Canada Lynx Conservation Assessment and Strategy

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Lynx Biology Team

Member:	*Representing:*
Bill Ruediger	USDA Forest Service (Team Leader)
Jim Claar	USDA Forest Service, Northern Region
Bob Naney	USDA Forest Service, Pacific Northwest Region
Fred Wahl	USDA Forest Service, Rocky Mountain Region
Nancy Warren	USDA Forest Service, Northern Region
Dick Wenger	USDA Forest Service, Intermountain Region
Al Williamson/Steve Mighton/Tony Rinaldi	USDA Forest Service, Eastern Region
Lyle Lewis	USDI Bureau of Land Management
Bryon Holt	U.S. Fish and Wildlife Service, Pacific Region
Gary Patton	U.S. Fish and Wildlife Service, Mountain-Prairie Region
Joel Trick	U.S. Fish and Wildlife Service, Great Lakes—Big Rivers Region
Anne Vandehey	U.S. Fish and Wildlife Service, Mountain—Prairie Region
Steve Gniadek	USDI National Park Service

Lynx Steering Committee

Member:	*Representing:*
Kathy McAllister	USDA Forest Service (Chair)
Kemper McMaster	U.S. Fish and Wildlife Service, Mountain-Prairie Region
Phil Laumeyer/Susan Martin	U.S. Fish and Wildlife Service, Pacific Region
Cindy Swanson	USDA Forest Service, Northern Region
Dave Anderson	USDA Forest Service, Rocky Mountain Region
Bill Burbridge	USDA Forest Service, Intermountain Region
Bob Devlin	USDA Forest Service, Pacific Northwest Region
Steve Kessler	USDA Forest Service, Eastern Region
Dean Knighton	USDA Forest Service, Rocky Mountain Research Station
Cal McCluskey	USDI Bureau of Land Management
Mark Morse	USDI Bureau of Land Management
Ken Elowe	State of Maine
Mike DonCarlos	State of Minnesota
Don Childress	State of Montana
Bob Vaught	USDA Forest Service, Colville National Forest
DeAnn Zwight	USDA Forest Service, Rocky Mountain Region
Martin Prather/Nancy Warren	USDA Forest Service (Committee Coordinator)

Acknowledgements

An action plan to prepare this Lynx Conservation Assessment and Strategy was approved by the Regional Foresters of the Forest Service, State Directors of the Bureau of Land Management, and Regional Directors of the Fish and Wildlife Service representing the pertinent geographic areas (memo of June 5, 1998). Overall guidance for implementation of the action plan was provided by an interagency Steering Committee.

The Steering Committee appointed an interagency Lynx Biology Team to prepare the conservation strategy, and a Science Team to assemble the best available scientific information. Two additional teams, the Biological Assessment Team and the Planning Team, were chartered to assess how well current programmatic plans provide for the habitat requirements of lynx, and to determine whether and how the plans might need to be changed. These two teams drew heavily from this document as a basis for their evaluations.

This document received extensive internal and external review. During the course of its development, the Lynx Biology Team arranged an independent scientific peer review; solicited review by the Science Team to ensure that their findings were properly and appropriately incorporated; conducted an internal review by agency personnel; and offered a second opportunity for comment by state wildlife management agencies. Forest Service members of the Lynx Biology Team held a two-day briefing of the five Regional Foresters and their resource staff directors. Following the internal review, the Biology Team worked with an interdisciplinary review team to address and incorporate review comments.

We would like to express our thanks to all those who provided us with their insights, information, and many useful suggestions and comments.

We owe special thanks to our facilitator, Ginny Tribe. Her exceptional skills, perceptiveness, and tireless efforts were critical to ensuring careful consideration of all viewpoints and timely completion of this document.

Interdisciplinary Review Team members:

Julie Richardson	Silviculturist	USDA Forest Service, Colville National Forest
Warren Ririe	Range Conservationist	USDA Forest Service, Boise National Forest
Ed Ryberg	Recreation Special Uses and Ski Areas Coordinator	USDA Forest Service, Rocky Mountain Region
Helen Smith	Fire Ecologist	USDA Forest Service, Rocky Mountain Research Station
Paul Stantus	Transportation Engineer	USDA Forest Service, Kootenai National Forest

Executive Summary

Purpose of this Document

The Lynx Conservation Assessment and Strategy was developed to provide a consistent and effective approach to conserve Canada lynx on federal lands in the conterminous United States. The USDA Forest Service, USDI Bureau of Land Management, and USDI Fish and Wildlife Service initiated the Lynx Conservation Strategy Action Plan in spring of 1998.

The lynx was proposed for listing as a threatened species under the Endangered Species Act on July 8, 1998 (Federal Register Volume 63, No. 130). The final rule listing the contiguous United States Distinct Population Segment (DPS) was published on March 24, 2000 (Federal Register Volume 65, No. 58). In the final rule, the U.S. Fish and Wildlife Service concluded that the factor threatening the contiguous U.S. DPS of lynx is the inadequacy of existing regulatory mechanisms, specifically the lack of guidance for conservation of lynx in the National Forest Land and Resource Management Plans and the BLM Land Use Plans. This lack of guidance may allow or direct actions that cumulatively adversely affect the lynx.

Under provisions of the Endangered Species Act, federal agencies shall use their authorities to carry out programs for the conservation of listed species, and shall insure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of critical habitat (16 USC 1536). The conservation measures presented in this document were developed to be used as a tool for conferencing and consultation, as a basis for evaluating the adequacy of current programmatic plans, and for analyzing effects of planned and on-going projects on lynx and lynx habitat.

Guiding Principles

The conservation strategy must provide guidance that retains future options, provides management consistency, offers necessary flexibility, and ultimately will accomplish the objective of conserving the lynx. In the face of a high degree of scientific uncertainty, we relied on five guiding principles:

- *Use the best scientific information available about lynx.* We relied on information from research throughout the range of the species, recognizing that behavior and habitat use may be different in the southern portion of its range. We also incorporated information about the ecology of the primary lynx prey species, snowshoe hare, and an important secondary prey species, red squirrel. Where no information exists, we made assumptions or inferences, based on the collective experience and professional judgment of team members and other scientists.

• *Until more conclusive information concerning lynx management is developed, retain future options.* In some cases, this led us to recommend no increase in certain types of development within lynx habitat, even though the effects of current levels may be unknown. A conservative approach is prudent to avoid irrevocably committing resources that may ultimately prove to be important to the survival and/or conservation of lynx.

• *Integrate a consideration of natural ecological processes and landscape patterns, and explicitly consider multiple spatial scales.* A blending of the ecological process and species-centered approaches is more likely to maintain diversity, species viability, and sustainability.

• *Consider the habitat requirements of other wildlife species, including other forest carnivores.* A management plan that integrates recommendations for a variety of species is more likely to be feasible and to be successfully implemented.

• *Develop a useful, proactive plan to conserve lynx on federal lands.* Although analysis may consider all ownerships to provide context, conservation measures apply only to federal lands.

How the Document is Organized

Chapters 1 through 6 of the document provide an assessment of lynx status and risk. An overview of lynx ecology is presented first, followed by identification and description of risk factors. Lynx population status, habitat, and relevant risk factors are assessed for four spatial scales: range-wide, each of 5 geographic areas (Cascade Mountains, Northern Rocky Mountains, Southern Rocky Mountains, Great Lakes, and Northeast), planning unit, and home range. The assessment lays the conceptual and scientific foundation for later chapters, the conservation strategy.

Chapter 7 contains recommended conservation measures that address each of the risk factors. The conservation measures are sorted into programmatic and project level objectives and standards. Chapters 8 and 9 provide guidance for analysis of effects and project conferencing and consultation, inventory and monitoring, and management priorities.

Lynx Habitat

Lynx occur in mesic coniferous forests that have cold, snowy winters and provide a prey base of snowshoe hare (Quinn and Parker 1987, Koehler and Brittell 1990, Koehler 1990, Koehler and Aubry 1994, Mowat et. al. 2000, McKelvey et. al. 2000*b*, Ruggiero et al. 2000*b*). In North America, the distribution of lynx is nearly coincident with that of snowshoe hares (McCord and Cardoza 1982, Bittner and Rongstad 1982). Lynx are uncommon or absent from the wet coastal forests of Canada and Alaska (Mowat et al. 2000).

Both snow conditions and vegetation type are important factors to consider in defining lynx habitat. Across the northern boreal forests of Canada, snow depths are relatively uniform and only moderately deep (100-127 cm or 39-50 inches) (Kelsall et al. 1977). Snow conditions are very cold and dry. In contrast, in the southern portion of the range of the lynx, snow depths generally increase, with deepest snows in the mountains of southern Colorado. Snow in southern lynx habitats also may be subjected to more freezing and thawing than in the taiga (Buskirk et al. 2000*b*). Crusting of snow may reduce the competitive advantage that lynx have in soft snow, with their long legs and low foot loadings (Buskirk et al. 2000*a*).

Vegetation types and elevations that provide lynx habitat include:

- **Northeastern U.S.:** Most lynx occurrences (88%) fell within Mixed Forest-Coniferous Forest-Tundra province; 77% of occurrences were associated with elevations of 250-500 m (820-2,460 ft) (McKelvey et al. 2000*b*). Lynx habitat includes coniferous and mixed coniferous/deciduous vegetation types dominated by spruce, balsam fir, pine, northern white cedar, hemlock, aspen, and paper.
- **Great Lakes states:** Most lynx occurrences (88%) fell within the Mixed Deciduous/Conifer Forest province (McKelvey et al 2000*b*). Lynx habitat includes boreal, coniferous, and mixed coniferous/deciduous vegetation types dominated by pine, balsam fir, black and white spruce, northern white cedar, tamarack, aspen, paper birch, conifer bogs and shrub swamps.
- **Western U.S.:** Most lynx occurrences (83%) were associated with Rocky Mountain Conifer Forest, and most (77%) were within the 1,500-2,000 m (4,920-6,560 ft) elevation zone (McKelvey et al. 2000*b*). There is a gradient in the elevational distribution of lynx habitat from the northern to the southern Rocky Mountains, with lynx habitat occurring at 2,440-3,500 m (8,000-11,500 ft) in the southern Rockies. Primary vegetation that contributes to lynx habitat is lodgepole pine, subalpine fir, and Engelmann spruce (Aubry et al. 2000). In extreme northern Idaho, northeastern Washington, and northwestern Montana, cedar-hemlock habitat types may also be considered primary vegetation. In central Idaho, Douglas-fir on moist sites at higher elevations may also be considered primary vegetation. Secondary vegetation that, when interspersed within subalpine forests, may also contribute to lynx habitat, includes cool, moist Douglas-fir, grand fir, western larch, and aspen forests. Dry forest types (e.g., ponderosa pine, climax lodgepole pine) do not provide lynx habitat.

Landscapes are more heterogeneous in terms of topography, climate, and vegetation in the southern portion of its range, as compared to the northern taiga, (Buskirk et al. 2000*b*). In the southern portion of its range, lynx populations exhibit large home range sizes, high kitten mortality due to starvation, and greater reliance on alternate prey, especially red squirrels, which is similar to characteristics of populations in the taiga during the declining or low phase of the snowshoe hare cycle (Koehler 1990, Apps 2000). This suggests the importance of designing management practices to maintain or enhance habitat for snowshoe hare and alternate prey such as red squirrel.

Snowshoe hares are the primary prey of lynx, comprising 35-97% of the diet throughout the range of the lynx (Koehler and Aubry 1994). Red squirrels have been shown to be an important alternate prey species, especially during snowshoe hare population lows (Koehler 1990, O'Donoughue 1997). Summer food habits of lynx have been poorly defined, but McCord and Cardoza (1982) indicated that the diet might include other species such as mice, squirrels and grouse. Lynx at the southern periphery of the range may prey on a wider diversity of prey because of differences in small mammal communities and lower average hare densities, as compared with northern taiga.

The common component of natal den sites appears to be large woody debris, either down logs or root wads (Koehler 1990, Mowat et al. 2000, Squires and Laurion 2000). These den sites may be located within older regenerating stands (>20 years since disturbance) or in mature conifer or mixed conifer-deciduous (typically spruce/fir or spruce/birch) forests (Koehler 1990, Slough *in press* cited in Mowat et al. 2000). Stand structure appears to be of more importance than forest cover type (Mowat et al. 2000).

Risk Factors

The lynx assessment, Chapters 2 through 6, includes a list of potential risk factors (Chapter 2, Table 1). This is a thorough list of programs, practices, and activities that may influence lynx or lynx habitat, and may need to be addressed during conferencing or consultation. The risk factors are limited to those within the authority and jurisdiction of the federal land management agencies.

Risk factors were not ranked by priority of effects to lynx or lynx habitat. Risk factors may interact, and their relative importance may vary in different areas. Lynx population distribution, habitat components, and risk factors are described for four spatial scales: range-wide; geographic areas (Cascade Mountains, Northern Rocky Mountains, Southern Rocky Mountains, Great Lakes, and Northeast); planning area; and home range.

Conservation Measures

Chapter 7 of the document contains the conservation measures. These were developed to address each risk factor, in order to conserve the lynx and to avoid or reduce adverse effects from the spectrum of management activities on federal lands.

Plans that incorporate the conservation measures, and projects that implement them, are generally not expected to have adverse effects on lynx, and implementation of these measures across the range of the lynx is expected to lead to conservation of the species. However, because it is impossible to provide standards and guidelines that will address all possible actions, in all locations across the broad range of the lynx, project specific analysis and design also must be completed.

The conservation measures will likely be implemented through two scales of decision-making: programmatic and project planning. Programmatic plans provide broad direction for management activities by establishing goals, objectives, desired future condition statements, standards, guidelines, and land allocations. Project planning implements the broad programmatic direction, by accomplishing procedural requirements and designing activities that tailor substantive management direction to the unique conditions and circumstances of a particular site.

Conservation measures address a variety of programs and activities that occur on federal lands, or are authorized or funded by federal agencies.

Introduction

Purpose of this Strategy

The Lynx Conservation Assessment and Strategy was developed to provide a consistent and effective approach to conserve Canada lynx (*Lynx canadensis*), hereafter referred to as lynx, on federal lands in the conterminous United States. An action plan to prepare a Lynx Conservation Strategy was approved by the Regional Foresters of the Forest Service, State Directors of the Bureau of Land Management, and Regional Directors of the Fish and Wildlife Service representing the pertinent geographic areas (memo of June 5, 1998); the National Park Service assigned a member to the team in June of 1998. The overall goals were to develop recommended lynx conservation measures, provide a basis for reviewing the adequacy of Forest Service and BLM land and resource management plans with regard to lynx conservation, and to facilitate Section 7 conferencing and consultation at the programmatic and project levels.

On July 8, 1998, the U.S. Fish and Wildlife Service published a proposed rule to list the lynx under the Endangered Species Act of 1973, as amended (Federal Register Volume 63, No. 130). The final rule listing the contiguous United States Distinct Population Segment was published on March 24, 2000 (Federal Register Volume 65, No. 58).

The U.S. Fish and Wildlife Service considered the lynx to have been historically resident within 14 states: Maine, New Hampshire, Vermont, New York, Michigan, Wisconsin, Minnesota, Montana, Wyoming, Idaho, Washington, Oregon, Utah, and Colorado. In the listing proposal, the U.S. Fish and Wildlife Service concluded that the population in the United States is threatened by human alteration of forests, low numbers as a result of past overexploitation, expansion of the range of competitors, particularly bobcats (*Lynx rufus*) and coyotes (*Canis latrans*), and increasing levels of human access into lynx habitat. In the final rule, the U.S. Fish and Wildlife Service concluded that the single factor threatening the contiguous U.S. Distinct Population Segment of lynx is the inadequacy of existing regulatory mechanisms, specifically the lack of guidance for conservation of lynx in the National Forest Land and Resource Management Plans and the BLM Land Use Plans. This lack of guidance may allow or direct actions that cumulatively adversely affect the lynx.

