced a litter of four kittens in May 1998 (Chapter 11). Prior to 1973, when the lynx was given full protection in Wyoming, it was considered a predator that could be harvested legally anytime of year without a license; consequently, no reliable harvest records are available from Wyoming.

Colorado—A thorough review of the history of documented lynx records in Colorado was conducted by Halfpenny et al. (1989, unpublished) and, except for the discovery of several more historical specimen records, little new information has become available since their analysis. Unlike other western montane regions considered thus far, boreal forest habitat in Colorado is insular in nature and isolated from similar habitat in Utah and Wyoming by more than 150 km of lower elevation habitats in the Green River Valley and Wyoming Basin (Findley and Anderson 1956). All but a few specimen records are from the center of this island of boreal forest habitat in west-central Colorado. There are four specimens from the late 1800s: one without a specific collecting locality, one from Cumbres County near the New Mexico border, one from Breckenridge, Summit County, and one from Colorado Springs, El Paso County. Halfpenny et al. (1989, unpublished) reported that Edwin Carter's taxidermy notes in the Denver Museum of Natural History included a lynx trapped in Soda Gulch, Clear Creek County in 1878. Museum specimens were also found from Grand Lake, Grand County in 1904-1905; Jefferson, Park County in 1912; and southwestern Gunnison County in 1925. Terrell (1971) reported one lynx trapped at Red Cliff, Eagle County in 1929 and one at Marble, Gunnison County in 1931. Through interviews with trappers, Halfpenny et al. concluded that reports of three lynx being trapped in Eagle County in 1930 and 1936 were reliable.

After 1936, no lynx specimens or reports of kills are known until 1969, when a specimen was trapped near Leadville, Lake County, and others were reportedly shot on the Frying Pan River, Pitkin County (Terrell 1971) and on the south side of Vail Mountain, Eagle County (Halfpenny et al. 1989, unpublished). In 1972, a lynx specimen was trapped on Guanella Pass, Clear Creek County and, in 1974, two were trapped (one is preserved as a specimen) on the north side of Vail Mountain, Eagle County. Since that time, only tracks have been found, including three sets on the Frying Pan River, Eagle and Pitkin Counties and five sets near Mt. Evans, Clear Creek County (Halfpenny et al. 1989, unpublished). There are no verified records of lynx in Colorado since 1974, despite large-scale snow-tracking efforts (Carney 1993, unpublished). The management history of lynx in Colorado is similar to that reported for Wyoming: The lynx was designated an unprotected predator until 1970, when all harvest of lynx was prohibited; in 1973, it was classified as a state endangered species.

Utah—Our understanding of the distribution and status of lynx in Utah comes entirely from scattered mortality records. Barnes (1927) reported that 103 lynx were trapped in a number of counties in Utah in 1915 and 1916, but Durrant (1952) questioned the validity of these records and believed that most were actually large bobcats. The relative scarcity of early specimen records supports this conclusion. Only three specimens of lynx from Utah in the early 1900s were found in museums, including one collected in 1916 from Wasatch County, one in 1931 from Sanpete County, and one in 1937 from Daggett County. Later records are all from the northwestern portion of Utah near the southern borders of Wyoming and Idaho. Those records include one museum specimen collected in 1957 from Daggett County, mortality reports from Uintah County in 1958 and Summit County in 1958 and 1962 (McKay 1991, unpublished), one specimen from Summit County in 1963, a mortality report from the north slope of the Uinta Mountains in 1972 (McKay 1991, unpublished) and a lynx trapped in Cache County in 1991 (R. McKay, personal communication). No verified records are known after this time. The lynx is listed as a sensitive species in Utah and has been protected from all intentional harvest since 1974.

Nevada—There are two museum specimens from Nevada; both were collected in 1916 in Elko County in north-central Nevada near the Oregon border (Schantz 1947). These specimens represent the southernmost records of lynx occurrence west of the Rocky Mountains and are the only verified records of lynx from Nevada. Three of the 12 specimens from Oregon were also collected in 1916, suggesting that this may have been a year during which lynx were dispersing south of their primary range; peaks in lynx pelt returns from British Columbia and southern Alberta were recorded in 1915 and 1916, respectively (Elton and Nicholson 1942; p. 229).

Synchrony Between United States and Canadian Trapping Data

Lynx populations in the contiguous United States occur at the southern margin of a large, interconnected distribution whose geographic center lies in the northern taiga (McCord and Cardoza 1982; Quinn and Parker 1987). It has been suggested that the persistence of some lynx populations in the contiguous United States may be dependent upon the periodic immigration of lynx into the United States during the crash of northern lynx populations (Thiel 1987). In the following section, we analyze harvest data, occurrence data, and verified records from the United States in relation to lynx cycles in Canada to address the following questions: (1) Are lynx records in the contiguous United States associated with cyclic population highs in Canada? and (2) If so, do similar patterns occur repeatedly across time and space?

In southern boreal forests, lynx are believed to occur at relatively low population densities (Koehler and Aubry 1994), and throughout the 20th century, harvest records for lynx in Canada have been two to three orders of magnitude larger than those for the contiguous United States (Novak et al. 1987). In the taiga, long-range emigrations from core populations are associated with the crash of snowshoe hare populations; when prey becomes scarce, home ranges dissolve and lynx become nomadic (Chapter 9). Thus, it is possible that periodic immigrations of lynx into the United States from southern Canadian provinces may occur during such events.

Thiel (1987) argues that periodic immigrations of lynx into the United States from Canada will produce large increases in lynx records in the United States occurring several years after cyclic highs in Canada, the lag being the immigration time. Additionally, we would expect many of these records to occur in cover types generally not used by lynx and in geographic areas in which lynx records are generally scarce. However, lagged dynamics and unusual occurrence patterns, while suggestive, do not necessarily mean that such occurrences are directly attributable to transients. Complex asynchronous dynamics are predicted by predator/prey diffusion reaction models (see Hastings and Harrison 1994 for a review) and occur due to the interactions between local population dynamics and changes due to dispersal. Mowat et al. (Chapter 9), for instance, suggest that lynx dynamics in the taiga exhibit lagged synchrony and that the lynx cycle in Canada "emanates" from central Canada with the patterns in Yukon, Alaska, and Quebec lagged several years behind those of Saskatchewan and Manitoba. Correlation analyses of Canadian trapping data (Ranta et al. 1997) also indicate that, on a continental scale, patterns are least synchronous at intermediate distances and most synchronous when comparing locations that are either very close or very far.

Methods

We evaluated Mowat et al.'s (Chapter 9) hypothesis by comparing data from the central provinces of Alberta and Saskatchewan with data from areas to the northwest (Alberta + Saskatchewan ➔ Yukon ➔ Alaska) and the east (Alberta + Saskatchewan ➔ Manitoba ➔ Ontario ➔ Quebec). We computed correlation coefficients between trapping data for the provinces of Alberta and Saskatchewan and the other provinces and Alaska incrementally shifted back in time 0-5 years, noted the time lag associated with the highest correlation, and tested whether lagging the data caused significant changes in correlation coefficients (Zar 1996, pp. 384-386).

For states with reliable and long-term lynx harvest data (New Hampshire, Minnesota, Montana, and Washington), we repeated the correlation analyses (above) to determine the extent to which these data were correlated with harvest data from Canadian provinces and whether these data were lagged. For these analyses we correlated state trapping data with those Canadian provinces which, due to their proximity, were most likely to contribute to the local populations. For each state, we visually examined the data using the most correlated lag time to determine if the patterns appeared synchronous.

Because our primary data are trapping records, which may show patterns and synchrony that result solely from social and economic factors, we looked to other data to provide a check on the trapping records as well as to provide information for times and places where trapping data were absent. Occurrence data and the verified records are not directly associated with trapping activity and are available for states such as Michigan and Wisconsin where we have no state-level trapping data. For comparisons of Canadian trapping data with verified records and general occurrence data, we used the most correlated lag times for the Canadian data from the analyses of trapping data described above. Because occurrence data are often sparse and erratic, we used visual methods to identify potential associations between these data sets. For Michigan and Wisconsin, where we lacked trapping data, we compared patterns in the occurrence of verified lynx records to peaks in harvest data from the Canadian provinces using the lag time that was most correlated with the Minnesota trapping data. For the Great Lakes region we estimated the degree to which general occurrence patterns in data other than harvest records were correlated with Canadian harvest data lagged as indicated by correlation with Minnesota trapping records.

Another line of inquiry concerns the degree to which patterns in the lynx data are correlated with local patterns of hare abundance. For the Great Lakes region, hare data were available and were highly correlated within the region (Chapter 7). For Minnesota, we were able to check these data against independently collected hare occurrence data and the relationship was strong ($r = 0.89$, Fig. 8.8). Local lynx populations should respond to changes in local hare abundances, and the resultant patterns, therefore, may allow separation of local and dispersal dynamics. We compared lynx trapping and

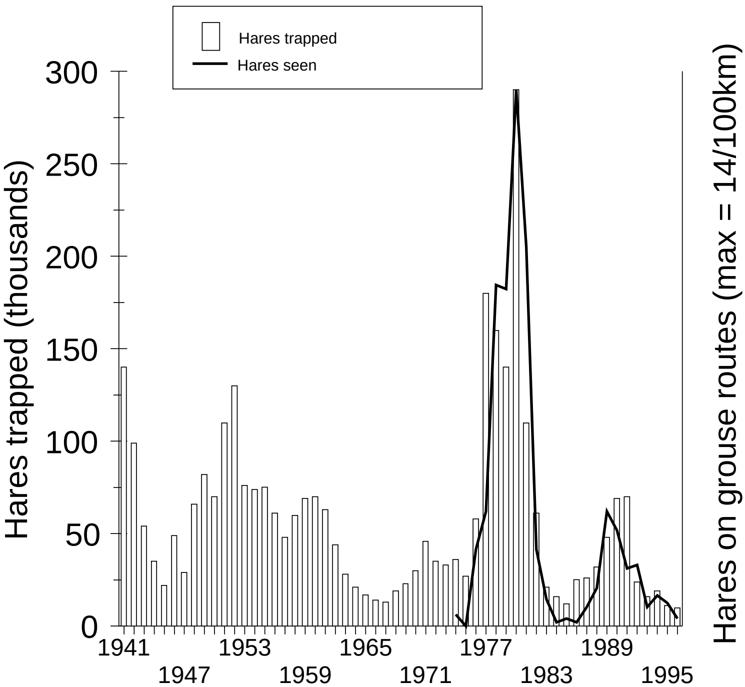

Figure 8.8—A comparison between snowshoe hare trapping data and numbers of hares observed on grouse drumming routes in Minnesota. Unpublished data provided by the Minnesota Department of Natural Resources.

occurrence data in the Great Lakes region with local patterns of hare abundance for the period in which hare-trapping was recorded. We used hare-trapping data from Minnesota because it is complete, is highly correlated with data from Wisconsin and Michigan, and has been independently verified for the last 22 years. Additionally we could compare it directly to lynx harvest records in Minnesota. Specifically, we were looking for local increases in hare harvest associated with the peak lynx harvests in the 1960s and 1970s and a response in lynx occurrence data to a large increase in hare abundance between 1975 and 1983 (Fig. 8.8). This increase was thought to be unusually large, perhaps representing the highest densities of hares in that region during the 20th century (Fig. 8.8; B. Berg, personal communication); thus, if resident lynx populations were present, they should have responded numerically to this large irruption in primary prey populations.