Under provisions of the Endangered Species Act, federal agencies shall use their authorities to carry out programs for the conservation of listed species, and shall insure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of critical habitat (16 USC 1536). The conservation measures presented in this document were developed as a tool for conferencing and consultation, at the programmatic and at the project levels.

Interim Nature of this Guidance

Most lynx research has been conducted in Alaska and Canada, with very few studies conducted in the southern portions of its range in the contiguous United States (Ruggiero et al. 1994). The majority of this work has focused on demographics and ecology, with little emphasis on management, except for regulating trapping quotas. Currently, managers must rely on research from the taiga of Canada andAlaska, and the small foundation of data collected in southern British Columbia, Montana, and Washington.

Throughout this document, we cited the literature to support management recommendations, where it exists. On many issues, however, no empirical information exists. In these cases, assumptions or inferences were made based on the collective experience and professional judgment of team members, in consultation with other lynx experts. The rationale is documented in these situations.

Concurrent with this effort, a team of scientists prepared an assessment of the scientific basis for lynx conservation (Ruggiero et al. 2000*a*). Findings of their report are integrated into this strategy. Results of research currently underway in southern British Columbia, Montana, Wyoming, and elsewhere may lead to further insights for lynx management. This document represents a compilation of the best knowledge available at this time, but will be updated as new information becomes available.

Single-species vs. Ecosystem Process Approaches

A notion that seems to be gaining support is that single-species management plans are ineffective and may result in conflicting direction for different species. Proponents of this argument typically contend that maintaining ecosystem processes is sufficient as a management strategy.

We do not believe that the two approaches (single-species management and ecological processes) are mutually exclusive. Alone, each approach has significant limitations. The single-species approach may fail to address the needs of other species inhabiting similar habitats, and may not adequately consider ecosystem dynamics (Camp et al. 1997, Simberloff 1998). The ecological process approach may be biased towards more severe and therefore more detectable disturbances, and cannot address modern stresses that have no historical analogue (Hansen et al. 1991). Both approaches are plagued by missing or incomplete information.

Everett and Lehmkuhl (1996) recommend a strategy of seeking to maintain or restore natural ecological processes and patterns, adjusted as needed to accommodate the habitat requirements of species of concern. A blending of the ecological process and species-centered approaches is more likely to maintain diversity, species viability, and sustainability. Furthermore, species-centered environmental analysis can provide a deeper understanding of the factors limiting populations, and the knowledge necessary to correctly establish priorities for restoration efforts (James et al. 1997).

In the Lynx Conservation Assessment and Strategy, we sought to integrate these two approaches. The document contains a description of the historical disturbance processes that molded lynx habitat. Management recommendations were developed based on current understandings of the ecology of the lynx, the ecosystems in which they evolved, and the ways in which humans are using and altering lynx habitat today.

Some reviewers suggested that we address multiple species of wildlife (specifically all mid to large-sized carnivores) in this conservation strategy. This was beyond the scope, time frame, and budget for this project, particularly as many aspects of lynx ecology are quite different from most of the other carnivores. However, members of the team were familiar with current management plans for other carnivore species, and we looked for opportunities to make lynx conservation measures compatible with habitat needs of other carnivores.

Guiding Principles

Writing a conservation strategy when so little information exists is a daunting task. Irrespective of the limitations of current knowledge, management of lynx habitat will occur on nearly 50 national forests, BLM field offices in 7 states, 7 national parks, and possibly on a few wildlife refuges within the range of the lynx in the lower 48 states. The conservation strategy must provide guidance that retains future options, provides management consistency, offers necessary flexibility, and conserves lynx and lynx habitat.

In the face of a high degree of scientific uncertainty, we relied on five guiding principles in developing this conservation strategy:

- *Use the best scientific information available about lynx.* We relied on information from research throughout the range of the species, recognizing that behavior and habitat use may be different in the southern portion of its range. We also incorporated information about the ecology of the primary lynx prey species, snowshoe hare, and an important secondary prey species, red squirrel. Where no information exists, we made assumptions or inferences, based on the collective experience and professional judgment of team members and other scientists.

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Chapter 7 contains recommended conservation measures that address each of the risk factors. The conservation measures are sorted into programmatic and project level objectives and standards. Chapters 8 and 9 provide guidance for analysis of effects and project conferencing and consultation, inventory and monitoring, and management priorities.

How the Document Will Be Updated

Given the limited information currently available regarding lynx distribution and ecology in the southern portion of its range, this document should be reviewed and adjusted to reflect new information. We propose that an interagency review be conducted periodically, at intervals of no longer than 5-years, across the entire range of the species in the United States south of Canada. Based on this review of new scientific information as well as experience in implementing the conservation measures, this document should be adjusted as appropriate.

Chapter 1

Overview of Lynx Ecology

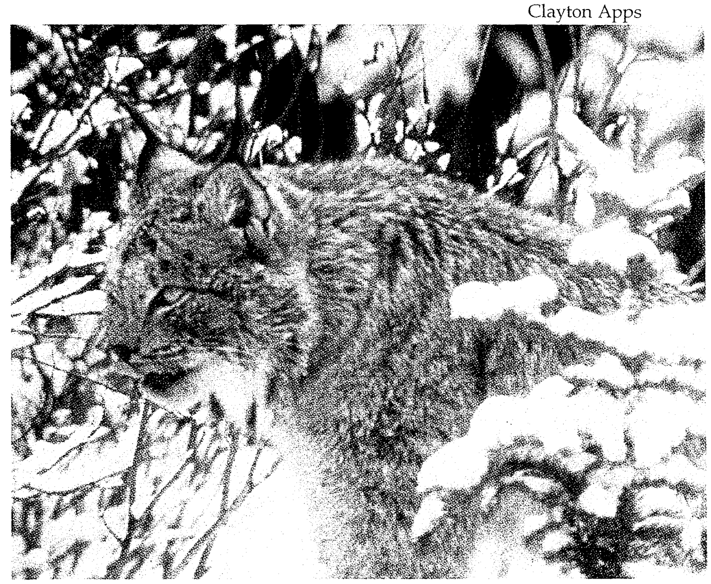
Description

Canada lynx are medium-sized cats, 75-90 cm long (30-35 inches) and weighing 8-10.5 kg (18-23 pounds) (Quinn and Parker 1987). They have large feet adapted to walking on snow, long legs, tufts on the ears, and black-tipped tails. Their historical range extends from Alaska across much of Canada (except for coastal forests), with southern extensions into parts of the western United States, the Great Lakes states, and New England (McCord and Cardoza 1982).

Lynx Diet

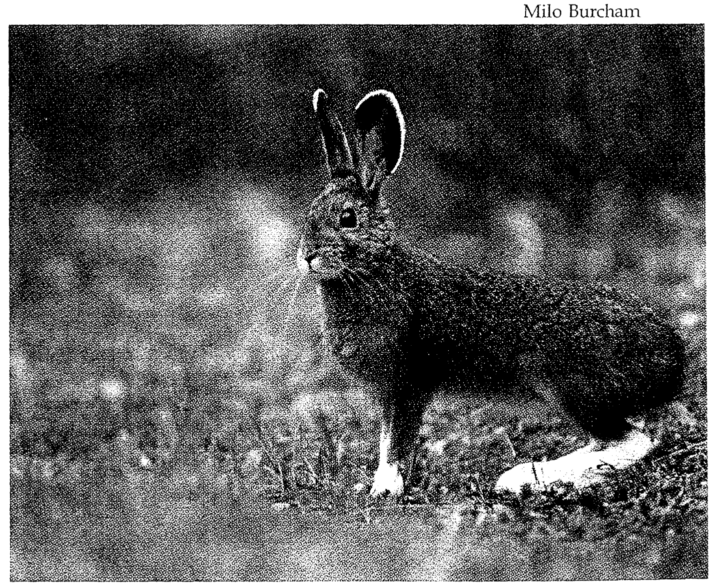
Snowshoe hares *(Lepus americanus)* are the primary prey of lynx, comprising 35-97% of the diet throughout the range of the lynx (Koehler and Aubry 1994). Other prey species include red squirrel *(Tamiasciurus hudsonicus)*, grouse *(Bonasa umbellus, Dendragopus spp., Lagopus spp.)*, flying squirrel *(Glaucomys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

Clayton Apps



Canada lynx

Milo Burcham



Snowshoe hare

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

Most research has focused on the winter diet, and diets in the summer are poorly understood throughout the range. Indications are that the summer diet may include a greater diversity of prey species (Quinn and Parker 1987, Koehler and Aubry 1994). Mowat et al. (2000) reported through their review of the literature that summer diets have less snowshoe hare and more alternative prey, possibly because of a greater availability of other species.

There has been little research on lynx diet specific to the southern portion of its range except in Washington (Koehler et al. 1979, Koehler 1990). Southern populations of lynx may prey on a wider diversity of species than northern populations because of lower average hare densities and differences in small mammal communities. In areas characterized by patchy distribution of lynx habitat, lynx may prey opportunistically on other species that occur in adjacent habitats, potentially including white-tailed jackrabbit *(Lepus townsendii)*, black-tailed jackrabbit (*Lepus californicus)*, sage grouse *(Centrocercus urophasianus)*, and Columbian sharp-tailed grouse *(Tympanichus phasianellus)* (Quinn and Parker 1987, Lewis and Wenger 1998).

Lynx Habitat

McKelvey et al. (2000b) summarized locations of documented lynx occurrences in the conterminous United States. Lynx presence has been recorded in states such as North Dakota, South Dakota, Illinois, Nebraska, and Indiana, where typical lynx habitat is not present (Adams 1963, Gunderson 1978). These occurrences may be explained as animals dispersing southward from Canada following snowshoe hare population crashes (McKelvey et al. 2000b). The conservation strategy does not address conservation for lynx in these regions, but rather focuses on areas where habitat could support resident populations and contribute to the long-term conservation of lynx.

There is substantial uncertainty as to the historical distribution and status of lynx in Wisconsin, Michigan, New York, and Vermont (McKelvey et al. 2000b). Although suitable habitat appears to exist, local snow conditions may or may not have allowed lynx populations to successfully compete and persist in these areas. National forests within these states were included in the conservation strategy (Appendix A). However, it is recognized that future information may indicate that conservation of lynx within these states is not warranted.

Lynx occur in mesic coniferous forests that have cold, snowy winters and provide a prey base of snowshoe hare (Quinn and Parker 1987, Koehler and Brittell 1990, Koehler 1990, Koehler and Aubry 1994, Mowat et. al. 2000, McKelvey et. al. 2000b, Ruggiero et al. 2000b). In North America, the distribution of lynx is nearly coincident with that of snowshoe hares (McCord and Cardoza 1982, Bittner and Rongstad 1982). Lynx are uncommon or absent from the wet coastal forests of Canada and Alaska (Mowat et al. 2000).

Both snow conditions and vegetation type are important factors to consider in defining lynx habitat. Across the northern boreal forests of Canada, snow depths are relatively uniform and only moderately deep (total annual snowfall of 100-127 cm or 39-50 inches) (Kelsall et al. 1977). Snow conditions are very cold and dry. In contrast, in the southern portion of the range of the lynx, snow depths generally increase, with deepest snows in the mountains of southern Colorado. Snow in southern lynx habitats may be subjected to more freezing and thawing than in the taiga (Buskirk et al.

2000b), although this varies depending on elevation, aspect, and local weather conditions. Crusting or compaction of snow may reduce the competitive advantage that lynx have in soft snow, with their long legs and low foot loadings (Buskirk et al. 2000a).

Vegetation types and elevations that provide lynx habitat include:

- **Northeastern U.S.:** Most lynx occurrences (88%) fell within Mixed Forest-Coniferous Forest-Tundra province; 77% of occurrences were associated with elevations of 250-500 m (820-2,460 ft) (McKelvey et al. 2000b). Lynx habitat includes coniferous and mixed coniferous/deciduous vegetation types dominated by spruce, balsam fir, pine, northern white cedar, hemlock, aspen, and paper birch.
- **Great Lakes states:** Most lynx occurrences (88%) fell within the Mixed Deciduous/Conifer Forest province (McKelvey et al 2000b). Lynx habitat includes boreal, coniferous, and mixed coniferous/deciduous vegetation types dominated by pine, balsam fir, black and white spruce, northern white cedar, tamarack, aspen, paper birch, conifer bogs and shrub swamps.
- **Western U.S.:** Most lynx occurrences (83%) were associated with Rocky Mountain Conifer Forest, and most (77%) were within the 1500-2000 m (4,920-6,560 ft) elevation zone (McKelvey et al 2000b). There is a gradient in the elevational distribution of lynx habitat from the northern to the southern Rocky Mountains, with lynx habitat occurring at 2,440-3,500 m (8,000-11,500 ft) in the southern Rockies. Primary vegetation that contributes to lynx habitat is lodgepole pine, subalpine fir, and Engelmann spruce (Aubry et al. 2000). In extreme northern Idaho, northeastern Washington, and northwestern Montana, cedar-hemlock habitat types may also be considered primary vegetation. In central Idaho, Douglas-fir on moist sites at higher elevations may also be considered primary vegetation. Secondary vegetation that, when interspersed within subalpine forests, may also contribute to lynx habitat, include cool, moist Douglas-fir, grand fir, western larch, and aspen forests. Dry forest types (e.g., ponderosa pine, climax lodgepole pine) do not provide lynx habitat.

Lynx habitat quality is believed to be lower in the southern periphery of its range, because landscapes are more heterogeneous in terms of topography, climate, and vegetation (Buskirk et al. 2000b). Population recruitment and home range sizes of lynx in the United States are similar to those reported during the decline or low phase of snowshoe hare cycle at more northern latitudes (Koehler 1990, Apps 2000).

In the United States, lynx inhabit conifer and conifer-hardwood habitats that support their primary prey, snowshoe hares. Disturbance processes that create early successional stages exploited by snowshoe hares include fire, insect infestations, catastrophic wind events, and disease outbreaks (Kilgore and Heinselman 1990, Veblen et al. 1998, Agee 2000). Wind and insects are particularly dominant processes in New England, with fire dominating in the western U.S. (Agee 2000). Both timber harvest and natural disturbance processes can provide foraging habitat for lynx when resulting understory stem densities and structure meet the forage and cover needs of snowshoe hare (Keith and Surrendi 1971, Fox 1978, Conroy et al. 1979, Wolff 1980, Parker et al. 1983, Livaitis et al. 1985, Monthey 1986, Bailey et al. 1986, Koehler 1990 and 1991). These characteristics include a dense, multi-layered understory that maximizes cover and browse at both ground level and at varying snow depths throughout the winter (crown cover within the lower 4.5 m (15 feet) in order to provide cover and food for snowshoe hares to 6 feet high at maximum snow depths).

In the winter, lynx do not appear to hunt in openings, where lack of above-snow cover limits habitat for snowshoe hares

(Mowat et al. 2000). Within about 10 to 30 years following disturbance (length of time varies, depending on site productivity, forest type and intensity of disturbance), lynx begin to forage for hares in vegetation that provides a high density of young conifer stems and/or branches that protrude above the snow (Sullivan and Sullivan 1988, Koehler 1990). In northcentral Washington, "high" density of stems and/or branches was quantified as >11,250/ha (>4,500/acre). This habitat is ephemeral, as the tree stems and branches eventually grow out of reach of snowshoe hares and shade out understory saplings and shrubs.

Older forests with a substantial understory of conifers or small patches of shrubs and young trees that provide dense cover that touches the snow in winter, generally also provide good quality lynx foraging habitat (Murray et al. 1994). Such older stands may provide snowshoe hare habitat over a longer time period than stands regenerating following a disturbance, and also support red squirrel populations, an important alternate prey species for lynx (Buskirk et al. 2000b).

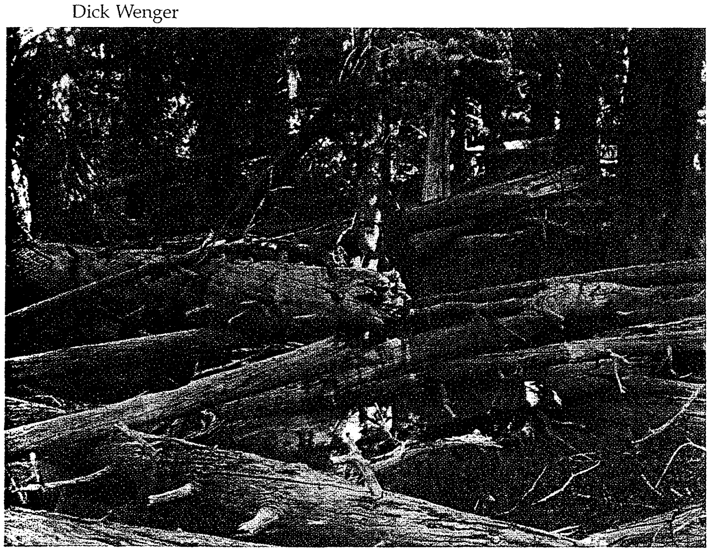
Landscapes with various age classes, primarily mid to advanced successional stages resulting from burns or clearcuts that support dense understory vegetation, may be more likely to support high snowshoe hare populations (Poole et al. 1996). Recent burns may provide herbaceous summer foods, while older burns provide woody browse during winter for snowshoe hares (Fox 1978). A complex mosaic of age-classes may provide a greater range of available browse as snow depths vary throughout the winter.

Lynx seem to prefer to move through continuous forest, and frequently use ridges, saddles, and riparian areas (Koehler 1990, Staples 1995). Although cover is important to lynx when searching for food (Brand et al. 1976), lynx often hunt along edges (Mowat et al. 2000). Kesterson (1988) and Staples (1995) reported that lynx hunted along the edge of mature stands within a burned forest matrix, and Major (1989) found that lynx hunted along the edge of dense riparian willow stands. Lynx have been observed (via snow tracking) to avoid large openings (Staples 1995), either natural (Koehler 1990) or created (J. Rohrer, pers. comm.), during daily movements within their home range.

The common component of natal den sites appears to be large woody debris, either down logs or root wads (Koehler 1990, Mowat et al. 2000, Squires and Laurion 2000). These den sites may be located within older regenerating stands (>20 years since disturbance) or in mature conifer or mixed conifer-deciduous (typically spruce/fir or spruce/birch) forests (Koehler 1990, Slough in press cited in Mowat et al. 2000). Stand structure appears to be of more importance than forest cover type (Mowat et al. 2000).

Information on maternal denning habitat is limited throughout the range of lynx. Large amounts of large coarse woody debris provide escape and thermal cover for kittens. During the first few months of life, kittens are left alone at these sites when the female lynx hunts. Downed logs and overhead cover provide protection of kittens from predators, such as owls, hawks, and

Dick Wenger



Denning habitat/logs

other carnivores during this period. This structure must be available throughout the home range, because it is likely that these structures are used when the kittens are old enough to travel but not hunt, similar to bobcat behavior (Bailey 1974).

For denning habitat to be functional, it must be in or adjacent to foraging habitat. At the time of parturition, the hunting range of females is more restricted and her need to feed kittens requires an abundance of prey. Because lynx, like other carnivores, may frequently move their kittens until they are old enough to hunt with their mother, multiple nursery sites are needed that provide overhead cover and protection from predators and the elements.

Density and Home Range Size

In Alaska and central Canada, lynx population numbers commonly cycle upward and downward, coincident with snowshoe hare population cycles (Keith et al. 1977, Poole 1994, Mowat et al. 2000). Although it had been thought that snowshoe hares did not cycle in the contiguous U.S., recent analyses suggest that southern hare populations do fluctuate, but not at the same amplitudes as described in the north (Hodges 2000b). Snowshoe hares occur at lower densities in the southern portion of their range (Koehler and Aubry 1994). Snowshoe hare population densities in the western United States appear to be similar to population lows in the northern taiga (Dolbeer and Clark 1975, Wolff 1980, Koehler 1990, Koehler and Aubry 1994).

Home range sizes of lynx are quite variable. For example, average winter home range sizes of three lynx in Newfoundland were about 18 km^2 (7 mi^2) in size (Saunders 1963b); in Riding Mountain National Park, Manitoba, home ranges for two females with kittens averaged 156 km^2 (60 mi^2), and the home range of a male was 221 km^2 (85 mi^2) (Carbyn and Patriquin 1983). In the southwestern Yukon, Ward and Krebs (1985) found a clear trend of increasing home range size as hare densities declined. Mean home range size (n=4) corresponding with high hare densities (15 hares/ha or 6 hares/acre) was 13 km^2 (5 mi^2), while 7 home range sizes at lowest hare densities (<1 hare/ha or <0.4 hares/acre) averaged 39 km^2 (15 mi^2) in size. In the Northwest Territories, Poole (1994) reported average home range size of about 17 km^2 (7 mi^2) for 23 male and female lynx in a year of peak hare abundance, increasing to 44 km^2 (17 mi^2) for 2 males and 62 km^2 (24 mi^2) for 2 females in the second year of the snowshoe hare decline.

In northcentral Washington, Koehler (1990) reported average home range sizes to be 39 km^2 (15 mi^2) for 2 females and 69 km^2 (27 mi^2) for 5 males. Apps (2000) in southern British Columbia found much larger home ranges of 381 and 239 km^2 (147 and 92 mi^2) for males and females, respectively. In Montana, 4 female home ranges averaged 43 km^2 (17 mi^2) (Koehler et al. 1979). In Minnesota, 2 female home range sizes were 51 and 122 km^2 (20 and 47 mi^2) (Mech 1980). Generally, home range sizes at the southern extent of lynx range in boreal and montane forests are larger than those reported from the taiga during snowshoe hare peaks (Aubry et al. 2000). Based on previous studies, the mean home range sizes of females in southern boreal forests are more than twice as large as female home ranges in the taiga, regardless of hare densities (Aubry et al. 2000).

Lynx and Snowshoe Hare Relationships

The ranges of snowshoe hare and lynx are nearly coincident across North America (Bittner and Rongstad 1982, McCord and Cardoza 1982). Snowshoe hares provide the primary prey for lynx (Quinn and Parker 1987, Koehler and Aubry 1994, O'Donoghue et al. 1998, Mowat et al. 2000). Recommendations for conservation and management of snowshoe hare and their habitats are a

Milo Burcham

Snowshoe hare in winter

critical component of the lynx conservation strategy.

Based on the Hudson's Bay Company fur trading records, Elton and Nicholson (1942) documented cyclic eight to ten year oscillations of lynx populations, which corresponded with similar fluctuations in snowshoe hare abundance. Since then, studies of lynx in the northern taiga forests have provided further evidence that lynx populations are inextricably linked to the cyclic abundance of snowshoe hares. Lynx density, home range size, dispersal patterns, reproductive parameters, and survival rates are strongly correlated to snowshoe hare abundance (Nellis et al. 1972, Brand and Keith 1979, Ward and Krebs 1985, Breitenmoser and Slough 1993, Poole 1994). Although it is unknown to what extent snowshoe hare populations cycle in the contiguous U.S., recent analyses suggest that southern populations do fluctuate and are not stable as previously believed (Hodges 2000b).

Results of several studies of the snowshoe hare population cycle in northern boreal forests were reported in Keith (1990). Overwinter browse estimates during the hare peak and post-peak indicated a shortage of food. Weight losses of hares were significantly negatively correlated with browse availability. Lower rates of reproduction, growth, and survival followed winters of high weight loss. In food manipulation experiments, mean winter weights were lower and overwinter weight losses greater for hares in food scarce treatments. In addition, all major components of reproduction were affected by food scarcity, which led to shorter breeding seasons and a decrease in mean natality in food short treatments. Keith (1990) concluded that food shortage at a regional rather than local scale controls the hare cycle. Krebs et al. (1986) found that food additions may increase hare densities, but did not prevent the decline phase of the cycle. Boonstra et al. (1998) found evidence that risk of predation causes hares to be chronically stressed, which may increase hare vulnerability to predation and/or decrease hare fecundity. This indicates the snowshoe hare population cycle is driven by an interaction between food and predation (Krebs et al. 1995).

Under optimal habitat conditions, snowshoe hares periodically exhibit high rates of population growth (Keith 1990). Snowshoe hares are capable of producing up to 4 litters per year, with 1-4 young per litter (Keith et al. 1966, Cary and Keith 1979). In Alberta, Canada, annual reproductive output varied from 16-18 young/female in the population increase phase, to 7-9 young/female in the low phase of the population cycle (Keith and Windberg 1978, Cary and Keith 1979). In the northern taiga, peak densities commonly are roughly 4-6 per ha (1.6-2.4 per acre), with low densities of 0.1-1 per ha (0.04-0.4 per acre) (Krebs et al. 1995, Slough and Mowat 1996, Hodges 2000a). In southern habitat studies in

Montana, Utah, Washington, West Virginia and some of the Great Lakes states, peak hare densities of 1-2 per ha (0.4-0.8 per acre) were reported (summarized in Hodges 2000b).

Snowshoe hares have small home ranges, of 5-10 ha (12-25 acres) (Dolbeer and Clark 1975, Wolff 1980, Hodges 2000a). Snowshoe hares are known to disperse for distances up to 20 km (12 miles), but there is no clear season or age of dispersal (review in Hodges 2000a).

Primary forest types that support snowshoe hare are subalpine fir, Engelmann spruce, Douglas-fir, and lodgepole pine in the western U.S., and spruce/fir, pine and deciduous forests in the eastern U.S. (Hodges 2000b). Within these types, the understory vegetation and density appears to be the key component (Wolfe et al. 1982, Litvaitis et al. 1985, Sievert and Keith 1985, Fuller and Heisey 1986, Thomas et al. 1997, Sullivan and Sullivan 1988). Hodges (2000b) reported that certain successional stages were more important for hare use and this appeared to be correlated with horizontal cover. Livaitis et al. (1985) found hare densities in Maine to be higher in dense conifer vegetation than in hardwood stands, and Fuller and Heisey (1986) found similar results in Minnesota. This likely was due to better thermal properties and predator protection provided by conifers. Wolfe et al. (1982) suggested that, in the Intermountain West, aspen stands with dense understory provide only marginal hare habitat during typical winter snow depths.

Koehler (1990) found lodgepole pine to be an important browse species for hares in northcentral Washington. Thomas et al. (1997) reported winter browse use on a variety of shrubs (serviceberry *(Amelanchier alnifloria)*, rose *(Rosa spp.)*, *Ceanothus spp.*, thimbleberry *(Rubus parviflora)*, and huckleberry *(Vaccinium spp.)* and on lodgepole pine and Douglas-fir; however, their data were collected during winters with low snow accumulation, whereas these shrubs would normally be unavailable under the winter snowpack. Hodges (2000b) stated that there is no evidence that food availability limits snowshoe hare populations in the southern part of their range.

Koehler (1990) suggested that snowshoe hares avoid clearcuts and very young stands, and Conroy et al. (1979) found that areas with greater interspersion of habitats may receive greater use by hares. Snowshoe hares prefer areas with dense protective understories composed of edible shrubs and trees (Wolfe et al. 1982). Population densities and overwinter survival are positively correlated with understory density, particularly of conifers that provide winter forage, thermal cover and escape cover (Adams 1959, Pease et al. 1979, Wolff 1980, Litvaitis et al. 1985). Overstory trees do not appear to be necessary, but may have the benefit of reducing snow accumulation (Hodges 2000b). Based on preliminary observations in Montana, horizontal cover influences hare abundance, and overstory cover could be an important habitat component (J. Squires, Univ. of Montana, pers. comm. 1999). In the Great Lakes region, conifer bogs and swamps may provide important snowshoe hare habitat.

During summer, snowshoe hares forage on a variety of forbs, grasses, and small shrubs. During the winter, food for snowshoe hares is limited to twigs and stems that are within reach above the snow surface (Pease et al. 1979). Small-diameter twigs (less than 10 mm (0.4 inch) in diameter) are preferred (Wolff 1980) and may be necessary to maintain body weight (Hodges 2000a).

Snowshoe hares may use denser conifer cover in winter than in summer (Parker et al. 1983, Litvaitis et al. 1985). In north-central Washington, where hardwood browse was not available, hares fed almost exclusively on lodgepole pine seedlings (Koehler 1990). Litvaitis et al. (1985) suggested that snowshoe hare densities would be greatest in areas having both softwood and hardwood species in the understory. Hares may be more likely to use deciduous forests in the east than in the west, and this again appears to be related to understory cover (Hodges 2000b).

Studies reviewed by Hodges (2000a) indicate that > 90 percent of hare mortality is a result of predation. In northern boreal forests, major predators of snowshoe hare include lynx, northern goshawk *(Accipiter gentilis)*, and great horned owl *(Bubo virginianus)* (Keith et al. 1977, O'Donoghue et al. 1997). Juvenile hares are preyed upon by small raptors, red squirrels, ground squirrels, and weasels (O'Donoghue et al. 1998). In the southern portions of the range of snowshoe hare, a more complex suite of predators that includes bobcat, coyote, red fox *(Vulpes vulpes)*, fisher *(Martes pennanti)* and mountain lion *(Puma concolor)*, in addition to goshawk and great horned owl, may limit the abundance of snowshoe hare populations (Dolbeer and Clark 1975, Powell 1993, Koehler and Aubry 1994).

Wolff (1980) and Dolbeer and Clark (1975) suggested that discontinuous conifer forests in the southern part of the range of snowshoe hare may not provide adequate habitat for dispersing hares to survive and thus reach the high densities achieved in the northern taiga. It is also possible that predators are able to suppress snowshoe hare populations at the southern edge of their range. The range of snowshoe hares overlaps with other lagomorph species (mountain cottontail *(Sylvilagus nutallii)* and white-tailed jackrabbit) in the western U.S. Although significant competition between these species is not likely, some overlap in habitat use does occur, particularly in or near ecotones.

Lynx and Red Squirrel Relationships

The most widespread species of tree squirrel in the genus Tamiasciurus is the red squirrel (Obbard 1987). Red squirrels range from Alaska, the Yukon Territory, the Northwest Territories and Quebec southward to the Rocky Mountains of New Mexico in the west and, in the east, to the southern Appalachian Mountains of South Carolina (Miller and Kellogg 1955, Hall and Kelson 1959, Peterson 1966, Walker 1968, Banfield 1974, Honacki et al. 1982). Their range is closely associated with the boreal forests of Alaska and northern Canada, and the subalpine, montane coniferous forest of western Canada and the United States, but also extends into the mixed coniferous and hardwood forests of the eastern U.S. and Canada (Peterson 1966, Walker 1968, Rowe 1972, Banfield 1974). The Douglas squirrel *(T. douglasii)*, a largely allopatric species, occurs in the Coast and Cascade ranges and the Sierra Nevada of the Pacific Coast from southwestern British Columbia to Southern California (Walker 1968, Honacki et al. 1982).