Results

Trapping data—Lagging provincial and Alaskan trapping data 0-2 years produced the highest correlations when compared with the central provinces of Alberta and Saskatchewan (Table 8.5). With the exception of Yukon,

Table 8.5—Pearson correlation coefficients (r) between trapping data from central Canada and states in the United States and provinces to the northwest and east. Correlations are to central Canadian data shifted 0-5 years. The best fit for each state or province is indicated in bold type. In the contiguous United States, correlation coefficients are only significantly different (Zar 1996, pp. 384-386) for Montana.

Comparison	Time period	Shifted						
		0 years	1 year	2 years	3 years	4 years	5 years	Significance
Contiguous U.S.								
New Hampshire with Quebec	1928-1964	**0.23**	0.20	0.02	–0.13	–0.20	–0.18	0.273
Minnesota with Ontario + Manitoba + Saskatchewan	1930-1983	–0.10	0.12	0.22	**0.32**	0.24	0.00	0.240
Montana with Alberta + British Columbia	1950-1989	0.35	0.69	**0.74**	0.62	0.35	0.05	<0.001
Washington with Alberta + British Columbia	1961-1977	–0.24	–0.29	–0.05	0.17	**0.25**	0.21	0.538
Northwest								
Yukon with Alberta + Saskatchewan	1934-1996	0.08	0.28	**0.36**	0.26	0.06	–0.12	0.070
Alaska with Alberta + Saskatchewan	1934-1996	0.30	0.63	**0.79**	0.77	0.60	0.31	<0.001
East								
Manitoba with Alberta + Saskatchewan	1924-1997	**0.92**	0.68	0.38	0.11	–0.04	–0.01	<0.001
Ontario with Alberta + Saskatchewan	1924-1997	0.74	**0.77**	0.64	0.39	0.12	–0.06	<0.001
Quebec with Alberta + Saskatchewan	1924-1997	0.38	0.60	**0.71**	0.68	0.53	0.33	<0.001

lagging the data caused significant ($p < 0.05$) changes in the correlation coefficients. The correlation patterns to the east were consistent with Mowat et al.'s "emanation" hypothesis. Manitoba was synchronous with Alberta and Saskatchewan, Ontario lagged one year, and Quebec lagged two years (Table 8.5). Patterns to the northwest were not as clear. Both Yukon and Alaska had the highest correlations when lagged two years, and Alaska was much more highly correlated than was Yukon (Table 8.5).

For those states and years for which reliable annual trapping data were recorded, correlations between harvest totals from the United States and adjacent Canadian provinces were generally modest (Table 8.5), Montana being the exception. New Hampshire was the only state for which non-lagged data provided the strongest correlation. Correlations between United States and Canadian harvest data for the other three states were all improved by shifting the Canadian data back in time: two years gave the best fit for Montana, three years for Minnesota, and four years for Washington. Visual inspection of these data suggests that increases in correlation coefficients were due to improved alignment of the oscillations in numbers of lynx trapped (Figs. 8.9-8.12).

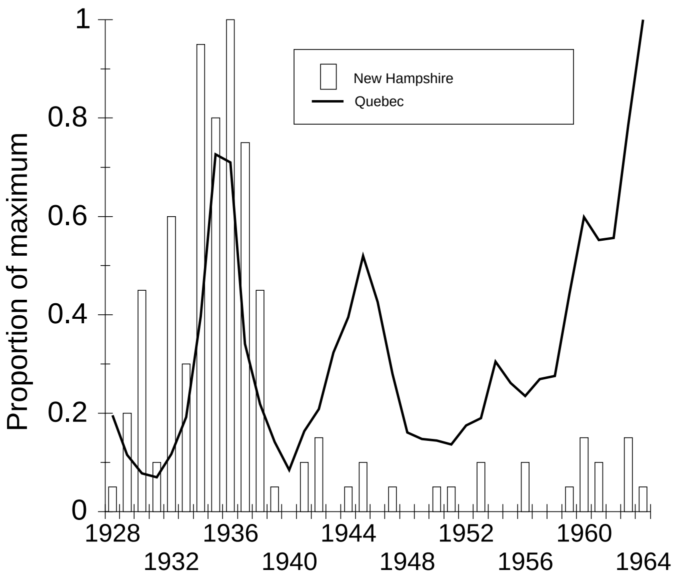

Figure 8.9—Lynx trapping data from New Hampshire (Fig. 8.1) overlaid on lynx trapping data from Quebec (Fig. 8.2). The strongest correlation between these data sets was with no lag between New Hampshire and Quebec.

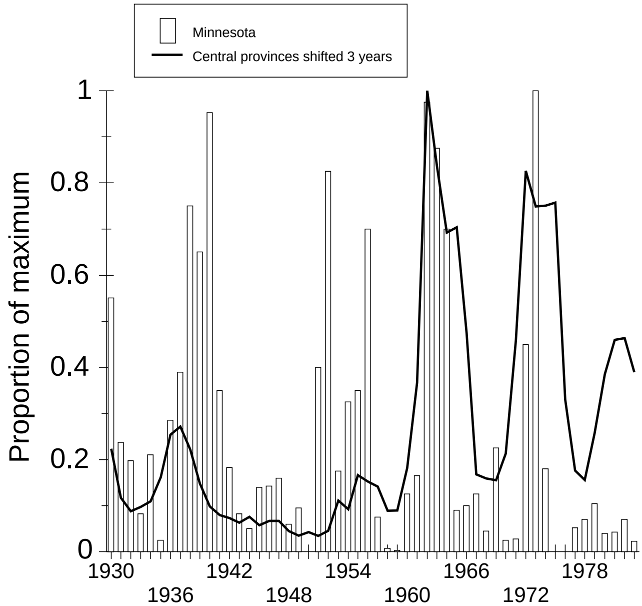

Figure 8.10—Lynx trapping data from Minnesota (Fig. 8.4) overlaid on lynx trapping data from Ontario, Manitoba, and Saskatchewan combined (Fig. 8.3). The strongest correlation between these data sets was with a three-year lag between Minnesota and south-central Canada.

Figure 8.11—Lynx trapping data from Montana (Fig. 8.5) overlaid on lynx trapping data from Alberta and British Columbia combined (Fig. 8.6). The strongest correlation between these data sets was with a two-year lag between Montana and southwestern Canada.

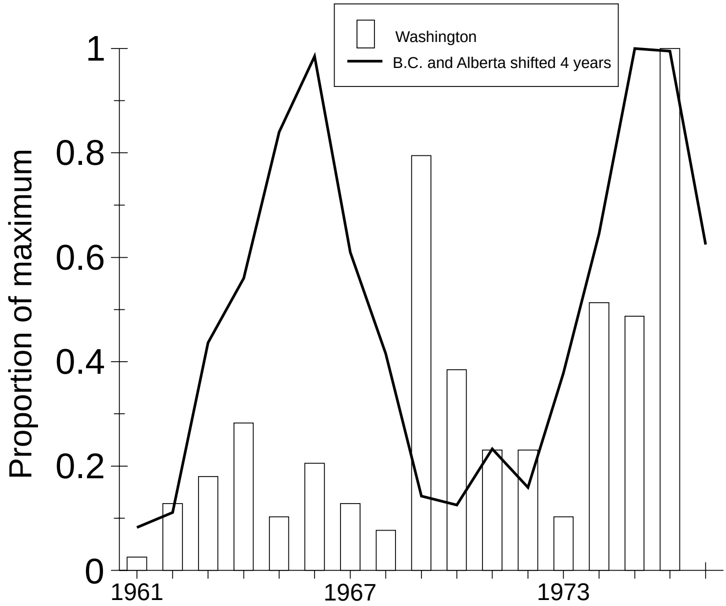

Figure 8.12—Lynx trapping data from Washington (Fig. 8.7) overlaid on lynx trapping data from Alberta and British Columbia combined (Fig. 8.6). The strongest correlation between these data sets was with a four-year lag between Washington and southwestern Canada.

One reason that the correlations were not stronger between states and adjacent provinces was that the patterns were not constant over time. For example, in New Hampshire, raw data for the first 12 years (1928-1939) are highly correlated with populations in Quebec ($r = 0.76$), when an average of 10 lynx were harvested each year; after this period, however, harvest records declined to only 0-3 lynx per year and the data become erratic and difficult to interpret (Fig. 8.9). In Minnesota, a three-year lag with data from the south-central Canadian provinces resulted in a strong correlation for the most recent period ($r = 0.73$, 1960-1983) but the pattern is out of phase in the previous 26 years (Fig. 8.10).

Occurrence data—Trapping data were removed from the general lynx occurrence database (Table 8.1) to produce as independent a data set as possible. Visual inspection of occurrence data from the Great Lakes region suggest that these fluctuations were aligned with trapping data from the south-central Canadian provinces with a three-year lag (Fig. 8.13). The verified lynx occurrences for Michigan and Wisconsin (Tables 8.3 and 8.4), for the period 1934-1997, are a subset of the occurrence data presented above and, in some years, make up the bulk of these data. These data are also

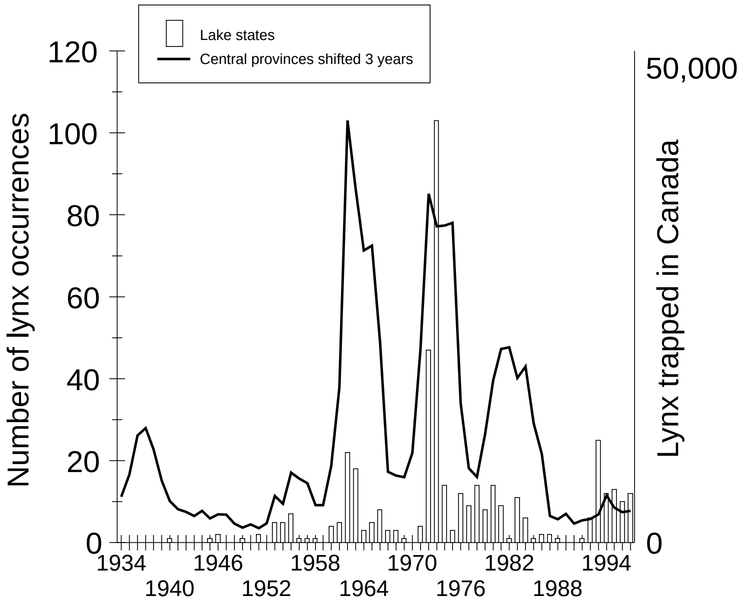

Figure 8.13—Lynx occurrence data, with trapping records removed (see Table 8.1), for the states of Wisconsin, Minnesota, and Michigan combined overlaid on lynx trapping data from Saskatchewan, Manitoba, and Ontario combined (Fig. 8.3). Canadian data were lagged three years based on the best fit to Minnesota trapping data (Table 8.5, Fig. 8.10).

concordant with the general occurrence data and are aligned with trapping data from the south-central provinces with a three-year time lag (Fig. 8.14).