Red squirrels are commonly preyed upon by a variety of mammalian predators (Obbard 1987). Among the most common are fisher (Hamilton and Cook 1955, Brown and Will 1979) and marten *(Martes americana)* (Marshall 1946, Quick 1955, Soutiere 1979). The most common avian predator is northern goshawk (Meng 1959). Great horned owls (Rusch et al. 1972), red-tailed hawks *(Buteo jamaciensis)* (Luttich et al. 1970), broad-winged hawks *(Buteo platypterus)* (Rusch and Reeder 1978), and Cooper's hawks *(Accipiter cooperii)* (Meng 1959) have also been noted to prey upon red squirrels.

Lynx are known to prey on red squirrels. Red squirrel remains occurred in 56 percent (10 of 18) of lynx winter scats from the Northwest Territories (More 1976) and 9 percent (2 of 23) of the summer digestive tract samples from northern Alberta and the Northwest Territories (Van Zyll de Jong 1966). Koehler (1990) reported red squirrels in 24 percent of lynx diets in northcentral Washington. Staples (1995) reported that red squirrels were the second most important food source for lynx during his study in Alaska. O'Donoghue (1997) found red squirrels were the main alternate prey of lynx during periods of hare low abundance. Although a diet of red squirrels alone may not be adequate to ensure lynx reproduction and survival of kittens (Koehler 1990), the species appears to be the most important alternate prey throughout the range of the lynx (Brand et al. 1976, O'Donoghue et al. 1998, Apps 2000). Lynx appear to capture red squirrels opportunistically when hares are abundant, and to actively hunt red squirrels when hares are scarce (O'Donoghue 1997).

Red squirrels are primarily associated with the coniferous forests of northern and western North America, but are also common in eastern forests containing some mature conifers or nut-bearing hardwoods. Red squirrel densities tend to be highest in older, closed-canopy forests with substantial quantities of coarse woody debris, and lower in young stands that lack cone production (Layne 1954, Obbard 1987, Klenner and Krebs 1991). Population densities are highest (250-400/km^2 or 96-154 /mi^2) in spruce forests, lower (100-200/km^2 or 38-77/mi^2) in mixed conifers and mixed conifer/hardwoods, and lowest (25-100/km^2 or 10-38/mi^2) in pines and hardwoods (Obbard 1987). A study in interior British Columbia showed that red squirrel densities and recruitment were significantly higher in young (20-year old) unthinned lodgepole pine stands (stem density 20,000-35,000/ha or 8,000-14,000/acre), as compared with thinned stands (stem density 850-2,300/ha or 350-900/acre) (Sullivan and Moses 1986).

Red squirrels are active year-round throughout their range, and are primarily diurnal (Godin 1977). However, during winter they often switch to a unimodal pattern, becoming most active during the warmer mid-day period (Layne 1954, C. Smith 1968, Pauls 1978). They are seldom active above the snow surface when temperatures fall below -32 C (-25 F) (Pruitt and Lucier 1958, M. Smith 1968) and often become subnivean or subterranean during extremely cold winter periods, especially in the northern portions of their range (Pruitt and Lucier 1958, Zirul 1970).

The basis of the red squirrel's year-round diet is coniferous seeds, but deciduous and coniferous buds are also important components during winter and spring (C. Smith 1968, M. Smith 1968, Kemp and Keith 1970, Reichard 1976, Rusch and Reeder 1978). Newly matured conifer cones are cut and cached to help assure a year-round food supply (C. Smith 1968, 1981, Gurnell 1984). The activity center of each territory is the midden (Larsen and Boutin 1995). Caches often accumulate over several years and provide food during cone crop failures (M. Smith 1968). Large species of fungi are eaten fresh and also cached in the canopy for later consumption (Seton 1910, Klugh 1927, Hatt 1929, Layne 1954). In deciduous forests, red squirrels utilize and cache a large variety of seeds and mast from species such as oaks *(Quercus spp.)*, hickory *(Carya spp.)*, maple *(Acer spp.)*, elm *(Ulmus spp.)*, and beech *(Fagus grandifolia)* (Seton 1910, Hatt 1929, Williams 1936, Layne 1954, Kemp and Keith 1970). But, these caches do not normally accumulate from year to year (Hatt 1929). Douglas squirrels rely heavily on coniferous seeds during all seasons, but fungi may

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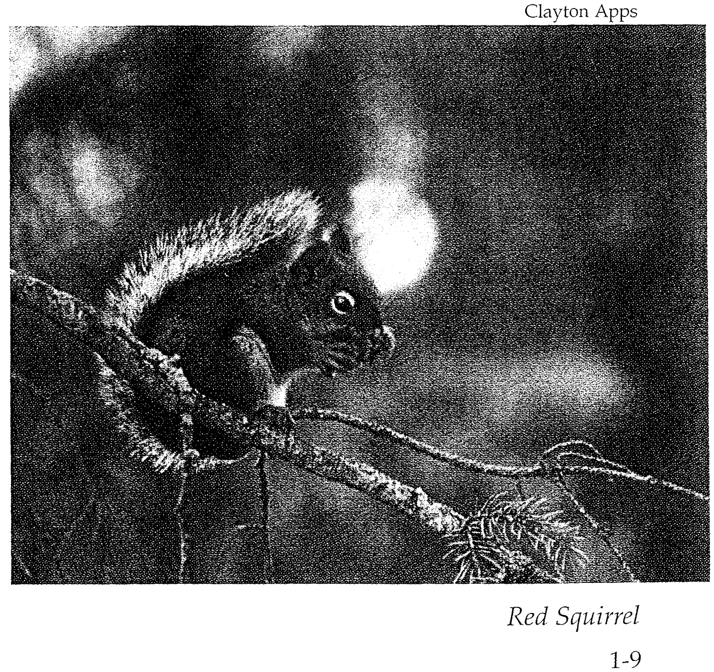

Red Squirrel

constitute over half their diet during fall (McKeever 1964).

In coniferous forests, red squirrels occupy solitary, non-overlapping contiguous territories that are defended from conspecifics of either sex (Gordon 1936, Clarke 1939, Hatt 1945, Kilham 1954, C. Smith 1968). Females only accept males onto their territories during their 1-day estrous cycle (C. Smith 1968, Rusch and Reeder 1978). In deciduous forests, red squirrel home ranges overlap broadly and no exclusive territories are evident (Layne 1954, Yahner 1980). This is thought to reflect a more abundant and diverse food base, which eliminates the dependence on a cached food supply (Kemp and Keith 1970, Rusch and Reeder 1978).

Throughout most of its range, the red squirrel produces one litter per year (Obbard 1987). However, in the southern and eastern portion especially, two litters per year have often been documented (Hamilton 1939, Layne 1954, Wrigley 1969, Lair 1985). Average litters range from about 3 to 5 young (Obbard 1987), depending upon annual variations in food supply (C. Smith 1968, Kemp and Keith 1970, Rusch and Reeder 1978).

Cavities in coniferous trees are relatively uncommon so underground nests and outside tree (leaf) nests are commonly used (Fancy 1980). Where available, spruces *(Picea spp.)* are used as nest trees but other conifers with a high branch density are also utilized (Hatt 1945, Fancy 1980). In eastern hardwood forests, tree cavities offer preferred nest sites but underground and outside tree nests are also used (Hatt 1929, Hamilton 1939, Layne 1954). Wherever found, tree nests are usually located in contact with the trunk in dense stands with high canopy closure (Rothwell 1979). Dense conifer clumps, especially when associated with snags or fallen logs, provide important shade and protective cover for food caches (Vahle and Patton 1983).

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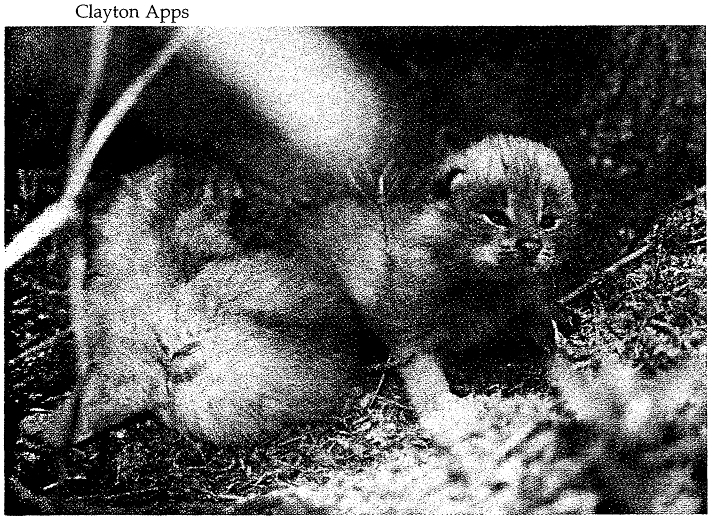

Lynx kittens

Lynx Recruitment

Breeding occurs through March and April in the north (Quinn and Parker 1987). Kittens are born in May to June in southcentral Yukon (Slough and Mowat 1996). The male lynx does not help with rearing young (Eisenberg 1986). Slough and Mowat (1996) reported yearling females giving birth during periods when hares were abundant; male lynx may be incapable of breeding during their first year (McCord and Cardoza 1982).

In northern study areas during the low phase of the hare cycle, few if any live kittens are born, and few yearling females conceive (Brand and Keith 1979, Poole 1994, Slough and Mowat 1996). However, Mowat et al. (2000) suggested that in the far north, some lynx recruitment occurs when hares are scarce and this may be important in lynx population maintenance during hare lows. During periods of hare abundance in the northern taiga, litter size of adult females averages 4 to 5 kittens (Mowat et al. 1996).

Koehler (1990) suggested that the low number of kittens produced in northcentral Washington was comparable to northern populations during periods of low snowshoe hare abundance. In his study area, radio-collared females (n=2) had litters of 3 and 4 kittens in 1986, and 1 and 1 kitten in 1987 (the actual litter size of one of the females in 1987 was not determined) (Koehler 1990). Of the known-size litters in Washington, only one kitten survived the first winter.

In Montana, Squires and Laurion (2000) reported that one marked female produced two kittens in 1998. In 1999, two of three females produced litters of two kittens each. In Wyoming (Squires and Laurion 2000), one female produced 4 kittens in 1998, but snowtracking indicated that the kittens were not with the female in November and presumed dead. The same female produced 2 kittens in 1999.

Lynx Mortality

Reported causes of lynx mortality vary between studies. The most commonly reported causes include starvation of kittens (Quinn and Parker 1987, Koehler 1990), and human-caused mortality, mostly fur trapping (Ward and Krebs 1985, Bailey et al. 1986).

In cyclic populations of the northern taiga, significant mortality due to starvation has been demonstrated during the first two years of hare scarcity (Poole 1994, Slough and Mowat 1996). Various studies have shown that, during periods of low snowshoe hare numbers, starvation can account for up to two-thirds of all natural lynx deaths. Trapping mortality may be additive rather than compensatory during the low period of the snowshoe hare cycle (Brand and Keith 1979). Hunger-related stress, which induces dispersal, may increase the exposure of lynx to other forms of mortality such as trapping and highway collisions (Brand and Keith 1979, Carbyn and Patriquin 1983, Ward and Krebs 1985, Bailey et al. 1986).

Paved roads have been a mortality factor in lynx translocation efforts within historical lynx range. In New York, 18 translocated lynx were killed on highways (Brocke et al. 1990). It has been suggested by Brocke et al. (1990) that translocated animals may be more vulnerable to highway mortality than resident lynx. Two lynx were killed on 2- and 4-lane Colorado highways following their release as part of a reintroduction effort there (G. Byrne CDOW, pers. comm. 1999).

Other than translocated animals, there have been 2 documented occurrences of highway mortality, in Wisconsin (Theil 1987) and Minnesota (Don Carlos, unpubl. report 1997). Twelve resident lynx were documented being killed on highways in Canada and Alaska (Staples 1995, Gibeau and Heur 1996, T. Clevenger pers. comm. 1999, Alexander pers. comm. 1999).

Predation on lynx by mountain lion, coyote, wolverine (Gulo gulo), gray wolf (Canis lupus), and other lynx has been confirmed (Berrie 1974, Koehler et al. 1979, Poole 1994, Slough and Mowat 1996, O'Donoghue et al. 1997, Apps 2000, Squires and Laurion 2000). Squires and Laurion (2000) reported 2 of 6 mortalities of radio-collared lynx in Montana were due to mountain lion predation. To observe such events is rare, and the significance of predation on lynx populations is unknown.

Lynx Movement and Dispersal

Daily movement distances vary. Ward and Krebs (1985) documented an increase in daily cruising radius from 2.7 km (1.6 miles) during moderate to high hare densities, to 5.4 km (3.2 miles) during low hare densities (<0.5 hares/ha or <0.2 hares/acre). Parker et al. (1983) reported a female's daily cruising distance as 8.8 km (5.3 mi) in winter and 10 km (6 mi) in summer.

Ongoing studies in Montana, Wyoming and southern British Columbia have documented exploratory movements by resident lynx during the summer months (Apps 2000, Squires and Laurion 2000). Aubry et al. (2000) described this type of movement as long-distance movements beyond identified home range boundaries, but returning to the

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Lynx feeding on squirrel

original home range. Distances of exploratory movements in Montana ranged from about 15 km (9 miles) to 40 km (25 miles), and duration away from the home range was 1 week to several months (Squires and Laurion 2000). This type of movement was not detected during the study in northcentral Washington (Koehler 1990), nor has it been recorded from the taiga (Mowat et al. 2000). Aubry et al. (2000) speculated that these movements might be more likely to occur in areas with high spatial heterogeneity, especially montane systems.

In the taiga, both adult and subadult lynx are known to make long-distance movements during periods of prey scarcity; recorded distances have been up to 1,000 km (600 miles) (Mech 1980, Slough and Mowat 1996, Poole 1997). During dispersal, the minimum daily travel rate was 1.7 to 8.3 km (1-5 miles) per day (n=3) (Ward and Krebs 1985), suggesting dispersing lynx do not travel farther per day than resident lynx (Mowat et al. 2000). There have been no successful dispersals (where breeding has been documented after moving to a new location) in the southern part of the range (Aubry et al. 2000). Dispersal distances in southern boreal and montane forests are similar to those from the Canadian taiga.

Many of the lynx habitats in the Rocky Mountains occur as islands of coniferous forest surrounded by shrub-steppe habitats. Movement of lynx between these forested habitats is poorly understood. Lynx have been documented in shrub-steppe habitats adjacent to western boreal forests (within approximately 40 km or 25 miles) during a peak in the jackrabbit population (Lewis and Wenger 1998). It is possible that the occasional availability of abundant alternate prey, such as jackrabbits or Wyoming ground squirrels *(Spermophilus elegans)*, may attract lynx into shrub-steppe habitats. It is not known whether these shrub-steppe habitats are important to lynx persistence at the southern edge of their range, or whether they are only used opportunistically (Ruggiero et al. 2000b).

Periodically, influxes of dispersing lynx have occurred in the northern United States during lows in the snowshoe hare cycle. There is no evidence that immigrating lynx are able to successfully colonize southern areas (McKelvey et al. 2000b). Nevertheless, connectivity between habitats in Canada and United States may be necessary for the persistence of some southern lynx populations, which if isolated may be too small to sustain themselves over the long term.

Interspecific Relationships with Other Carnivores

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

As described previously, major predators of snowshoe hare include lynx, northern goshawk, great horned owl, bobcat, coyote, red fox, fisher, and mountain lion. In southern portions of snowshoe hare range, predators may limit hare populations to lower densities than in the taiga (Dolbeer and Clark 1975, Wolff 1980, Koehler and Aubry 1994). Exploitation competition may contribute to lynx starvation and reduced recruitment. During periods of low snowshoe hare numbers, starvation accounted for up to two-thirds of all natural lynx deaths in the Northwest Territories of Canada (Poole 1994).