Hare densities—To look for responses to the regional increase in hare populations in the Great Lakes states during the late 1970s and early 1980s (Fig. 8.8), we compared hare harvest data from Minnesota with general occurrence data from the Great Lakes region. Based on these data, there appears to be no relationship between this recent increase in hare density and numbers of lynx observed (Fig. 8.15). We also compared hare and lynx harvest data for the state of Minnesota (Fig. 8.16). The large peaks in lynx harvest in the 1960s and 1970s, which occurred three years after similar irruptive dynamics in central Canada, do not appear to be associated with increases in local hare harvest.

Discussion

The idea that lynx population dynamics emanate from the center of the taiga outward toward the periphery is supported by these analyses.

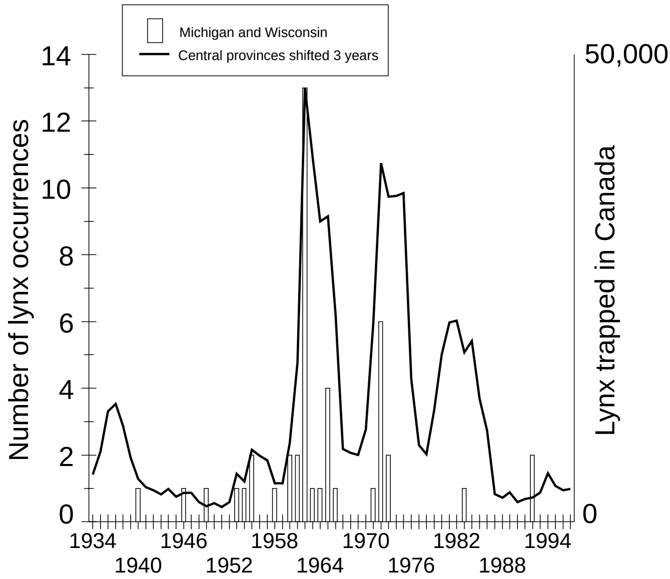

Figure 8.14—Verified lynx records for Wisconsin and Michigan combined (Tables 8.3 and 8.4) overlaid on lynx trapping data from Saskatchewan, Manitoba, and Ontario combined (Fig. 8.3). Canadian data were lagged three years based on the best fit to Minnesota trapping records (Table 8.5, Fig. 8.10). Note that verified records for these states are weak, with a maximum number per year of 13 in 1962.

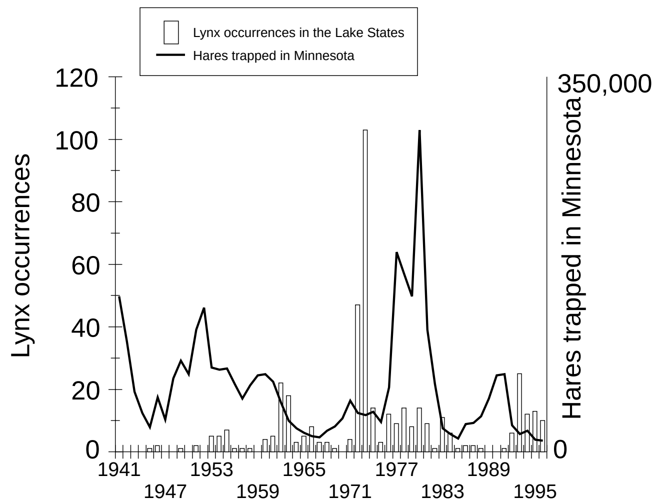

Figure 8.15—Lynx occurrence data for the Great Lakes region (Fig. 8.13) overlaid on snowshoe hare harvest data for Minnesota.

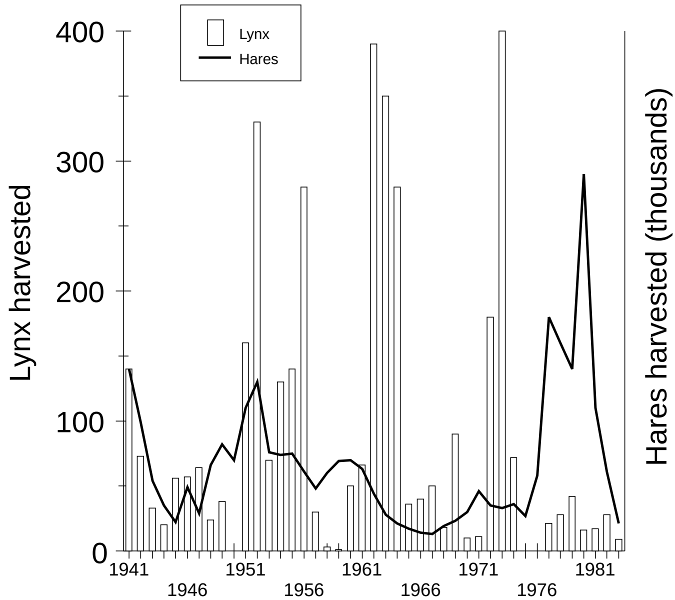

Figure 8.16—Lynx and hare harvest data for Minnesota.

Patterns in the contiguous United States, while weaker, are consistent with the patterns observed within Canada and between Canada and Alaska. With the exception of the northeastern United States, both correlation metrics (for those data where we applied them) and visual inspection suggested that lagging the Canadian data forward by two to four years improved the correlation with United States data. While there are several nonbiological factors that could lead to these patterns, the consistency of lagged correlations between the trapping data and the occurrence data and across various states and regions suggests that these patterns are biologically based.

For the Canadian provinces and Alaska, correlation patterns were generally very strong and were consistent across the entire time series (>60 years in all cases). In the United States, correlations were generally weak and, with the exception of New Hampshire, were primarily associated with the large irruptive peaks in the 1960s and 1970s.

If we assume that observed patterns indicate general changes in numbers of lynx, then there are several hypotheses that could explain these patterns. One is the immigration hypothesis presented above, another is that local populations are responding to the same factors that are controlling northern populations and, hence, are in synchrony, and a third is that the dynamics are some combination of the two.

In the Canadian provinces, Alaska, Montana, and Washington, we know that there are local reproductive populations, knowledge that invalidates a pure immigration hypothesis. For these areas, we can only state that they appear to be a part of a population in which lagged synchronous dynamics occur. Because we do not know why these dynamics occur, we cannot say to what extent they are affected by changes in local dynamics and the role that immigration might play.

For the most recent decades, dynamics in the Great Lakes region may be strongly driven by immigration. Though the data are weak, the lack of a response in the occurrence data to an extremely large regional increase in hares that peaked in 1980 coupled with low hare densities during the lynx peaks in the 1960s and 1970s suggest these irruptive dynamics may not be local in origin. This does not tell us whether or not there are local populations present, however; it merely indicates that the large "spikes" that dominate recent temporal patterns of lynx occurrence in the Lake States are at least partially Canadian in origin.

Given this, we find puzzling the lack of lynx occurrence records associated with a large population peak occurring in the central provinces during the early 1980s. This population peak was higher than any recorded in the 20th century prior to 1959, but there was no evidence from museum specimens, verified mortality records, or anecdotal observations that unusual numbers of lynx occurred in any portion of its range in the contiguous United States. In 1984, after the expected increase in lynx numbers in Minnesota failed to occur, the state closed the lynx harvest (DonCarlos 1994, unpublished).

The "explosions" of lynx in the early 1960s and 1970s were unprecedented events in the 20th century (Fig. 8.3). Many lynx observed during these "explosions" were found in anomalous habitats and geographic regions, exhibited abnormal behavior, and suffered high mortality (Gunderson 1978; Thiel 1987). Mech (1980) reported that lynx numbers declined dramatically in Minnesota after the 1972 influx; trapping records also indicate that post-irruptive populations were low: 215 were trapped in 1972, 691 in 1973, 88 in 1974, and 0 in 1975 and 1976. Lynx occurrence records in Michigan and Wisconsin similarly declined to very low levels within a few years after the peak irruptive periods (Thiel 1987; Fig. 8.14). It may be that the correlations which we observed between lynx occurrences in the northern United States and Canada following these irruptions are historically unusual as well.

Lynx Associations With Broad Cover Types

By considering lynx occurrence data over broad scales of space and time, we can describe patterns in the distribution of occurrences relative to topography and vegetation to elucidate the nature of their range in the contiguous United States (Fig. 8.17). Because of the irregularities in the data, we do not use the data themselves to define the bounding polygons as one would for home range data (White and Garrott 1990). Instead, we simply ask: Which cover types and elevation zones contain most of the occurrences?

To examine the distribution of lynx occurrences by elevation, we used data from a Digital Elevation Model (1,040 m / pixel) re-coded into 250-m elevation classes. For the Northeast and Great Lakes states, we used provinces from Bailey's (1998) ecoregion classification to describe vegetation at the broader scale, and subsection-level "potential dominant vegetation-1" (Keys et al. 1995) at the finer scale. For western states, Bailey's ecoregions were overly broad, and we lacked a subsection-level map. We therefore characterized western vegetation using Küchler (1964), with the form classification representing a large-scale cover class, and "vegetation type" representing a finer-scale class of potential vegetation.

All occurrences with at least county-level resolution within the three regions (Table 8.1) were included in these habitat analyses. In the Northeast and Great Lakes states, where most of the data were at county-level resolution, counties were assigned to vegetation and elevation classes using a majority-area rule, and occurrences with county-level resolution were then assigned to these county-level classes. To describe the distribution of occurrences by habitat type, we emphasized the classes of vegetation and elevation which encompassed at least 75% of the occurrences in a region and referred to them as "primary" types. The distribution of occurrences was also compared to the areal distribution of the types within each region. Because elevational relationships are likely to vary among states along ecological gradients, we also considered elevation distributions on a state-by-state basis.

Habitat Patterns Associated With Lynx Occurrences

West—Elevations in the West are variable, ranging from 0 to 4,180 m. Lynx occurrences generally occurred at higher elevations than is reflected by the areal distribution of elevation zones: 70% of occurrences fell within the 1,500-2,000-m class, which comprised only 42% of the area. This pattern is highly influenced by variation among states in the number of occurrences: 95% of the occurrences in the 1,250-2,000-m range are from Montana and Washington. However, frequency distributions for the individual states continue to demonstrate peak numbers of occurrences at mid-elevations that deviate from the areal distribution of elevation classes (Fig. 8.18). Additional patterns emerge from the state-by-state distributions. Examining elevation patterns across the region, both point and area distributions

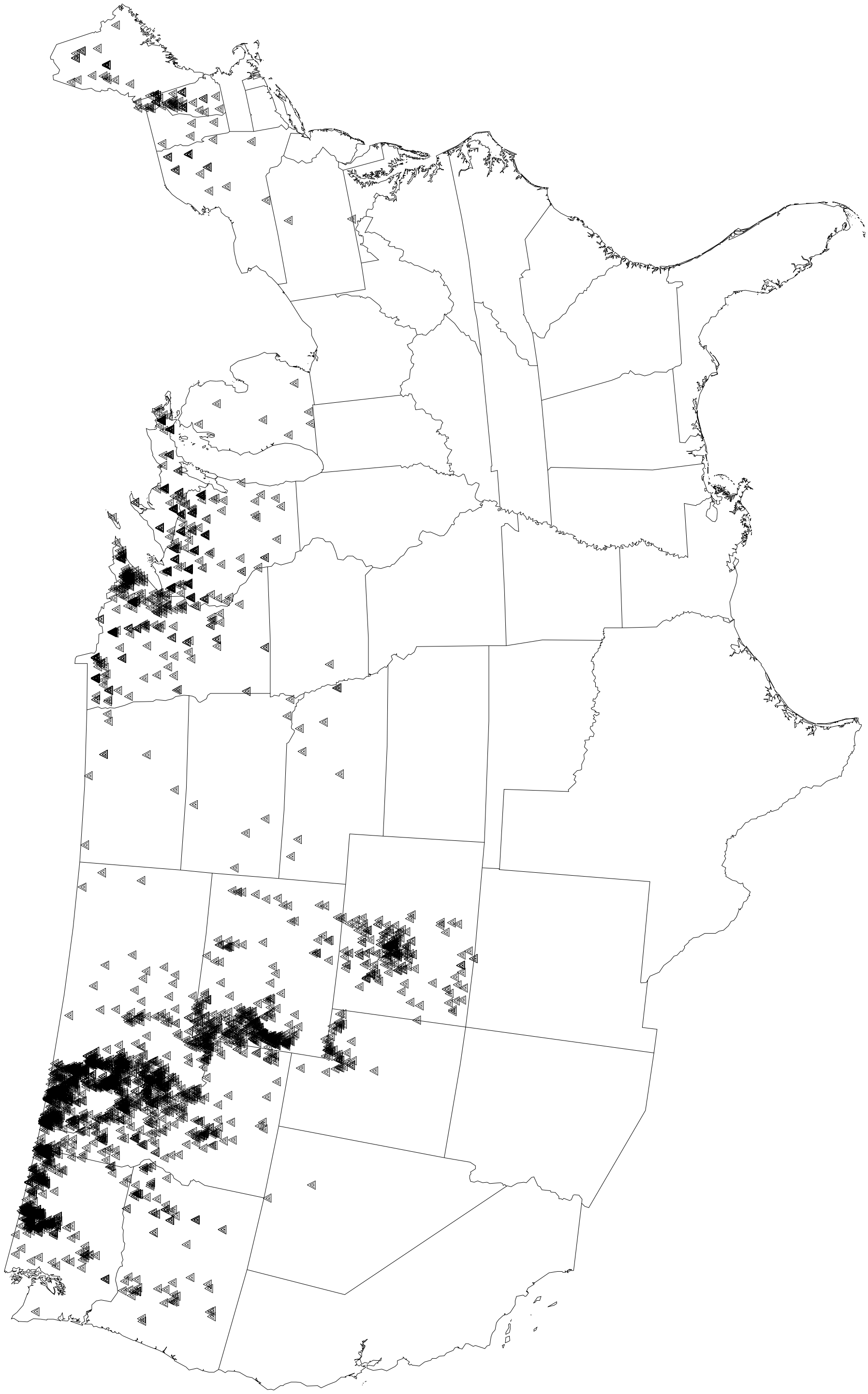

Figure 8.17—Spatial distribution of lynx occurrence data from 1842 to 1998 (Table 8.1).

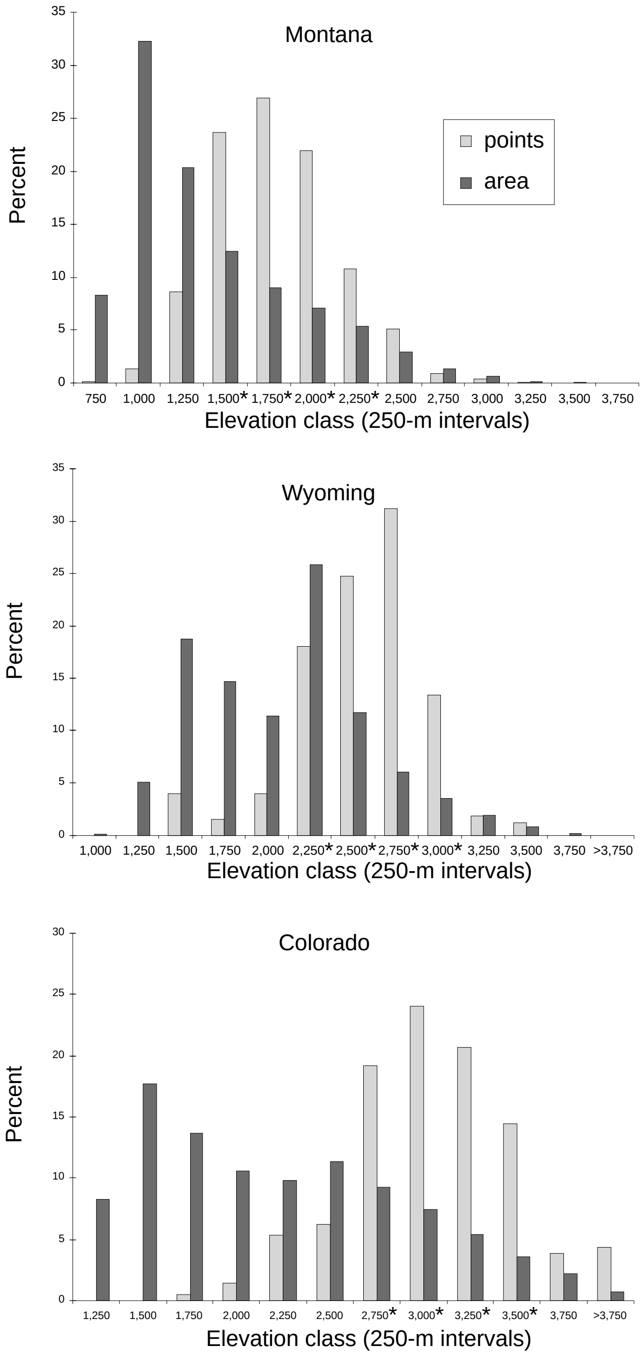

Figure 8.18—Relationships between lynx occurrence and elevation for Montana, Wyoming, and Colorado. Elevation zones marked with a (★) were included in the definition of primary areas of occurrence.

shift to increasingly higher elevations as one moves southward from Idaho and Montana to Wyoming, Utah, and Colorado (Fig. 8.18).

Vegetation types are also effective in characterizing the distribution of occurrences. At the larger vegetation scale, Rocky Mountain Conifer Forest contains 83% of the occurrences but represents only 27% of the area in the region (Fig. 8.19). The other conifer-dominated class in the region, PNW Conifer Forest, had the second highest point frequency (7%), which was generally equivalent to its areal frequency, but occurrences were located only in areas adjacent to Rocky Mountain Conifer Forest. Less than 3% of the occurrences were located in each of the remaining classes, with decreasing frequencies of occurrences with greater distance from areas of Rocky Mountain Conifer Forest (Fig. 8.19). On the finer scale of vegetation classification, the distribution of occurrences also differed significantly from the areal distribution of types. The primary types, Douglas-fir and western spruce/fir forests of the Rocky Mountain Conifer class, and fir/hemlock of the PNW Conifer class, encompass 79% of the occurrences but only 15% of the area. Occurrences are rare within the remaining vegetation types, which include both non-forest and drier forest types.

Areas that encompass primary classes of both elevation and vegetation contain 67% of the occurrences, including a majority of the occurrences within most states (Fig. 8.20). The area within this combined habitat type generally increases from south to north. From Montana southeast to Utah and Colorado, clusters of this combined habitat type become increasingly isolated. From Washington to Oregon, the width of the strip representing primary habitat narrows as one moves southward.

Great Lakes region—Elevations in this region are low and of low variability, ranging from 170 to 660 m. The distribution of occurrences parallels the areal distribution of elevations in the region, with 80% of occurrences falling in the mid-elevation zone of 250-500 m, which represents 78% of the total area. This relationship also holds within the individual states; thus, elevation was not important in characterizing the distribution of occurrences in this region.

The locations of lynx records in these states were associated with vegetation type, however. At the coarser vegetation scale, 88% of occurrences are within Mixed Deciduous-Coniferous Forest, which accounts for <50% of the area (Fig. 8.21). The remaining 12% of occurrences were located in Broadleaved Continental Forests and Forest-Steppes and Prairies. At the finer vegetation scale, the seven vegetation types containing occurrences encompassed 73% of occurrences but only 32% of the area; of the seven types, sugar maple-basswood, jack pine, and white pine-red pine forest types had the highest frequencies of occurrences (each >15%). All of these

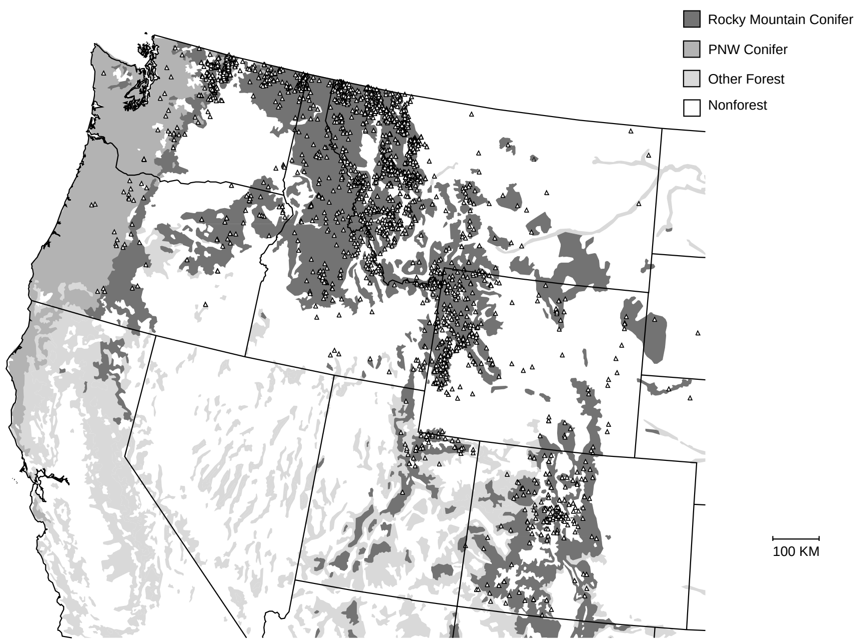

Figure 8.19—Lynx occurrence data overlaid on Küchler (1964) vegetation classes in the western United States. The Rocky Mountain Conifer cover-type enclosed 83% of lynx occurrences.