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

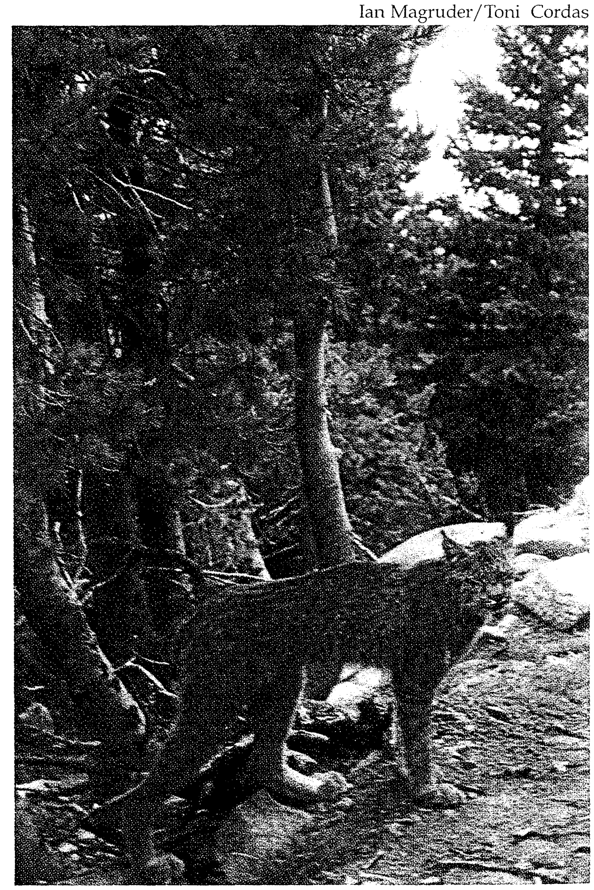
Predation on adult lynx has rarely been observed and recorded in the literature. As described previously, documented predators of lynx include mountain lion, coyote, wolverine, gray wolf, and other lynx. The magnitude or importance of predation on lynx is unknown.

Behavioral Response to Humans

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

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

Ian Magruder/Toni Cordas



Risk Factors

The Lynx Biological Team identified potential risk factors (Table 1). These include programs, practices, and activities that may influence lynx or lynx habitat. Our approach was to be inclusive, so that we would not overlook areas that biologists may need to address during conferencing and consultation. However, the risk factors are limited to those within the authority and jurisdiction of the federal land management agencies.

In this section, the risk factors are each defined and thoroughly described. In the next sections of the document, the risk factors that are applicable to each of four spatial scales are identified and briefly discussed. Conservation measures that address the risk factors are presented in Chapter 7 of this document.

Table 1. Lynx Risk Factors.

Factors Affecting Lynx Productivity

A. Timber Management
B. Wildland Fire Management
C. Recreation
D. Forest / Backcountry Roads and Trails
E. Livestock Grazing
F. Other Human Developments (Oil and Gas Leases, Mines, Reservoirs, Agriculture)

Factors Affecting Lynx Mortality

A. Trapping (legal and non-target)
B. Predator Control
C. Incidental or Illegal Shooting
D. Competition and Predation as Influenced by Human Activities
E. Highways (vehicular collisions)

(continued next page)

Table 1. Lynx Risk Factors. (cont.)

Factors Affecting Lynx Movements

A. Highways, Railroads and Utility Corridors
B. Land Ownership Pattern
C. Ski Areas and Large Resorts

Other Large-Scale Risk Factors

A. Fragmentation and Degradation of Lynx Refugia
B. Lynx Movement and Dispersal Across Shrub-Steppe Habitats
C. Habitat Degradation by Non-native Invasive Plant Species

Factors Affecting Lynx Productivity

A. Timber Management

Boreal and montane forests in the lower 48 states have been described by Franklin and Dyrness (1973), Elliot-Fisk (1988), Greller (1988), and Agee (2000). Natural disturbances, including fire, insects, disease and windthrow, are common in these ecosystems (Agee 2000) but tend to occur relatively infrequently. Resulting landscape patterns are generally a large-scale mosaic.

Research on the effects of forest management on lynx is limited (Koehler 1990, Koehler and Brittell 1990). Effects on snowshoe hare habitats vary across the range of the species and are not well understood (Conroy et al. 1979, Sullivan and Sullivan 1988, Koehler 1990, Swayze 1994, Thomas et al. 1997). Effects are even less well understood for red squirrels (Sullivan and Moses 1986).

Forest management practices such as thinning, commercial harvest, road construction, and post harvest treatments all influence habitats for lynx and prey. As described previously, snowshoe hares may reach highest densities in young, dense coniferous or coniferous-deciduous forests, or mature forests with a dense understory of shrubs, aspen, and/or conifers. Red squirrels appear to be most abundant in mature cone-bearing forests. Lynx natal dens, described by Berrie (1974), Kesterson (1988), Koehler (1990), and Slough (in press cited in Mowat et al. 2000) are generally located in areas with large quantities of coarse woody debris, such as blowdown, root wads, etc., which may occur in mature forests or in regenerating stands.

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

- Removal of most standing biomass, especially larger size classes of trees, from the site;
- Smaller, more dispersed patch sizes and concentrated harvest at lower elevations, resulting in a greater degree of habitat fragmentation;
- Selective removal of particular tree species;

- Soil disturbance and compaction by heavy equipment, which may result in increases of exotic plants that can compete with native vegetation;
- Harvest, planting and thinning treatments that may give a competitive advantage to certain tree species;
- Construction of roads that may be used during winter as designated or groomed travel routes for snowmobiles or cross-country skiers.

The objectives of forest management projects in lynx habitat must address maintenance or improvement of vegetation structure for lynx and their prey. Silvicultural prescriptions can be designed to address the needs of lynx, red squirrels, and snowshoe hares. Current practices are now giving greater emphasis to retention of live and dead trees and coarse woody debris, which are important lynx and prey habitat components. For red squirrels, consideration should be given to the landscape pattern (amount and arrangement) of mature coniferous forests, snags, and down logs. Snowshoe hares inhabit both early and later successional forests. Mature and late successional forests may provide more stable habitat for a longer period (Buskirk et al. 2000). Where it is desirable to create additional early successional habitat for snowshoe hares, considerations include harvest unit design (size and shape), selection of highly productive sites that quickly regenerate and provide desirable habitat for lynx prey, choice of fuels treatment practices, retention of adequate amounts of coarse woody debris, and maintenance of high stem densities in regenerated forests (Koehler and Brittell 1990).

Koehler (1990), Koehler and Brittell (1990) and Mowat et al. (2000) suggested that resident lynx may not hunt in large openings within forested habitats, even though they commonly use edges (Mowat et al. 2000). During dispersal, on the other hand, several authors have reported on lynx movement through large areas of non-forest (Murray et al. 1994, Poole et al. 1996).

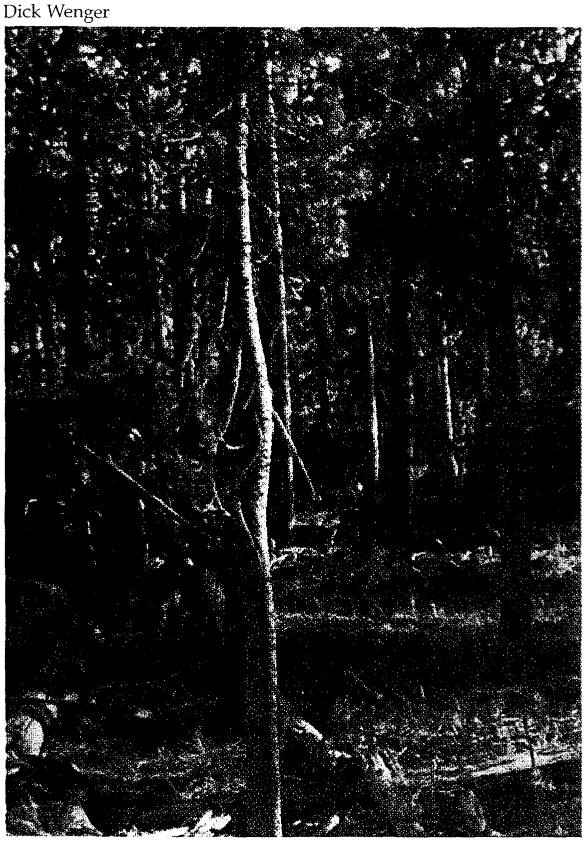
Mowat et al. (2000) suggested that relatively few snowshoe hares are found in large openings, and thus lynx do not spend much time hunting in open areas, especially in winter. Koehler (1990) speculated that clearcuts, shelterwood cuts, seed tree cuts, and diameter-limit prescriptions that result in distance to cover greater than 100 m (325 feet) may restrict lynx movement and use patterns until forest regeneration occurs.

In the eastern U.S., it generally takes 3 to 12 years after fire or timber harvest for broadleaf species to regenerate to heights sufficient to extend above average winter snow levels and create habitat for snowshoe hare. In the west, it may take approximately 15 to 30 years following forest management practices or fire for conifers and/or brush species to regenerate to heights sufficient to extend above average winter snow levels and create high quality habitat for snowshoe hare (Saunders 1963a, Nellis 1971, Parker et al. 1983, Bailey et al. 1986, Quinn and Thompson 1987, Koehler 1990, Koehler and Brittell 1990, Johnson et al. 1995, Poole et al. 1996, Slough and Mowat 1996). The time it takes for the vegetation to develop varies, depending on factors such as site productivity, climatic conditions, and forest type.

Regeneration: Even-aged harvest removes or alters stand structure, and temporarily eliminates snowshoe hare forage/cover and lynx cover until the site is regenerated to forest cover. Even-aged harvest generally reduces potential for denning habitat by removing large trees and down logs from the site. Red squirrel habitat is also reduced by the harvest of large trees. Regeneration harvest may be used to create high quality snowshoe hare habitat in the future, especially where natural regeneration would be expected to respond and provide dense young vegetation. Size of the opening, habitat type, distance to cover, landscape location, and expected vegetation response are considerations in evaluating the likely effects on lynx.

Uneven-aged management, such as single tree selection or group selection, results in varying effects to snowshoe hare, red squirrel and lynx, depending on the stems removed, harvest system and post sale treatments. This harvest method can be used to replicate or mimic forest gap dynamics. In drier forests, particularly at the southern edge of lynx range, snowshoe hare abundance may exhibit unimodal distribution, with peaks in old growth forests (Buskirk et al. 2000). Harvest in these stands may therefore have greater effects.

Dick Wenger



Thinned stand

Salvage: The type of salvage harvest addressed here is following an event that results in a high proportion of tree mortality, rather than salvage of individual trees. Extensive salvaging following a blowdown of large trees, as happens with many tree species (spruce, pine, fir, hardwoods), could result in loss of denning potential. The same could result from a fire salvage operation, if the larger-sized trees were removed. Salvage sales can be designed to minimize effects on lynx habitat.

Intermediate Treatments: Intermediate treatments partially remove the understory or overstory to improve the growth, quality, vigor, and/or species composition of the stand. These treatments may temporarily reduce the cover and forage values for lynx, and reduce winter forage opportunities for snowshoe hare. This reduction in habitat may be due to the harvest of trees, or to mechanical operations that create skid trails or damage understory vegetation. These treatments can also modify vegetation structure that contributes to red squirrel habitat. The degree of stem removal, along with the site characteristics, will determine whether snowshoe hare habitat is improved or restored by subsequent reinitiation of understory conifers and shrubs. Commercial thinning, for example, may be designed to release conifers in the understory.

Depending on the density of stems remaining following treatment and the size of the treatment area, lynx movement across the landscape may or may not be affected (Koehler 1990). Large patches with low stem densities may be functionally similar to openings, and therefore lynx movement may be disrupted. The reduction of understory shrubs or conifers may reduce cover or food for prey, causing lynx to increase their foraging range. Potential for denning habitat may improve as tree growth increases, coarse woody debris accumulates, and the stand moves towards late successional structure.

Pre-commercial thinning: This includes silvicultural treatments designed to increase the growth of certain trees by the removal of competition (trees of the same species or shrubs/trees of other species). Generally, the treatment results in more homogeneous patches by more heavily thinning dense patches while leaving less dense patches intact. Stem density and snowshoe hare density appear to be directly and positively correlated (Conroy et al. 1979, Sullivan and Sullivan 1988, Koehler 1990, Koehler and Brittell 1990, Swayze 1994, Thomas et al. 1997, Hodges 2000a, Mowat et al. 2000). Precommercial thinning reduces the density of sapling sized conifer trees and understory shrubs, and therefore is likely to be detrimental to snowshoe hare habitat. Examples exist where precommercially thinned vegetation has "filled in" with understory trees and developed into snowshoe hare habitat. It has been suggested this could be a technique to extend the time vegetation provides habitat for hares. However, the duration between time of thinning and regrowth to a height providing winter snowshoe hare habitat has not been documented. Additionally, there are no available data to determine the amount of time habitat is lost for snowshoe hares post-thinning, or the extended period of time the precommercially thinned vegetation provides hare habitat as compared with sites that have not been thinned.

Debris treatment—pile and burn: Following timber harvest, the remaining large woody debris on site provides some level of habitat for snowshoe hares and other small mammals, primarily as cover during the summer season. Large logs left on-site could provide cover for lynx movements across openings, if they occur at very high density and live vegetation also is present. Where large-sized woody debris is piled and burned, the opportunity for use is reduced. Retention of unburned debris piles on the landscape may provide habitat for lynx prey.

Debris treatment - broadcast burn: Where burning prescriptions are designed to retain large-sized woody debris, habitat for snowshoe hare and lynx will likely not be affected. Broadcast burning likely will stimulate increased regrowth by many herbaceous plants beneficial to snowshoe hares during summer, and provide heat to release seeds of conifers with serotinous cones. Burning may also result in establishment of more tree seedlings per acre (especially lodgepole pine, jack pine, and aspen). Potential for development of denning habitat would be reduced if pockets of heavy debris burn up.

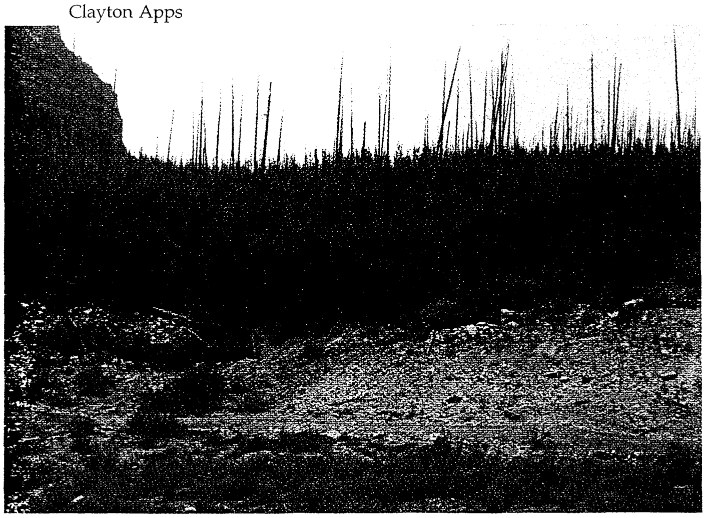
B. Wildland Fire Management

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

Lynx habitat in the Cascade Mountains was dominated historically by infrequent (70 - 150 years) stand-replacing fire regimes (Agee 2000). In much of the Rocky Mountains, the fire regime was much more variable in lynx habitat, with both frequent (35-100 years) stand-replacing or mixed severity fires, and infrequent (200+ years) stand-replacement fires (Hardy et al. 1998). Great Lakes boreal forests tended to have shorter fire return intervals of 50-150 years. Northeastern boreal forests had very long intervals of up to 500 years (Agee 2000). Disturbance interval and fire severity varied by cover type, with xeric pine types such as lodgepole or jack pine typically experiencing more frequent and more severe fires than mixed conifer types and spruce/fir.