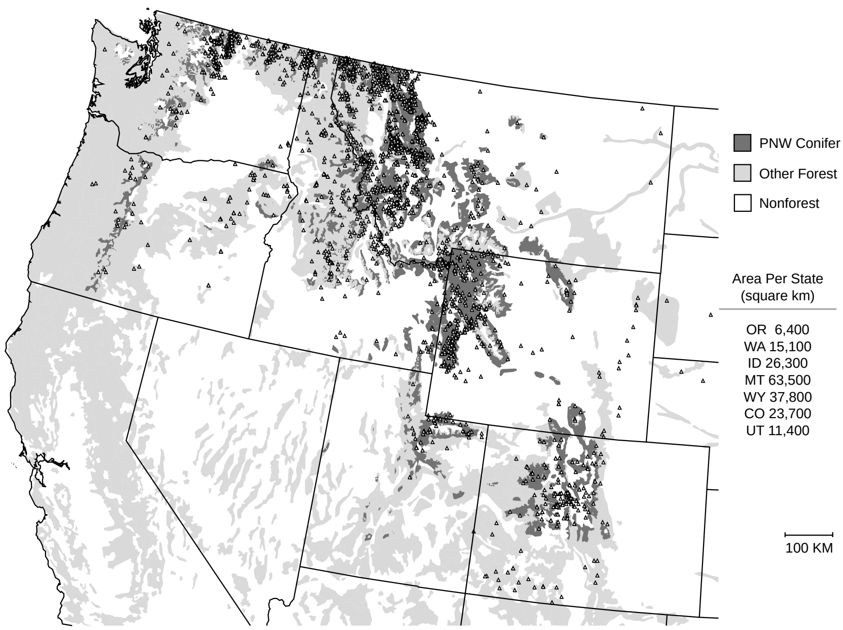

Figure 8.20—Areas of primary lynx occurrence are those areas that (1) consist of a cover type associated with at least 75% of lynx occurrences and (2) lie within an elevation zone enclosing at least 75% of lynx occurrences in each state; 67% of lynx records fell within this area.

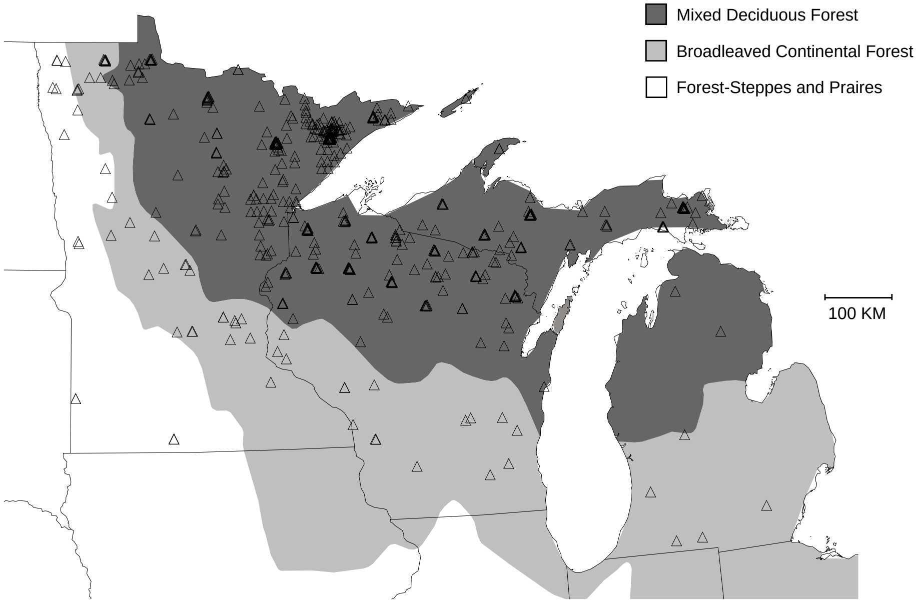

Figure 8.21—Lynx occurrence data overlaid on Bailey (1998) vegetation classes in the Great Lakes region. The Mixed Deciduous-Coniferous Forest type enclosed 88% of lynx records.

primary types are classified as Mixed Deciduous-Coniferous Forest, except for the sugar maple-basswood type which falls into Broadleaved Continental Forest. The distribution of these primary vegetation types occurs primarily in northern Wisconsin and Minnesota, with <15% within Michigan (Fig. 8.22). Conversely, areas lacking occurrences are found in southern areas and represent mostly non-conifer or unforested types.

Northeast—Elevations in the Northeast range from 0 to 1,745 m. The distribution of occurrences by elevation is shifted toward higher elevations compared to the areal distribution of elevations in the region: 77% of occurrences were at mid-elevations ranging from 250 to 750 m, which comprises 59% of the total area. The 0-250-m class has the greatest difference between occurrences and area with only 20% of occurrences compared to 39% of the area. These patterns also hold within Maine, New Hampshire, and New York, but Vermont, Massachusetts, and Pennsylvania had too few occurrences to allow comparison (Table 8.1).

Vegetation also serves to describe the distribution of lynx occurrences in the region (Fig. 8.23). At the broader scale, the most northerly and mountainous class in the region, Mixed Forest-Coniferous Forest-Tundra, encompasses 88% of the occurrences compared to only 29% of the area, and the remaining occurrences fell into five other provinces. At the finer scale,

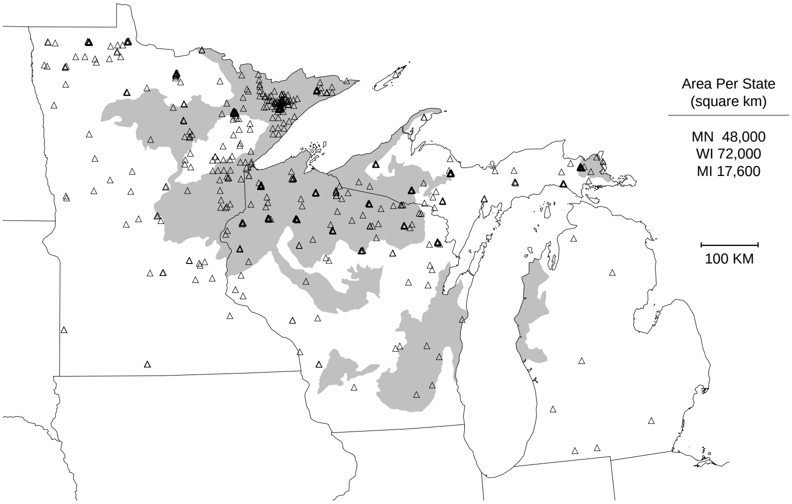

Figure 8.22—Areas of primary lynx occurrence in the Great Lakes region are those areas that enclose 73% of lynx records based on potential dominant vegetation types (Keys et al. 1995). Elevation was not used to define areas of primary occurrence in this region.

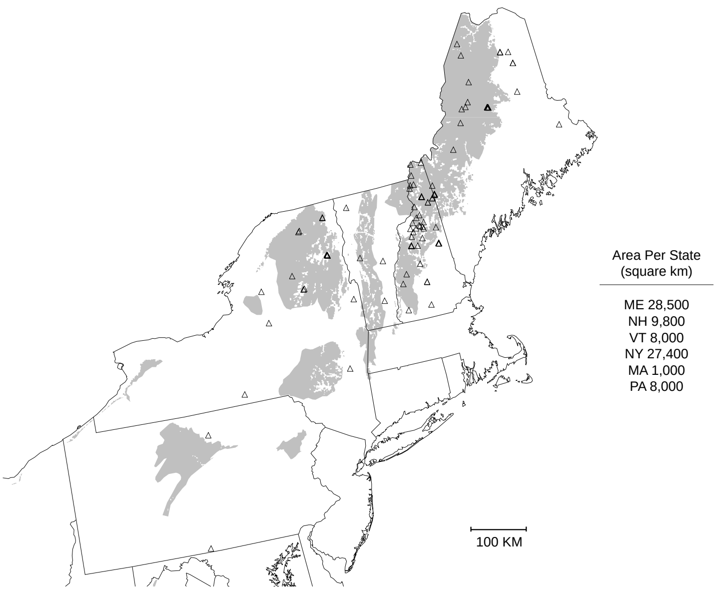

Figure 8.23—Areas of primary lynx occurrence in the northeastern states based on potential dominant vegetation types (Keys et al. 1995) and elevations >250 m; 70% of lynx records fell within these areas.

occurrences are located within 10 vegetation types, with the highest frequency in red spruce-balsam fir/sugar maple-birch-beech forest (53%). The primary types also include sugar maple-birch-beech forest and red spruce-balsam fir forest; the three types together comprise 84% of occurrences compared to 29% of the area and are found within Mixed Forest-Coniferous Forest-Tundra. The types that include spruce-fir are absent south of Vermont and the northern Adirondack Mountains. In general, lynx occurrences were rare within areas typed as dry forest or non-forest.

Intersecting the primary vegetation classes with the primary elevation classes left an area that is primarily contained within Mixed Forest-Coniferous Forest-Tundra, includes 70% of the occurrences, and encompasses a majority of the occurrences within each state (Fig. 8.23). More than 60% of this area occurs in Maine and New York, followed by Vermont, New Hampshire and Pennsylvania, with trace amounts in Massachusetts. From Maine south to Pennsylvania, areas of primary occurrence become increasingly disjunct.

Implications of Habitat Relationships

Because our analyses of habitat associations were conducted with data that varied greatly among states (Table 8.1), observed patterns within a region are heavily weighted by those states with the most occurrences. However, even in states with relatively few occurrences, the locations generally fell within the predicted habitat classes. In the Northeast, most of the occurrences were in the White Mountains of New Hampshire; but predicted vegetation associations that were based largely on these data include most of the locations in New York and Maine (Fig. 8.23). Thus, broad-scale patterns in vegetation and elevation effectively capture regional patterns in the distribution of lynx occurrences. The consistency across states within a region adds support to the idea that these patterns reflect general habitat use patterns of lynx.

For all three regions, high frequencies of occurrence records correspond to cool, coniferous forests in northern areas. For the western and northeastern regions, these forests occur at mid-elevations in montane areas; frequencies of occurrences decrease from these areas toward the more maritime zones. In all three regions, areas of primary occurrence become increasingly rare and fragmented as one moves away from these northerly concentrations of coniferous forests and, in the West, primary forest types also occur at higher elevations along this gradient. The range of the snowshoe hare, the primary prey of lynx, is also coincident with montane areas in the West and Northeast and northern areas in the Great Lakes region (Chapter 7).

Ephemeral locations and dispersal potential—Although the primary vegetation classes encompassed the majority of occurrences, many occurrences fell into other vegetation classes. Occurrences could be associated with these types because of location or vegetation classification errors or dispersal movements, or they could be indicative of small resident populations. While we cannot differentiate between these causes in an absolute sense, we can use the spatial distributions of these locations to explore the most likely explanations.

For those 349 occurrences in the focal states of the West that were located outside of the Rocky Mountain or PNW Conifer classes (Fig. 8.19), we calculated the nearest straight-line distance to a conifer-type polygon. We compared these distances to those of random locations placed within the non-conifer types using a X^2 homogeneity test. Data from the northeastern and Great Lakes regions were not analyzed because of their limited spatial resolution (generally only at county level).

Both error and dispersal occurrences should be close to source types, whereas occurrences from resident populations may be distributed randomly with respect to source areas. Occurrences representing errors are generally concentrated in a narrow "epsilon band" around the source type (Blakemore 1984; Dunn et al. 1990) due to granularity along the boundary. Such an error distribution should decline very quickly with distance from the source. In contrast, a simple dispersal model of constant probability of detection with distance (usually through mortality) should show exponential decline with distance.

Points located in non-conifer types are significantly closer to conifer forest types than expectation ($p < 0.001$), indicating that they are associated with conifer forests. Most of the occurrences are extremely close to a conifer type (Fig. 8.24), and 79% (274 of 349) are within 10 km of conifer forest. Undoubtedly, many of these occurrences actually occurred within conifer forests and lie outside of these types due to errors in location and vegetation mapping, while others may be associated with normal within-home range or short-range exploratory movements. Assuming that many of the non-conifer locations within 10 km of conifer types may be due to mapping error, we are left with 75 locations >10 km from conifer forest whose distance distribution generally declines exponentially with distance from conifer forests (Fig. 8.25).

These remaining occurrences are reasonably distant from the nearest area typed as conifer forest, at an average distance of 39 km and maximum distance of 259 km, and are probably in non-conifer, and generally non-forested types. In addition, because most of the non-conifer types in the region are non-forest (Fig. 8.19), these distances represent conservative

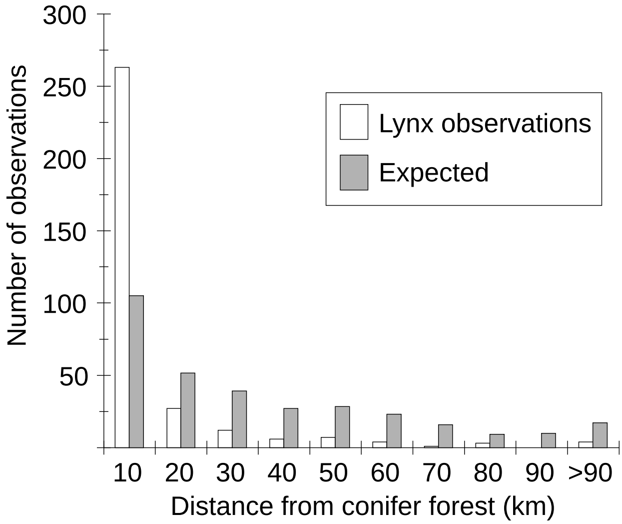

Figure 8.24—Distances to the nearest conifer forest for those lynx occurrences in non-conifer cover types in the West. Lynx occurrences were significantly closer to conifer types than would be expected based on random placement within non-conifer types.

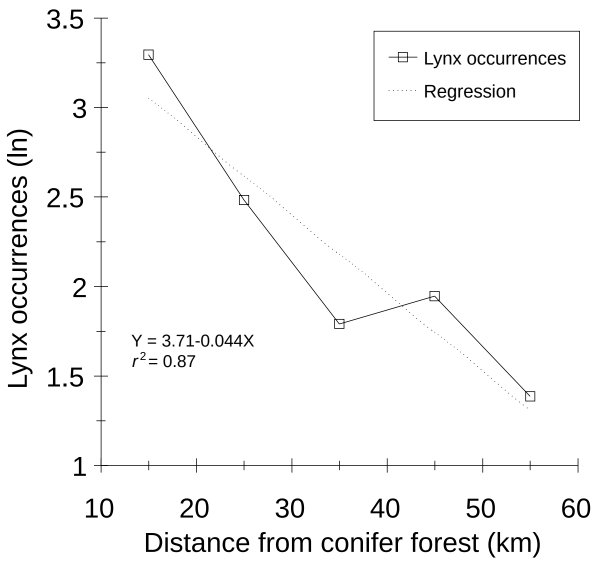

Figure 8.25—Lynx occurrences in areas that are >10 km from a conifer type decline exponentially with distance. An exponential distribution is transformed to a linear relationship by taking the log of the dependent variable.

estimates of the amount of non-forested landscape crossed by lynx prior to detection. We also have 20 records of lynx locations in Nevada and the Plains states (Table 8.1) that probably represent much longer dispersals across open lands. However, our data suggest that long-distance dispersals are relatively rare, as only four of 3,803 occurrences in the Western region were >100 km from conifer forest.

Conclusions

There are records of lynx occurrence in 24 states. Generally, verified records extend to the mid 1800s, and, due to confusion with bobcats, earlier accounts are often suspect. For four of these states—Minnesota, Montana, New Hampshire, and Washington—we have reliable trapping data, and for Minnesota and Montana, fairly large numbers of lynx were trapped in the 20th century (5,585 and 3,012, respectively). For most states, data are too fragmentary to infer much concerning lynx beyond simple occurrence. In the states where we have trapping data, dynamics appear to be associated with patterns of lagged synchrony that occur across Canada and Alaska, but the mechanisms that underlie these dynamics are unknown. Given our current lack of understanding of these dynamics, their presence increases our uncertainty concerning the meaning of an occurrence, or even many occurrences. In Minnesota, for instance, the 5,585 lynx trapped in the 20th century could have been produced by a local population, or as some researchers have hypothesized, be mostly immigrants or any combination of local lynx and dispersers.

Lynx occurrences in the 20th century are closely associated with conifer forest types associated with the southern extensions of the boreal forest, a pattern that conforms to our biological understandings of lynx habitat (Chapter 13). There is little evidence of occurrence in other types such as pure deciduous forests in the East or shrub-steppe types in the West. Where occurrences are in unusual types, most of the locations are immediately adjacent to the conifer cover types containing most of the occurrences.

Literature Cited

Adams, A. W. 1963. The lynx explosion. North Dakota Outdoors 26:20-24.

Anonymous. 1918. The Canadian lynx. The Conservationist 10:157.

Anonymous. 1952. Another lynx. The New York State Conservationist 6:34.

Anonymous. 1963. The lynx in New York. The Conservationist 17:39.

Anonymous. 1966. Another lynx. The Conservationist 20:41.

Anonymous. 1987. Endangered and threatened species of plants and animals in Vermont. Unpublished, Vermont Agency of Natural Resources, North Springfield, Vermont.

Anonymous. 1999. Canada lynx in Idaho: species conservation assessment. Unpublished Idaho Conservation effort: USDI Bureau of Land Management, Idaho Department of Fish and Game, Idaho Department of Parks and Recreation, U.S. Fish and Widlife Service, USDA Forest Service.

Bailey, R. G. 1998. Ecoregions map of North America: explanatory note. USDA Forest Service, Miscellaneous Publication No. 1548.

Bailey, V. 1918. Wild animals of Glacier National Park: the mammals. USDI National Park Service, Washington, DC.

Bailey, V. 1926. A biological survey of North Dakota. North American Fauna 49:1-229.

Bailey, V. 1930. Animal life of Yellowstone National Park. Charles C. Thomas Publisher, Springfield, IL.

Bailey, V. 1936. Mammals and life zones of Oregon. North American Fauna 55:1-416.

Baker, R. H. 1983. Michigan mammals. Michigan State University Press, Lansing, MI.

Barnes, C. T. 1927. Utah mammals. Bulletin of the University of Utah 17:1-88.

Barrus, H. 1881. History of the town of Goshen, Hampshire County, Massachusetts. Published by the author in Boston, MA.

Bergstrom, A. S. 1977. The status of the lynx in New York (*Lynx canadensis*). Unpublished, U.S. Fish and Wildlife Service, Endangered and Threatened Wildlife and Plants.

Blakemore, M. 1984. Generalization of error in spatial databases. Cartographica 21:131-139.

Brainerd, S. M. 1985. Reproductive ecology of bobcats and lynx in western Montana. Unpublished M.S. Thesis, University of Montana, Missoula, MT.

Brittell, J. D., R. J. Poelker, S. J. Sweeney, and G. M. Koehler. 1989. Native cats of Washington, Section III: lynx. Unpublished, Washington Department of Wildlife, Olympia, WA.

Brocke, R. H. 1982. Restoration of the lynx *Lynx canadensis* in Adirondack Park: a problem analysis and recommendations. Unpublished, Federal Aid Project E-1-3 and W-105-R. New York State Department of Environmental Conservation Study XII, Job 5.

Brocke, R. H., K. A. Gustafson, and A. R. Major. 1990. Restoration of the lynx in New York: biopolitical lessons. Transactions of the North American Wildlife and Natural Resources Conference 55:590-598.

Brocke, R. H., K. A. Gustafson, and L. B. Fox. 1991. Restoration of large predators: potentials and problems. Pages 303-315 *in* Challenges in the conservation of biological resources. a practitioner's guide. D. J. Decker, M. E. Krasny, G. R. Goff, C. R. Smith, and D. W. Gross, eds. Westview Press, Boulder, CO.

Burt, W. H. 1946. The mammals of Michigan. University of Michigan Press, Ann Arbor, MI.

Cardoza, J. E. In press. Lynx. *in* T. W. French and J. E. Cardoza, eds. Rare vertebrates of Massachusetts. Massachusetts Audubon Society, Lincoln, MA.

Carney, I. M. 1993. Colorado lynx study: winter 1993. Unpublished, Colorado Division of Wildlife, Glenwood Springs, CO.

Central. 1905. In Massachusetts. Forest and Stream 64:30-31.

Crane, J. 1931. Mammals of Hampshire County, Massachusetts. Journal of Mammalogy 12:267-273.

Dalquest, W. W. 1948. Mammals of Washington. University of Kansas Publications in Natural History 2:1-444.

Davis, W. B. 1939. The recent mammals of Idaho. The Caxton Printers, Ltd., Caldwell, ID.

DeKay, J. E. 1842. Natural history of New York. Part I. Zoology. D. Appleton and Co., New York.