Land management agencies began effective fire suppression with the advent of aircraft support, approximately 60 years ago. Over time, continued fire exclusion alters vegetative mosaics and species composition, and may have reduced the quality and quantity of habitat for snowshoe hares. In jack pine forests of the Great Lakes region, fire exclusion has changed stand composition and successional pathways, possibly permanently (Agee 2000). Effects of fire exclusion on western forests vary. Fire exclusion in areas with a history of infrequent fire returns has probably not had much impact (Habeck 1985, Agee 1993). On the other hand, areas where the fire regime was historically frequent or mixed have generally shifted to more intense fire regimes (Quigley et al. 1996, Morgan et al. 1998). As a result, forest composition and structure have changed in these areas, becoming more homogeneous, composed of more shade-tolerant species with more canopy layers, and being more susceptible to severe fires, insects, and diseases (Quigley et al. 1996).

Clayton Apps



Post-fire regeneration

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

C. Recreation

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

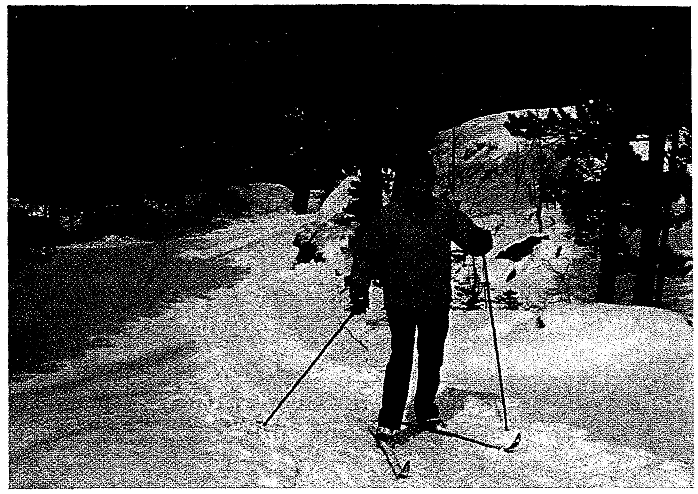
The demand for outdoor recreation opportunities by the public has grown rapidly since the revival of the U.S. economy following World War II (Knight and Gutzwiller 1995). Since the mid-1960's, public parks and recreational facilities have reported an annual growth rate in visitation exceeding 10% (Walsh 1986). This is generally attributed to a rise in personal affluence with more available disposable income, more leisure time and paid vacations, and improved transportation systems increasing our mobility (Clawson and Harrington 1991). The rapid growth in outdoor recreation has resulted in conflicts with the goals of natural resource conservation and wilderness preservation in some cases (Nash 1995, 1982).

The concurrent trends of rising public demand and decreasing available places for outdoor recreation implies greater pressure on federal and state-owned lands to support a variety of outdoor recreation activities. Although the United States has a large (300 million ha) public land base to support outdoor recreation, 60 percent of the land and water-based recreation occurs on private lands with restricted access. In 1997, only 23 percent of rural private lands were open for public use without restrictions, a decline of nearly 30 million ha (75 million acres) since 1977 (Cordell et al. 1990). There is a trend toward greater closure and exclusive leasing of private land (Cordell et al. 1993).

Nonconsumptive recreational activities are growing in popularity over the more traditional consumptive recreation uses of hunting and fishing (Duffus and Dearden 1990). Trends indicate that land-based activities occurring within developed recreation sites or near roads had the highest number of people participating. However, there have been vast improvements in bicycle and off-road vehicle technology, as well as a growing popularity in motorized off-road activities. Most increases in recreational activities are attributed to the technological advances allowing more inexperienced people to participate (Knight and Gutzwiller 1995) and to gain access into remote areas (Cordell et al. 1990, Cordell and Bergstrom 1991). Nationwide, ski resort development and downhill skiing are growing at moderate rates (Knight and Gutzwiller 1995). Bicycling, off-road driving and snowmobiling were projected to grow at respective rates of 24%, 4%, and 20% by the year 2000 (Knight and Gutzwiller 1995).

In the western and northeastern United States, biologists have suggested that unique morphological differences between coyotes and lynx should spatially segregate these species by snow conditions (Murray and Boutin 1991, Litvaitis 1992). Lynx and coyotes are generally thought to separate along elevation gradients in the western United States (Buskirk et al. 2000b). Murray et al. (1994) suggested that "coyotes were more selective of snow conditions than lynx, probably as a result of their high foot-load (ratio of body mass to foot area) relative to that of hares."

Dave Ozawa



Winter recreation

However, lynx and carnivore biologists (Bider 1962, Ozoga and Harger 1966, Murray and Boutin 1991, Koehler and Aubry 1994, Murray et al. 1995, Lewis and Wenger 1998, and Buskirk et al. 2000) have suggested that packed trails created by snowmobiles, cross-country skiers, snowshoe hares, and other predators may serve as travel routes for potential competitors and predators of lynx, especially coyotes. In Oregon, coyote tracks were "common" along wolverine survey routes (C. Lee, USFWS, pers. comm. 1999), suggesting that certain snow conditions permit coyotes to travel into lynx habitat. Buskirk et al. (2000a) hypothesize that the usual spatial segregation of lynx and coyotes "may break down where human modifications to the environment increase access by coyotes to deep snow areas. Such modifications include expanded forest openings throughout the range of the lynx in which snow may be drifted, and increased snowmobile use in deep snow areas of the western mountains." Recent advances in snowmobile technology allow snowmobiles to travel through deeper snow and into areas that were not accessible with the older machines. The sport of snowmobile "highmarking" and "hill climbing" are increasing in popularity, encouraging snowmobile travel into more remote areas in search of suitable "play" terrain.

Fuller and Kittredge (1996) noted that the distribution and numbers of coyotes have dramatically expanded in recent decades. Gier (1975) and Nowak (1979) suggested that coyotes are thought to have originated in areas where snow cover was minimal, and it is only within the last century that they have colonized the boreal forests.

U.S. Forest Service file photo

Snowmobiles

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

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

Recreational snowmobile use has expanded dramatically over the past 25 years in the contiguous United States. Knight and Gutzwiller (1995) reported 20 percent growth per year in recreational snowmobile use across the United States. In Maine, more than 19,000 km (11,400 mi) of trails are groomed for snowmobiling. In Idaho, a 1991 survey reported 9,357 km (5,600 mi) of snowmobile trails, which increased to 11,520 km (6,900 mi) as of 1994 (Idaho Department of Parks and Recreation 1997). The 4-year increase in trails reported was due to better reporting as well as new grooming programs within several counties of Idaho. On Hoodoo Pass in Oregon, snowmobile use in1990-91 was reported to be 5-10 snowmobiles per weekend, while a similar report for the years 1995-96 indicated that use levels had grown to 50-60 snowmobiles. The growth of snowmobile use and an expanded trail system over the past 2-3 decades imply an increase in human presence in lynx habitat throughout the United States.

Developed Recreation: To date, most investigations of lynx have not shown human presence to influence how lynx use the landscape (Aubry et al. 2000). An exception to this may be activities around a den site that may cause abandonment of the site, possibly affecting kitten survival (Ruggiero et al. 2000). Anecdotal information (Roe et al.1999, J. Squires pers. comm. 1999, G. Byrne pers. comm. 1999) suggests that individual lynx behave differently in response to the presence of humans and their associated activities, depending on the environmental setting where the interaction occurred. Intuitively, we assume that some threshold exists where human disturbance becomes so intense that it precludes use of an area by lynx.

A variety of factors may influence the effects of recreation on lynx. The following list may be helpful in evaluating how an activity might influence lynx.

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

2. *Time of year activity occurs.* For example, fall hunting in lynx denning habitat may have far less effect than spring alpine skiing, cross-country skiing, or snowboarding in such habitat. Lynx have been observed utilizing portions of ski areas in Colorado (Thompson and Halfpenny 1989, 1991) and western Canada (Roe et al. 1999) throughout most months of the year. Recreational facilities designed for summer time use, such as developed campgrounds or amphitheaters, most likely have very little effect on lynx.

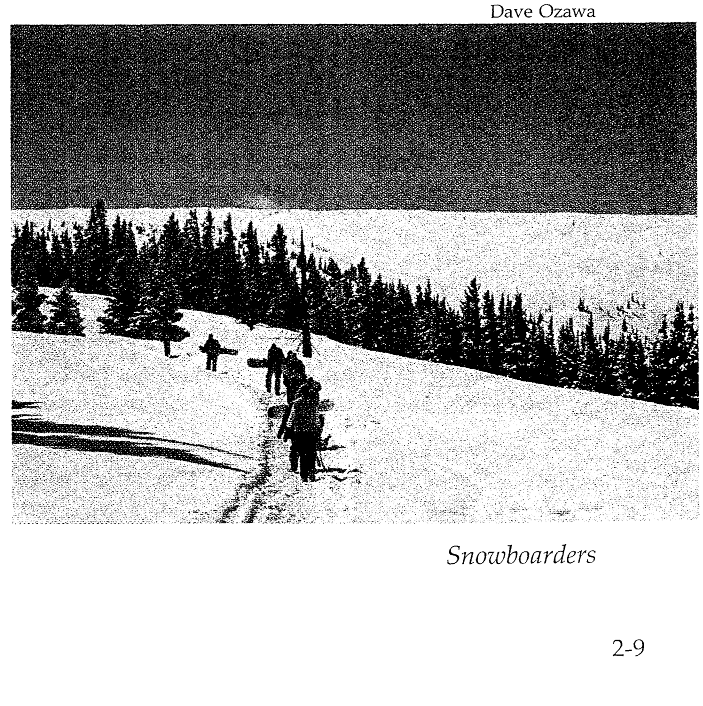
3. *Time of day activity occurs.* At developed facilities that receive high, concentrated human use (e.g., such as the most developed portions of ski areas or large-resorts), lynx may rest during the day in secure habitats while people use the remainder of the landscape. Lynx could emerge after dark to use the landscape when human activity has ceased or receded to acceptable levels. If extensive recreational activities occur at night in lynx habitat, this may diminish or preclude habitat use by lynx.

4. *Type of Activity.* The type of activity, pattern of human use, associated habitat impacts, and area of influence can affect the suitability of the landscape for lynx. Anecdotal information from western Canada's developed ski areas suggested that lynx used the mid to upper portions of the ski areas, but not the developed base areas or parking facilities (Roe et al. 1999). Many of the lynx observations were of animals crossing ski runs that were generally less than 200 m (650 ft) wide, and where forest cover was provided on both sides of the ski run (Roe et al. 1999).

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

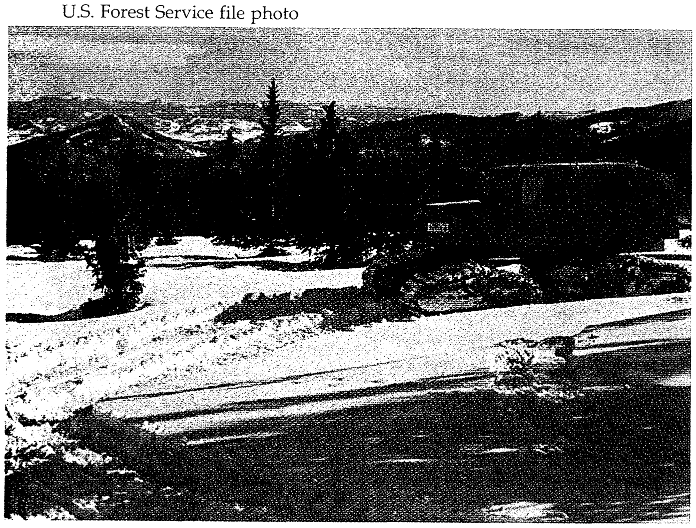
6. *Intensity and Frequency of Activity.* How often the activity occurs and the number of people involved in the activ-

Dave Ozawa



Snowboarders

U.S. Forest Service file photo



Snowcat

ity may influence the way lynx respond and use the surrounding environment. Encounters with a limited number of users might elicit a different behavioral response than frequent encounters with large groups of users.

Recreational activities may exert a variety of influences and effects on lynx and their habitat. Some highly developed and heavily used facilities (e.g., large ski areas and four season resorts) not only have direct effects on the land, but may also facilitate other indirect effects outside of the activity zone. Technological advances in recreational equipment have allowed a broader spectrum of users to access more remote backcountry areas. Sporting events that promote extreme recreational activities (typically outside the usual geographic and temporal constraints of most traditional uses) are on the upswing in popularity within the range of the lynx. The effects of these and other recreational activities on the long-term survival of the species are unknown.

Ski Areas and Four-Season Resorts – These can be year-round, highly developed recreational facilities. Most ski areas are located on north-facing slopes, where ample snow conditions provide for longer use periods during the ski season. In the western states, many of these landscapes feature spruce-fir forests. At the southern extent of the range of lynx, these tend to be the best habitat for snowshoe hares and lynx. In winter, alpine and Nordic skiing and snowboarding are the primary uses. Summer activities typically include mountain biking and hiking. Some of the most highly developed ski areas fragment the landscape, leaving only small inter-trail forest islands separating one ski run from the next. Ski runs often are intermixed with other open areas such as open or gladed bowls, rock outcrops or barren tundra ridges.

In the short term, resorts located on these sites may affect lynx denning, foraging, and diurnal security habitats. In the long term, naturally narrow bands of lynx habitat may be changed, possibly reducing the potential for lynx movement within and between home ranges. Medium to large ski areas have residential development and supporting businesses located at the base area on the flatter terrain. The availability of human refuse (trash and waste foods) may benefit coyotes, potentially affecting competition with lynx.

Single Season Ski Areas or Resorts – These recreational facilities are often much less extensive than the larger developed sites. Generally, the forested landscape is much less fragmented, and often the base area development is smaller and more concentrated than is typical of the larger facilities. Therefore, the short and long term impacts are considerably less than those described for 4-season resorts. Depending on the location, these resorts may affect foraging, diurnal security, or denning habitat, or possibly affect habitat connectivity.

Developed Nordic Ski Huts – Most backcountry ski hut sites are small and primitive in nature. However, in some areas within the southern range of lynx, these facilities have become highly developed and may require utilities and summer road access. In the short term, these sites probably result in a minor reduction of lynx habitat quality or quantity. They are generally located along designated cross-country ski routes, but have the potential of promoting off-trail travel, creating larger areas of compacted snow conditions that may facilitate access by lynx competitors. The location of these facilities and type of trail systems may play an important factor in how lynx use the landscape.

Snowmobile Warming Huts – Snowmobile warming huts can be highly developed facilities where grooming equipment and fuel storage exist, or they can be quite primitive. Snowmobile clubs and general public use is often focused or concentrated around these facilities. Many have developed trail systems that loop around the facility or provide access to other remote areas. Location of these facilities could play a role in encouraging more recreational use off designated snowmobile trails. At sites where this potential exists, there is also the potential of providing access to lynx competitors/predators through additional areas of compacted snow. Generally, these facilities are located close to year-round road access and not often located in more remote areas. Huts located in more remote locations might have the same effects on lynx as those described for Nordic ski huts.

Developed Campgrounds – Typically these are single-season summer facilities that might provide limited winter use, and generally supply such amenities as gas, electricity, water, and holding tanks for sewage disposal. These facilities are typically located outside of lynx habitat. When located in lynx habitat, the effects might be the same as those described for developed Nordic ski huts and snowmobile huts. If winter use is promoted at these sites, they may provide access for lynx competitors into areas not normally accessible because of deep snow conditions. Access could be further facilitated through the plowing of roads.

U.S. Forest Service file photo

Ski tracks and hut

Dispersed Recreation: Dispersed recreational uses and activities, such as snowmobiling, cross-country skiing and snowshoeing, are increasing within higher elevation environments. Advances in snowmobile technology are allowing the public to operate these new machines in deeper snow and rougher terrain than many of the older models. As mentioned earlier, snowmobile use across the United States has increased substantially over the last 20 to 30 years. Agencies, counties, states, and the public have requested or promoted more access into many of the more remote areas.

The number of forest visitors exploring undeveloped backcountry areas is increasing. In winter, dispersed recreation activities may be associated with huts, parking areas (snowmobiling, snowboarding and cross-country skiing), roadside rest areas, and other developed recreational facilities. Most of the opportunities for snowmobiling and backcountry skiing use tend to occur in the higher elevation landscapes where adequate snow conditions exist. Many remote areas are being visited more frequently because of improved snowmobile technology, availability of hut systems, and increased user trails.

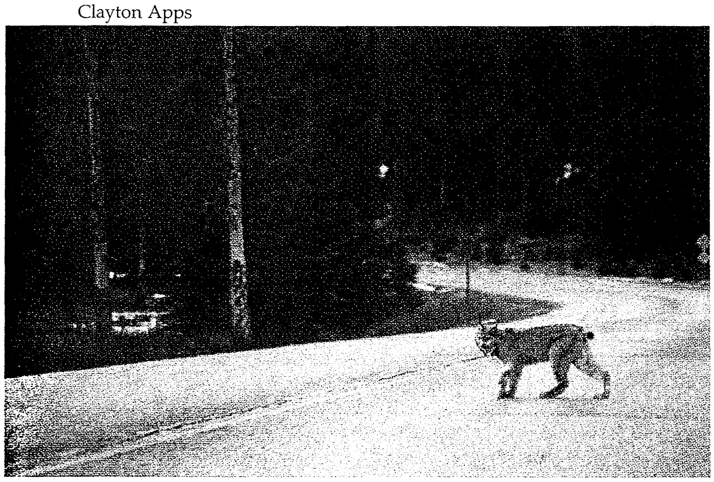
Most traditional dispersed recreational uses occurred during daylight hours.

However, nighttime activities and overnight trips are becoming more commonplace, possibly increasing the potential for disturbance at night when lynx had been more secure. Lynx have generally been thought to be nocturnal (active at night) or crepuscular (active at dawn and dusk), but some studies have shown that lynx may be active at all hours (Roe et. al. 1999). Apps (2000) hypothesized that weather may be the factor that determines when lynx are most active.

In contrast to the facilities provided at developed recreation sites, dispersed recreation typically involves very little infrastructure. Trails or roads often provide recreational access either as an intended or unintended consequence. Dispersed recreation activities seldom result in a direct loss of habitat, but are more likely to impart indirect effects (such as increased competition resulting from snow compaction).

Dispersed Campsites – These sites can be scattered anywhere across the landscape, but often occur as clusters around scenic (high alpine meadows, lakes, rivers) or geologic (mountains) features. Some sites are seldom used during the winter season. Sites where more use occurs can result in snow compaction spanning large areas, possibly providing lynx competitors with access to search for scarce prey resources.

Clayton Apps



Nordic Ski Huts – In contrast to highly developed Nordic ski huts, these are generally primitive. Backcountry use promoting large areas of snow compaction may occur in the vicinity of these sites. If heavy use occurs in lynx habitat, then lynx competitors may have an avenue to search for scarce prey along snow compacted trails.

D. Forest/Backcountry Roads and Trails

This section addresses the transportation system on public lands. Highways are described as a separate risk factor.

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

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

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

At this time, there is no compelling evidence to suggest management of road density is necessary to conserve lynx. However, new road construction continues to occur in many watersheds within lynx habitat, many of which are already highly roaded, and the effects on lynx are largely unknown. Further research directed at elucidating the effects of road density on lynx is needed.

Lynx may be more vulnerable to human-caused mortality near open roads (Koehler and Aubry 1994). This risk is discussed in a later section (Factors Affecting Lynx Mortality).

E. Livestock Grazing

Grazing by domestic livestock is common in the southern portions of lynx range in the western U.S.

In summer, snowshoe hares eat forbs, grasses, leaves of shrubs, and some woody browse, while the winter diet is restricted to smaller-diameter twigs and some bark of shrubs and trees (Adams 1959, Wolff 1978, Koehler 1990). In Alaska, for example, use of woody browse ranged from a high of 82% in winter, to 56% in spring, and 25% in summer (Wolff 1978). This pattern is similar to those of southern leporids. For example, the diet of black-tailed jackrabbits has been shown to include about 85% shrubs in winter and about 53% herbaceous material in summer (Sparks 1968, Fagerstone et al. 1980, MacCracken and Hansen 1984).

Dodds (1960) found that of 30 woody plant species browsed by moose, snowshoe hares in his study area also browsed 27. Heavy browsing by moose on balsam fir retarded tree growth, thus reducing hare winter cover and browse. Areas with high moose density had little sign of browsing by hares, and areas with the most dense hare populations had a low moose density. However, he suggested that competition most likely occurs in open habitats, rather than in areas with dense canopy cover.

Telfer (1972) found some overlap between browsing of white-tailed deer and snowshoe hare in Novia Scotia and New Brunswick. The vertical distribution of winter browsing by snowshoe hares, between 0.6 and 1.5 m (2-5 feet), was the same as white-tailed deer browsing during the fall and spring (Telfer 1974).

Although there have apparently been no studies of dietary overlap between livestock and snowshoe hares, or response of snowshoe hares to cattle grazing, several such studies have been done for other leporids. Johnson (1979) found the dietary overlap of black-tailed jackrabbits to be 51% with cows and 56% with domestic sheep, and stated that competition could occur, depending on stocking rates. In southeastern Idaho, MacCracken and Hansen (1984) found that leporids compete directly with livestock for forage.

Throughout the Rocky Mountains, grazing has been a factor in the decline or loss of aspen as a seral species in subalpine forests. Young, densely regenerating aspen stands with a well-developed understory provide good quality habitat for snowshoe hares and other potential lynx prey species, such as grouse. During winter, the cover and food value of aspen stands for snowshoe hares decreases markedly in areas with deep snow pack. However, aspen stands that occur in proximity to conifer forest provide important habitat diversity. Grazing should be managed so that it does not inhibit regeneration of aspen clones.

Snowshoe hare densities and overwinter survival appear to be positively correlated with understory density (Adams 1959, Wolff 1980, Litvaitis et al. 1985). Particularly in riparian areas within lynx habitat, large ungulate forage use levels may result in competition for forage resources. Browsing or grazing can have a direct effect on snowshoe hare habitat if it reduces winter browse. Browsing or grazing may also impact plant communities that connect patches of lynx habitat within a home range.

Domestic livestock and/or wild ungulates may change the structure and/or composition of native plant communities, thus changing their ability to support lynx and their prey. Livestock grazing may have the greatest potential to impact snowshoe hare habitat and populations, thus indirectly affecting lynx, in aspen stands and in high elevation riparian willow communities. In the western United States, high elevation shrub steppe habitats (especially high elevation sagebrush) may also constitute an important component of lynx habitat in areas with naturally fragmented forests. Therefore, within the elevational ranges of forested lynx habitat, livestock grazing should be managed to maintain or achieve mid seral or higher conditions, thereby providing maximum natural cover and prey availability. Those areas that are currently in late seral condition should not be degraded.

F. Other Human Developments

Other human developments that may alter lynx habitat include oil and gas exploration and development, mines, reservoirs, and agriculture. Most of these activities affect lynx habitat by changing or eliminating the native vegetation, and may also contribute to fragmentation. There may be an increased potential for human-caused mortality associated with the developments.

Leases (Oil & Gas) – The administration of mining and mineral leasing laws is primarily the responsibility of the Department of the Interior. Under certain legislation, the consent of the Secretary of Agriculture is required for exploration and development on national forest system lands. The Forest Service is responsible for managing surface use and occupancy on national forests. Decisions are made in two stages: request for leasing permit and permit for application to drill. If a lease is granted, the greatest amount of activity will occur during the exploration phase. During the production phase, human activity is focused on monitoring the wells, although remote monitoring is possible.

Development of wells can impact lynx habitat. However, the greatest impact is likely the development of road access to facilitate exploration and development. Snow compaction resulting from winter travel on roads may allow coyotes to easily move into higher-elevation lynx habitats, increasing competition for prey (Buskirk et al. 2000a). Brand and Keith (1979) found that improved access to remote areas from road construction associated with oil and mineral exploration and development, along with the advent of snowmobiles and all-terrain vehicles, greatly enhanced the mobility and efficiency of trappers.

Minerals (locatable & non-locatable) – Mining activity has waned since the turn of the century in much of the U.S. and Canada. Only a fraction of the historic sites operate today; those that continue to operate do so with more stringent environmental protection measures. The coal, phosphate, and oil and gas industries have been relatively stable or continue to grow. Mining may directly impact habitat and can promote recreational activities into certain areas, possibly influencing the distribution of lynx and other predators.

Reservoirs – Dam construction and inundation may directly affect habitat and may interrupt movements by resident lynx. Lynx dispersing after a snowshoe hare population decline in Canada were documented crossing large rivers and possibly portions of a large frozen lake (Poole 1997), but movements and behavior of dispersing and resident lynx differ. The location, size, type, and surrounding land use patterns strongly influence both the short and long term impacts of reservoirs.

Agriculture – Federal lands are normally not converted to agricultural uses, except for livestock pastures and corrals at some administrative sites. Agricultural uses on adjacent privately owned lands could possibly influence lynx habitat on federal lands, by attracting or providing habitat for competing species such as coyotes.

Factors Affecting Lynx Mortality

A. Trapping

Lynx, like most felids, are very vulnerable to trapping and easily overexploited (Mech 1980, Carbyn and Patriquin 1983, Parker et al. 1983, Ward and Krebs 1985, Bailey et al. 1986, Slough and Mowat 1996, Quinn and Thompson 1987). Ward and Krebs (1985) stated that trapping was the single most important mortality factor for lynx in their Yukon study area, where lynx harvest was responsible for seven of eight observed deaths. In another study, 65% of the estimated population was trapped the following winter and all marked lynx were harvested (Parker et al. 1983). Lynx populations may be even more susceptible to overexploitation as a result of expanding or abandoning their home ranges during years of low prey availability (Ward and Krebs 1985). At low population levels, or in situations where reproduction or recruitment are low, trapping mortality can be additive and lead to population declines (Brand and Keith 1979, Poole 1994, Slough and Mowat 1996, Mowat et al. 1996). In northern Canada, quotas, shortened seasons, season closures and/or untrapped refuges are commonly recommended during low periods of the snowshoe hare population cycle, to enhance the capability of lynx to respond as hare numbers rebound (Brand and Keith 1979, Parker et al. 1983, Bailey et al. 1986, Poole 1994, Mowat et al. 1996, Slough and Mowat 1996). Road access may increase the vulnerability of lynx to trappers (Bailey et al. 1986).

Lynx trapping is currently prohibited in all states except Montana and Oregon. In Montana, the lynx trapping season is closed for 1999-2000; however, up to 5 animals could be live-captured for translocations. In Oregon, furbearer harvest is regulated but lynx are not considered a furbearer by statute. Oregon Administrative Rules (OAR) can prohibit the harvest of unprotected mammals, but no OAR for lynx exists, which makes them a legal species for harvest.

Incidental trapping of lynx can occur in areas where regulated trapping for other species, such as wolverine, coyote, fox, and wolf, overlaps with lynx habitats (Mech 1973, Carbyn and Patriquin 1983, Squires and Laurion 2000). In addition, the various Native American Tribes are not subject to state trapping regulations. Tribal regulations vary, but many allow lynx harvest.

B. Predator Control

Predator control activities conducted on federal lands by USDA Wildlife Services (formerly Animal Damage Control) include trapping, shooting, and poisoning of carnivores on domestic livestock allotments, sometimes within occupied and/or suitable lynx habitats. Such actions are directed at specific species or offending animals. Individuals on adjacent private lands may conduct similar efforts. Wildlife Services captured and released a lynx in Idaho in 1991, but there are no other recent reports.

C. Incidental or Illegal Shooting

Lynx could be shot mistakenly by legal hunters or illegally by poachers. The actual magnitude of shooting mortality is unknown, but incidents were reported by Saunders (1963b), Mech (1973), Parker et al. (1983), Slough and Mowat (1996), and Lewis and Wenger (1998). Two of the lynx translocated into Colorado in 1999 were shot illegally (Shenk, pers. comm. 1999).

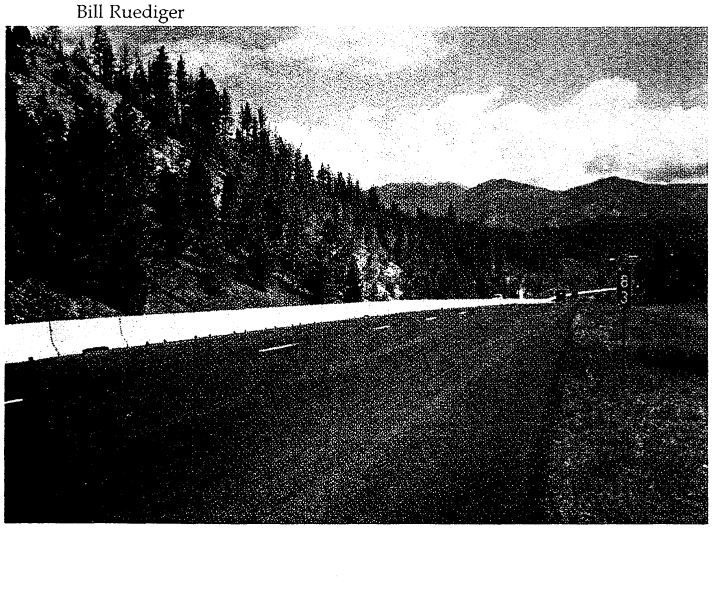
D. Competition and Predation as Influenced by Human Activities

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

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

Coyotes have expanded their range in recent decades (Fuller and Kittredge 1996). Mech (1970) reviewed reports of response of coyotes to wolf eradication. It appeared that coyotes expanded their range and increased in number as wolves were reduced in range and number. Crabtree and Sheldon (1999) also reported that in some areas of the contiguous U.S., wolves are increasing in numbers and distribution, while coyotes are decreasing in response.

Bill Ruediger



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

As described previously (in the recreation section), snow compaction due to resource management or recreation activities may facilitate movement of coyotes and other potential competitors and predators into lynx habitat, potentially increasing competition for primary lynx prey (Buskirk et al. 2000a).

E. Highways

There are few records of lynx being killed on highways, but direct mortality from vehicular collisions may be detrimental to small lynx populations in the lower 48 states. Other than translocated animals, there have been 2 documented occurrences of highway mortality, in Wisconsin (Theil 1987) and Minnesota (Don Carlos, unpubl. report 1997). Twelve resident lynx were documented being killed on highways in Canada and Alaska (Staples 1995, Gibeau and Heur 1996, T. Clevenger pers. comm. 1999, Alexander pers. comm. 1999).

An analysis done by Brocke in 1993 for the USDA Forest Service indicated that the three primary causes leading to extirpation of lynx in the White Mountain National Forest in New Hampshire likely were trapping, loss of habitat, and losses from highway kills. The model used suggested that trapping alone would not have accounted for the loss of lynx in New Hampshire (Brocke et al 1993).