Dice, L. R. and H. B. Sherman. 1922. Notes on the mammals of Gogebic and Ontonogon Counties, Michigan, 1920. Occasional Papers of the Museum of Zoology, University of Michigan 109:1-47.

DonCarlos, M. W. 1994. Fact sheet: management of the lynx (*Felis lynx*) in Minnesota. Unpublished, Minnesota Department of Natural Resources, St. Paul, MN.

Dunn, R., A. R. Harrison, and J. C. White. 1990. Positional accuracy in digital databases of land use: an empirical study. International Journal of Geographical Information Systems 4:385-398.

Durrant, S. D. 1952. Mammals of Utah: taxonomy and distribution. University of Kansas Publications, Museum of Natural History 6:1-549.

Eaton, W. P. 1919. Big game returning to New England hills. Bulletin of the American Game Protection Association 8:11.

Elton, C. and M. Nicholson. 1942. The ten-year cycle in numbers of the lynx in Canada. Journal of Animal Ecology 11:215-244.

Erickson, A. W. 1955. A recent record of lynx in Michigan. Journal of Mammalogy 36:132-133.

F. C. B. 1878. Lynxes in Massachusetts. Forest and Stream 1:531.

Findley, J. S. and S. Anderson. 1956. Zoogeography of the montane mammals of Colorado. Journal of Mammalogy 37:80-82.

Fountain, E. A., Jr. 1976. The Canada lynx. The Conservationist 31:2.

Godin, A. J. 1977. Wild mammals of New England. Johns Hopkins University Press, Baltimore, MD.

Goodwin, G. G. 1935. The mammals of Connecticut. State Geological and Natural History Survey, Bulletin No. 53.

Grimm, W. C. and R. Whitebread. 1952. Mammal survey of northeastern Pennsylvania. Unpublished, Pittman-Robertson Project 42-R:1-82.

Gunderson, H. L. 1978. A mid-continent irruption of Canada lynx, 1962-63. Prairie Naturalist 10:71-80.

Halfpenny, J.C., S. J. Bissell, and D. M. Nead. 1989. Status of the lynx (*Felis lynx*, Felidae) in Colorado with comments on its distribution in Western United States. Unpublished, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO.

Hall, E. R. 1981. The mammals of North America, 2nd Edition. John Wiley and Sons, New York.

Halloran, A. F. and W. E. Blanchard. 1959. Lynx from western Wyoming. Journal of Mammalogy 40:450-451.

Hamilton, W. J., Jr. 1943. The mammals of the Eastern United States. Comstock Publishing Co., Ithaca, NY.

Hamilton, W. J., Jr., and J. O. Whittaker, Jr. 1979. Mammals of the Eastern United States, 2nd edition. Cornell University Press, Ithaca, NY.

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

Harper, F. 1929. Notes on mammals of the Adirondacks. New York State Museum Handbook No. 8, New York State Museum, Albany, NY.

Hastings, A. and S. Harrison. 1994. Metapopulation dynamics and genetics. Annual Review of Ecology and Systematics 25:163-184.

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

Herrick, C. L. 1892. The mammals of Minnesota. Geological and natural history survey of Minnesota, Bulletin No. 7.

Hoffmann, R. S., P. L. Wright, and F. E. Newby. 1969. The distribution of some mammals in Montana: I. Mammals other than bats. Journal of Mammalogy 50:583-604.

Hunt, J. H. 1964. The lynx. Maine Fish and Game Magazine 6:14.

Hunt, J. H. 1974. The little-known lynx. Maine Fish and Game Magazine 16:28.

Jackson, H. H. T. 1961. The mammals of Wisconsin. University of Wisconsin Press, Madison, WI.

Jakubus, W. J. 1997. Lynx in Maine. Unpublished, Maine Department of Inland Fisheries and Wildlife, Bangor, ME.

Jones, J. K., Jr. 1964. Distribution and taxonomy of mammals of Nebraska. University of Kansas Publications, Museum of Natural History 16:1-356.

Keith, L. B. 1963. Wildlife's ten-year cycle. University of Wisconsin Press, Madison, WI.

Kennicott, R. 1855. Catalogue of animals observed in Cook County, Illinois. Transactions of the Illinois State Agricultural Society 1:577-595.

Keys, J., Jr., C. Carpenter, S. Hooks, F. Koenig, W. H. McNab, W. Russell, and M. L. Smith. 1995. Ecological units of the Eastern United States - first approximation (cd-rom), Atlanta, GA. U.S. Department of Agriculture, Forest Service. GIS coverage in ARC/INFO format, selected imagery, and map unit tables.

Koehler, G. M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology 68:845-851.

Koehler, G. M. and K. B. Aubry. 1994. Lynx. Pages 74-98 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, tech. eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the Western United States. USDA Forest Service General Technical Report RM-254.

Küchler, A. W. 1964. Potential natural vegetation of the conterminous United States (map and manual). American Geographical Society Special Publication 36.

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. 1994. New Hampshire's wild felines. New Hampshire Wildlife Journal 6:4-7.

Litvaitis, J. A., D. Kingman, Jr., J. Lanier, and E. Orff. 1991. Status of lynx in New Hampshire. Transactions of the Northeast Section of the Wildlife Society 48:70-75.

Long, C. A. 1965. The mammals of Wyoming. University of Kansas, Museum of Natural History Publication 14:493-758.

Lyon, M. W., Jr. 1936. Mammals of Indiana. The American Midland Naturalist 17:1-384.

Maj, M. and E. O. Garton. 1994. Fisher, lynx, wolverine summary of distribution information. Appendix B *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon and W. J. Zielinski, tech. eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the Western United States. USDA Forest Service General Technical Report RM-254.

McCord, C. M. and J. E. Cardoza. 1982. Bobcat and lynx. Pages 728-766 *in* J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America. Johns Hopkins University Press, Baltimore, MD.

McKay, R. 1991. Biological assessment and inventory plan for the North American lynx (*Felis lynx canadensis*) in the Uinta Mountains. Unpublished, Ashley National Forest and Utah Natural Heritage Program, Utah Department of Natural Resources, Salt Lake City, UT.

Mearns, E. A. 1899. Notes on the mammals of the Catskill Mountains, New York, with general remarks on the fauna and flora of the region. Proceedings of the U.S. National Museum 21:341-360.

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

Mech, L. D. 1980. Age, sex, reproduction, and spatial organization of lynxes colonizing northeastern Minnesota. Journal of Mammalogy 61:261-267.

Merriam, C. H. 1884. The mammals of the Adirondack region, northeastern New York. L. S. Foster Press, New York.

Miller, G. S., Jr. 1899. Preliminary list of the mammals of New York. Bulletin of the New York State Museum 6:339-340.

Mumford, R. E. 1969. Distribution of the mammals of Indiana. The Indiana Academy of Sciences, Indianapolis, IN.

Novak, M., M. E. Obbard, J. G. James, R. Newman, A. Booth, A. J. Satterthwaite, and G. Linscombe. 1987. Furbearer harvests in North America, 1600-1984. Ministry of Natural Resources, Ontario, Canada.

Orff, E. P. 1985. Lynx (*Felis lynx*) status report. Unpublished, New Hampshire Fish and Game Department, Concord, NH.

Osgood, F. L., Jr. 1938. The mammals of Vermont. Journal of Mammalogy 19:435-441.

Palmer, R. S. 1937. Mammals of Maine. Unpublished M.S. Thesis, University of Maine, Orono, ME.

Parker, H. C. 1939. A preliminary list of the mammals of Massachusetts. Proceedings of the Boston Society of Natural History 41:403-415.

Quinn, N. W. S. and G. Parker. 1987. Lynx. Pages 682-695 *in* Wild furbearer management and conservation in North America. M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Ministry of Natural Resources, Ontario, Canada.

Rafinesque, C. S. 1817. Description of seven new genera of North American quadrupeds. American Monthly Magazine 2:44-46.

Ranta, E., V. Kaitala, and J. Lindstrom. 1997. Dynamics of Canadian lynx populations in space and time. Ecography 20:454-460.

Rasmussen, J. L. 1969. A recent record of the lynx in Iowa. Journal of Mammalogy 50:370-371.

Reeve, A., F. Lindzey, and S. Buskirk. 1986. Historic and recent distribution of the lynx in Wyoming. Unpublished, Wyoming Cooperative Fishery and Wildlife Research Unit, Laramie, WY.

Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, tech. eds. 1994. The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the Western United States. USDA Forest Service General Technical Report RM-254.

Rust, H. J. 1946. Mammals of northern Idaho. Journal of Mammalogy 27:308-327.

Schantz, V. 1947. Record of *Lynx canadensis canadensis* in Nevada. Journal of Mammalogy 28:292-293.

Schorger, A. W. 1947. Canada lynx taken in Sauk County, Wisconsin. Journal of Mammalogy 28:186-187.

Seagers, C. 1948. Missing New Yorkers. The New York State Conservationist 2:32.

Seagers, C. 1951. The lynx is back. The New York State Conservationist 6:40.

Seton, E. T. 1929. Lives of game animals. Doubleday, Doran, and Co., Inc., Garden City, NY.

Shoemaker, H. W. 1929. The wild animals of Clinton County, Pennsylvania. Pennsylvania Alpine Club Wild Life Bulletin 10:1-110.

Siegler, H. R. 1971. The status of wildcats in New Hampshire. Pages 38-45 *in* S. E. Jorgensen and L. D. Mech, eds. Proceedings of a symposium on the native cats of North America: their status and management. U.S. Fish and Wildlife Service, Twin Cities, MN.

Silver, H. 1974. A history of New Hampshire game and furbearers, 2nd edition. New Hampshire Fish and Game Department, Survey Report 6, Concord, NH.

Smith, D. S. 1984. Habitat use, home range, and movements of bobcats in western Montana. Unpublished M.S. Thesis, University of Montana, Missoula, MT.

Smith, H. G., R. K. Burnard, E. E. Good, and J. M. Keener. 1973. Rare and endangered vertebrates of Ohio. The Ohio Journal of Science 73:257-271.

Spurrell, J. A. 1917. An annotated list of the mammals of Sac County. Proceedings of the Iowa Academy of Science 24:274-275.

Stouffer, A. L. 1961. The story of Shell Lake. The Washburn County Historical Society Register, Shell Lake, WI.

Taylor, W. P. and W. T. Shaw. 1927. Mammals and birds of Mount Rainier National Park. USDI National Park Service, U.S. Government Printing Office, Washington, DC.

Terrell, B. 1971. Lynx. Colorado Outdoors 20:19.

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

Turner, R. W. 1974. Mammals of the Black Hills of South Dakota and Wyoming. University of Kansas, Museum of Natural History, Miscellaneous Publication No. 60.

Verts, B. J. and L. N. Carraway. 1998. Land mammals of Oregon. University of California Press, Berkeley, CA.

Whish, J. D. 1919. Lynx in the Adirondacks. Forest and Stream 89:353.

White, G. C. and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, CA.

Williams, S. L., S. B. McLaren, and M. A. Burgwin. 1985. Paleo-archaeological and historical records of selected Pennsylvania mammals. Annals of Carnegie Museum 54:77-188.

Wood, N. A. 1922. The mammals of Washtenaw County, Michigan. Occasional Papers of the Museum of Zoology, University of Michigan, Ann Arbor, No. 123.

Wood, N. A. and L. R. Dice. 1924. Records of the distribution of Michigan mammals. Papers of the Michigan Academy of Science, Arts, and Letters 3:425-445.

Wydeven, A. P. 1998. Lynx status in Wisconsin, 1998. Unpublished, Wisconsin Department of Natural Resources, Madison, WI.

Zar, J. H. 1996. Biostatistical analysis. Prentice Hall, Upper Saddle River, NJ.

Appendix 8.1

Sources for Lynx Occurrence Data in the United States

Colorado: The Colorado Natural Heritage Program maintains a state database that is a compilation of museum records, Colorado Division of Wildlife harvest records, sightings reported to the Division, and published reports. The White River National Forest reported five visual observations and Rocky Mountain National Park reported one. Museum specimen records were obtained from the Denver Museum of Natural History, Academy of Natural Sciences of Philadelphia, Milwaukee Public Museum, and the National Museum of Natural History. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are also included.

Idaho: The state database for Idaho is maintained by the Idaho Fish Conservation Data Center (IDFG CDC) and is a compilation of museum records, IDFG harvest records, sightings of animals and tracks reported to the CDC and interviews of knowledgeable hound hunters and trappers. Visual observations and/or tracks were reported by the following National Forests: Beaverhead-Deerlodge, Bitterroot, Idaho Panhandle, Nez Perce, and Sawtooth. Museum specimen records were obtained from Harvard Museum of Comparative Zoology, National Museum of Natural History, University of Colorado Museum, and the Slater Museum of Natural History at the University of Puget Sound. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are also included.

Illinois: We have only one record for the state of Illinois and that is of a mounted skin from the Academy of Natural Sciences of Philadelphia.

Iowa: The one Iowa record we have is from a mounted skin belonging to the private collection of Jerry L. Rasmussen of Rock Island, Illinois.

Maine: Museum specimen records were obtained from the Harvard Museum of Comparative Zoology, the Museum of Zoology at the University of Michigan, and the National Museum of Natural History. Also included are harvest records as published in Ontario's Ministry of Natural Resources "Furbearer harvests in North America 1600-1984" by Milan Novak et al. Winter track counts were conducted from 1994 to 1997 by the State of Maine Department of Inland Fisheries and Wildlife, and track observations during the winter of 1994-1995 are reflected here. This same agency compiled records of incidental takings and historical observations.

Massachusetts: The only records for Massachusetts are from state harvest reports and bounty records kept by the Massachusetts Division of Fisheries and Wildlife.

Michigan: Museum specimen records were obtained from the following: Michigan State University Museum, Peabody Museum at Yale, Grand Rapids Public Museum, Milwaukee Public Museum, Museum of Zoology at the University of Michigan, and the National Museum of Natural History. Various sightings compiled by both the Michigan Department of Natural Resources and the Michigan Natural Heritage Natural Features Inventory are reported here as well as historical data from two articles, Elsworth M. Harger's 1965 "The Status of the Canada Lynx in Michigan" and "Michigan Mammals" by Rollin H. Baker, published in 1983. Dean Beyer (University of Northern Michigan) compiled a database of approximately 45 lynx records that includes sightings, tracks, and museum specimen records from various sources. One visual observation was reported by the Ottawa National Forest.

Minnesota: Data points for Minnesota include harvest records and records of confiscated carcasses and accidental lynx mortalities obtained from the Minnesota Department of Natural Resources (MNDNR). The MNDNR also provided us with records they had compiled of personal reports of sightings and tracks, reports from newspaper articles, and shootings. Two surveys were done by the MNDNR that yielded data points, a winter track survey conducted 1991 through 1997 (one observation of tracks), and a predator and furbearer scent post census 1975 through 1997 (four detections). L. David Mech trapped and radio-collared a number of lynx from 1972 through 1978 and published the results in "Age, Sex, Reproduction, and Spatial Organization of Lynxes Colonizing Northeastern Minnesota" in 1980. The capture points of those lynx are reflected here. Additionally, Mech kept autopsy records for lynx trapped, shot, or otherwise killed from 1972 to 1974, and those data points are included in our database. Museum specimen records were reported by the following: Bell Museum of Natural History; National Museum of Natural History; the Bird and Mammals Collection at University of California, Los Angeles; the Illinois State Museum, the University of Wisconsin Zoological Museum; and the Los Angeles County Museum.

Montana: The Montana state database is maintained by the Montana Department of Fish, Wildlife and Parks (MDFWP). Occurrence records for this database were obtained from MDFWP harvest records, logbooks, occurrence reports by individuals, and winter track surveys. A number of National Forests reported visual observations, tracks, and physical remains.

These forests include Flathead, Beaverhead-Deerlodge, Gallatin, Kootenai, Lewis and Clark, and Lolo National Forests. Glacier National Park also reported visual observations and tracks. Museum specimen records were obtained from the following: American Museum of Natural History, The Glacier Collection at Glacier National Park, University of Nebraska State Museum, University of North Dakota, Illinois State Museum, National Museum of Natural History, and the Philip Wright Zoological Museum. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are also included.

Nebraska: The U.S. Fish and Game, South Dakota Field Office provided seven confirmed lynx records. Museum specimen records were obtained from the University of Nebraska State Museum.

Nevada: Nevada has only two records; both were obtained from the National Museum of Natural History.

New Hampshire: The New Hampshire Fish and Game provided harvest/bounty reports as well as a compilation of records from various sources such as personal accounts of observations and newspaper articles. From the White Mountain National Forest we obtained a compilation of records from personal reports and responses to questionnaires. The Audubon Society of New Hampshire provided points from their Endangered Species Program database. Museum specimen records were obtained from the Museum of Comparative Zoology at Harvard, Cornell University Vertebrate Collections, and the University of Maine.

New York: The majority of the data points for New York came from the U.S. Fish and Wildlife Service report, "The Status of the Lynx in New York (*Lynx canadensis*)" by A.S. Bergstrom (1977, unpublished). The New York State Department of Environmental Conservation reported two rather recent lynx occurrences, one shot and one sighted. Museum specimen records were obtained from the American Museum of Natural History and the Academy of Natural Sciences of Philadelphia.

North Dakota: Most of the North Dakota points are from museum specimen records from the Los Angeles County Museum, University of North Dakota, the Museum of Southwestern Biology at the University of New Mexico, and the National Museum of Natural History. The North Dakota Game and Fish Department reported the total number of lynx taken for two time periods, 1962-65 and 1972-73, on a statewide basis.

Oregon: The Oregon Department of Fish and Wildlife (ODFW) maintains a state database made up of ODFW harvest records, published reports, and sightings reported to the ODFW. Three National Forests reported visual observations: Malheur, Umatilla, and Willamette. Museum specimen records in the database are from the following museums: National Museum of Natural History, Oregon State University, the private collection of Wendell Weaver, the University of Kansas Museum of Natural History, and the Slater Museum of Natural History at University of Puget Sound. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are also included.

Pennsylvania: The Nature Conservancy's Pennsylvania Science Office reported the "last known record" of naturally occurring lynx. One museum specimen record was obtained from the Reading Public Museum and Art Gallery.

South Dakota: Six records of lynx observations were obtained from the South Dakota Department of Game, Fish and Parks, which manages the South Dakota Natural Heritage Data Base. Museum specimen records were obtained from South Dakota State University and the National Museum of Natural History.

Utah: Records were obtained from the Utah Division of Wildlife Resources (UDWR) Rare Mammal Sighting Program, UDWR harvest records, other UDWR records, published reports, and interviews with various organizations and private individuals. These records make up the state database that is maintained by the UDWR Utah Natural Heritage Program. Museum specimen records were obtained from the Carnegie Museum of Natural History, Utah Museum of Natural History, and the National Museum of Natural History. Ashley National Forest reported five visual observations. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are also included.

Vermont: The points for Vermont come from two sources: the Vermont Department of Fish and Wildlife (historical records of lynx taken) and the Dartmouth College Museum.

Washington: Details of the Washington state database are lacking and as such, many of the sources are listed as "unknown." Sources that are listed include the U.S. Forest Service, U.S. Bureau of Land Management, the Washington Department of Natural Resources, and data from local counties. We received point data directly from the Okanogan National Forest. These observations were from winter track surveys and camera/bait stations during 1981-1988. Other survey data included here are from a telemetry study done by the Washington Department of Fish and Game, 1981-1988. The Idaho Panhandle and Mount Baker-Snoqualmie National Forests and North Cascades National Park reported a variety of visual observations, tracks, and physical remains. A number of museums contained specimens, including the Conner Museum at Washington State University, National Museum of Natural History, University of Washington Burke Museum, the Museum of Vertebrate Zoology at Berkeley, the University of Massachusetts, and the Slater Museum of Natural History at the University of Puget Sound. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are included.

Wisconsin: The Wisconsin Department of Natural Resources (WIDNR) provided data points from harvest records, trapper questionnaires, and confirmed personal accounts. Richard Thiel (Bureau of Endangered Resources, WIDNR) compiled quite an extensive collection of lynx/lynx sign observations from sources such as newspaper articles, hunter-trapper questionnaires, museum records, and personal accounts. This "raw data" is summarized in Thiel's 1987 publication "The Status of Canada Lynx in Wisconsin, 1865-1980." Another report by the WIDNR from which data points were taken is Adrian Wydeven's 1998 report, "Lynx Status in Wisconsin." The Nicolet National Forest ran winter track surveys 1993 through 1998, and track observations from that study are included here. Lastly, museum specimen records were obtained from the following: University of Wisconsin at Madison Zoological Museum, Museum of Natural History at the University of Wisconsin at Stevens Point, the Milwaukee Public Museum, the University of Wisconsin at Superior, and the University of Wisconsin Tech Center at Marinette.

Wyoming: The Wyoming state database is maintained by the Wyoming Department of Game and Fish (WDGF) and is a compilation of data from the following sources: WDGF records, publications, federal agency records, interviews with trappers, and a lynx research project in the Wyoming Range of southwestern Wyoming. A number of records were compiled by Reeve et al. (1986, unpublished) and some of the more recent records were compiled by Tom Laurion (WDGF). Three visual observations were reported by Yellowstone National Park. Museum specimen records were obtained from Harvard Museum of Comparative Zoology, University of Kansas Museum of Natural History, National Museum of Natural History, University of Wyoming Museum of Zoology, and the Carnegie Museum of Natural History. Records from the database compiled by O.S. Garton and Mary Maj and previously published in Ruggiero et al. (1994) are included.