In the Adirondack Mountains of New York, an attempt to reintroduce lynx failed, with 18 of 37 mortalities of translocated lynx attributable to road kills (Brocke et al. 1990). In a recent reintroduction into Colorado, two lynx have been killed on highways (G. Byrne, CDOW, pers. comm. 1999). Translocated animals may be more vulnerable to this form of mortality than resident lynx (Brocke et al. 1990), because they move extensively and are unfamiliar with their surroundings.

In Switzerland, the Eurasian lynx (Lynx lynx) population is threatened by the high rate of traffic accidents and illegal shooting that occur (Brietenmoser 1996). Ferreras et al. (1992) studying the Iberian lynx (Felis pardina) in southwestern Spain found that road traffic was the second most important cause of mortality. Highway mortality is the primary factor (along with habitat loss) endangering the Florida panther and the ocelot (Felis pardalis) (Jenkins 1996). Harris and Gallagher (1989) reported that 65% of known Florida panther kills since 1981 were road kills, while Maehr et al. (1991) calculated road mortality at a slightly more conservative figure of 49% of all documented deaths.

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

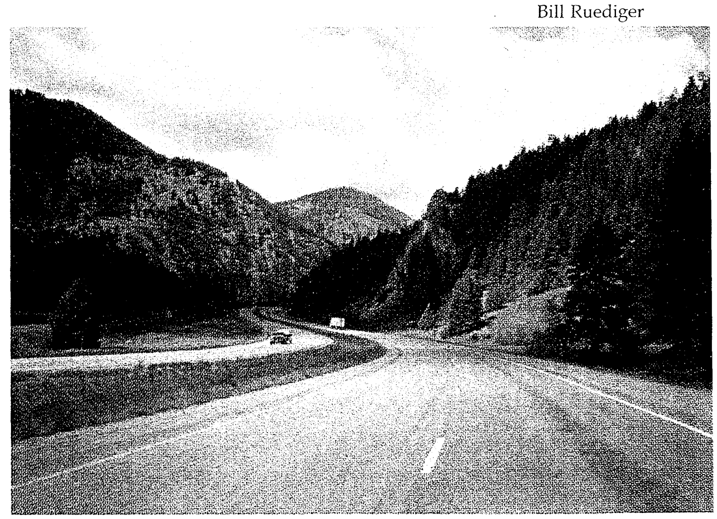
Traffic volumes that affect lynx mortality and dispersal have not been studied. However, recent contacts with biologists doing carnivore research on highways in Canada suggest that highway traffic volumes of 2,000-3,000 vehicles per day are thought to be problematic. Traffic volumes of 4,000 vehicles or more per day are considered to be serious impacts in terms of both mortality and habitat fragmentation (Clevenger and Alexander, pers. comm. 1999). Railroads, especially when paralleling major highways, increase both the mortality risks and habitat fragmentation (Woods and Munro 1996, Gibeau and Heuer 1996).

Factors Affecting Lynx Movement

A. Highways, Railroads and Utility Corridors

Highways can alter landscapes by fragmenting large tracts of land, some of which were previously homogenous habitats. Highways typically follow natural features such as lakes, rivers, and valleys that may have high habitat value for lynx. As the

Bill Ruediger



standard of road increases from gravel to 2-lane highways, traffic volumes increase. Lynx and other carnivores may avoid using adjacent habitat or become intimidated by highway traffic and may not cross (Gibeau and Heuer 1996). The degree of impact increases as highways are upgraded from 2-lanes to 4-lanes. Four lane highways, such as the Interstate Highway System, commonly have fences on both sides, service roads, paralleling railroads and impediments like "Jersey Barriers" that make successful crossing more difficult, or impossible. Highways can also directly affect the amount of feeding and denning habitat available to lynx by converting natural forests into road surface, right-of-ways or associated facilities such as maintenance areas or gravel pits.

Movements of radio-collared lynx were studied in the vicinity of a ski access road in Banff National Park. As many as 4,000 vehicles travel this road each day. Fifteen attempted crossings by lynx were recorded on this road, seven of which were aborted crossing attempts (Stevens et al. in prep., cited in Gibeau and Heuer 1996).

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

B. Land Ownership Pattern (federal, state, county, and private)

Lynx exemplify the need for landscape level ecosystem management. Land and population management must cross international, federal, state, county, and private land boundaries. Coordination within and between agencies and other landowners has often been difficult. In situations where habitat connectivity is needed to maintain adequate populations, private land development may preclude use by lynx, and may interrupt the connectivity of habitat and populations. In these situations, it will be important to provide conservation easements, land exchanges, or purchases to maintain adequate lynx habitat and populations.

Habitat fragmentation also may impede lynx movements. This could have negative effects by isolating lynx and/or prey populations, or by retarding movements to other areas.

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

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

C. Ski Areas and Large Resorts

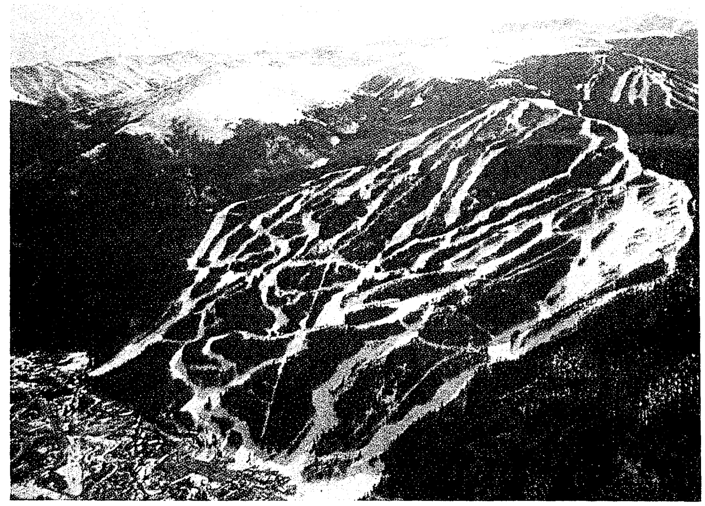
More than 50 ski areas exist throughout the range of the lynx in the contiguous United States. Even though these sites represent only a small fraction of the habitat available to lynx, their location on north-facing slopes, high seasonal and year-round use, and associated development may make them potentially important movement and dispersal risk factors.

In areas where lynx habitats occur as forested bands along mountainous terrain (e.g., Colorado and Idaho), ski runs and associated facilities may fragment continuous forest cover, or increase naturally fragmented conditions, and may thereby influence the movement of lynx. Increased development and use outside of the developed portion of permitted ski areas may provide access for lynx predators (i.e., coyotes) into deep snow environments where lynx would otherwise have the competitive advantage. Providing winter recreation access to areas outside of permitted boundaries using backcountry gates may preclude lynx from using certain portions of the landscape.

Several studies conducted in western Canada (Apps pers. comm. 1999, Roe et al. 1999) have documented lynx use of the middle to upper portions of ski areas. There is little evidence of lynx using the base area or other highly developed portions of the ski area, especially if forested cover is not present. Many of the ski areas in United States are larger and more developed than those investigated in western Canada. Several areas in the United States are clustered along narrow mountain ranges, such as those in the Tahoe Basin along the Sierra Mountain Range, Southern Rocky Mountains, White Mountains of New Hampshire, and Green Mountains of Vermont. A clustering of large resorts may have greater effects on lynx habitat use and movements than those reported in the western Canadian investigations.

Most highly developed facilities require supply, cleaning and maintenance throughout the operating season, generally outside of normal operating hours. Reports from some ski areas in western Canada indicate that lynx may be tolerant of grooming activities (Roe et al. 1999). However, the Canadian studies did not indicate how lynx might respond to other activities conducted outside normal operating hours. Therefore, consideration of operational guidelines may be especially important when ski areas expand or new ski areas are constructed into previously undisturbed lynx habitat. In areas where lynx habitat occurs in bands

Dave Ozawa



Ski areas

along the mountainous terrain (e.g., Colorado and Idaho), ski runs and facilities may dissect the forest, possibly restricting the movement of lynx. As development and use increase, snow compaction may enable other predators, such as coyotes, to gain a competitive advantage during the deep snow season when lynx would otherwise have an advantage.

Other Large-Scale Risk Factors

A. Fragmentation and Degradation of Lynx Refugia

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

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

Refugia have been recommended for lynx to avoid over-harvest by trapping (Ward and Krebs 1985, Bailey et al. 1986). Refugia must be large enough to protect a proportion of the local population (Poole 1994). Although the minimum size is unknown, evidence from Alaska and Manitoba indicate that areas as large as 3,000 km2 (1,170 mi2) may not be large enough for cyclic and heavily exploited populations (Carbyn and Patriquin 1983, Bailey et al. 1986). In north-central Washington, a lynx population of about 25 lynx has persisted in an area of about 1,800 km2 (700 mi2); this area is connected to additional lynx habitat and populations in Canada.

Given its susceptibility to human-caused mortality (e.g., trapping) and relatively specialized foraging strategy, refugia were identified as a possible element in a long-term conservation strategy for the lynx. However, we lacked sufficient time and information to establish mapping criteria and management recommendations for refugia. At a later time, refugia should be identified as part of an overall carnivore strategy. The identification of refugia will undoubtedly require the coordination and cooperation of a variety of landowners, both public and private, and could be addressed in a recovery plan.

B. Lynx Movement and Dispersal Across Shrub-Steppe Habitats

The apparent genetic homogeneity of the lynx throughout its range (Koehler and Aubry 1994) may suggest that genetic interchange has occurred, even in local populations that appear to be geographically isolated. Connectivity between island populations and populations in contiguous habitats is probably important for lynx persistence in many areas (McKelvey et al. 2000a).

In the western United States, lynx have been documented to occur in at least 23 mountain ranges that are surrounded by shrub-steppe habitats (Lewis and Wenger 1998). It is highly improbable that any of these mountain ranges have sustainable lynx populations in and of themselves. It is likely, however, that the animals that reside in these mountain ranges are part of a larger metapopulation (McKelvey et al. 2000a) and that dispersal across shrub-steppe habitats periodically occurs.

Within a lynx home range, inclusions of shrub-steppe habitat also may occur. Resident lynx are known to occasionally make exploratory movements into shrub-steppe habitats (Squires and Laurion 2000). In Idaho, more than 30 lynx were harvested in or immediately adjacent to shrub-steppe habitats during the relatively brief interval of jackrabbit population highs (Lewis and Wenger 1998).

It is possible that the occasional availability of abundant prey, such as jackrabbits, ground squirrels, sage grouse, and Columbian sharp-tailed grouse, could attract lynx into adjoining shrub-steppe habitats and enable lynx to successfully move between these mountain ranges. However, lynx dispersal between island habitats is poorly understood, and it is not known whether or to what extent lynx rely on these alternate prey species while dispersing.

It seems plausible that alteration of habitat could contribute to reduced incidence and success of lynx dispersal across shrub-steppe habitats. Conversion of shrub land to grasslands could be an important factor, because it involves large acreages and removes protective cover offered by shrubs. In the Snake River Birds of Prey National Conservation Area (NCA) in Idaho, studies found successive declines in jackrabbit densities through three population peaks, and concluded this may have been the result of increased cover of grasslands in the NCA from the 1970s until present (MacCracken and Hansen 1982). If the abundance of these species is important for successful dispersal of lynx, their decline could contribute to habitat fragmentation and isolation of lynx populations.

Livestock grazing can reduce forage availability to the point that it limits leporid population density (MacCracken and Hansen 1984). Studies have found black-tailed jackrabbit dietary overlap of 51% with cows and 56% with sheep (Johnson 1979). On the Idaho National Engineering Laboratory, leporids were most abundant on ungrazed sites (MacCracken and Hansen 1984). Similar impacts to sage grouse and Columbian sharp-tailed grouse populations have been recorded, due to reduction of available nesting cover by livestock grazing.

Overgrazing can also contribute to invasion of native grass and shrub communities by non-native plants.

C. Habitat Degradation by Non-native Invasive Plant Species

The impact of non-native invasive plants on biodiversity is a major concern in North America. Non-native species threaten two-thirds of all endangered species (Westbrooks 1998). They are considered by some experts to be second only to habitat destruction in the significance of their impact on native biodiversity (Pimm and Gilpin 1989, Randall 1996). Nonnative invasive plants may become established in both disturbed and undisturbed ecosystems, and pose an increasing threat to the integrity of wildland ecosystems. Currently, 2.4 to 2.8 million ha (6-7 million acres) of national forest lands are infested with nonnative invasive plants, and affected areas are increasing at rates of 8 to 12 percent per year (USDA Forest Service 1998). The Bureau of Land Management (BLM) estimated in 1996 that over 3.4 million ha (8.5 million acres) of BLM administered lands had serious nonnative invasive plant problems. They estimated that these invasive plants were spreading at a rate of 930 ha/day (2,300 acres/day), which would more than double the infested area by the year 2000 (USDI Bureau of Land Management 1996).

Although there is no documentation of the magnitude of effects of non-native invasive plant infestations specifically on lynx habitat in the United States, the potential exists for large-scale impacts and alteration of habitat. Weeds such as diffuse and spotted knapweed *(Centaurea diffusa, C. maculosa)*, leafy spurge *(Euphorbia spp.)*, rush skeletonweed *(Chondrilla juncea)*, dalmation toadflax *(Linaria dalmatica)*, and Canada thistle *(Cirsium arvense)* have the potential to alter these habitats at both the local and ecosystem scale. Many of these plants are more easily eradicated at infestation levels of a few plants or a few acres. Once established, they spread aggressively and become extremely difficult to control.

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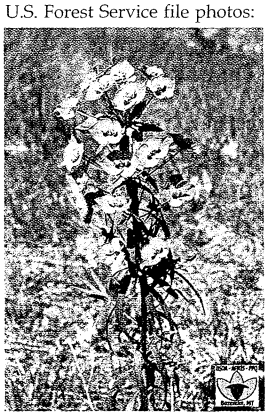
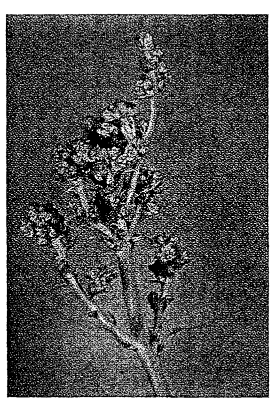
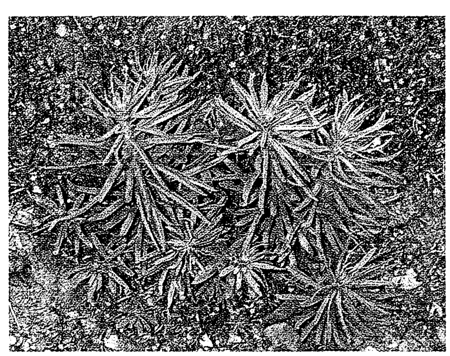


Leafy Spurge



Rush Skeletonweed



Dalmation Toadflax

Canada Thistle

Range-Wide Description and Risk Factors

Geographic Extent

The lynx occurs primarily in the boreal forests of Alaska and Canada, and adjoining areas in the contiguous U.S., extending southward down the mountain ranges in the western U.S. (Koehler and Aubry 1994). Large, contiguous areas of boreal, sub-boreal, and western montane forest appear to be necessary for the persistence of lynx populations. In Appendix A, the national forests, BLM field offices, national parks, and wildlife refuges that should develop or refine maps of known lynx occurrence and potential lynx habitat are identified.

Lynx Population Distribution

McKelvey et al. (2000b) reported on the history and distribution of lynx in the contiguous U. S. They compiled verified records of lynx occurrence in the lower 48 United States from 88 museums and private collections with > 10,000 specimens. In total, 345 records from 41 museums or private collections dating between 1842 and 1993 were obtained. The records indicate occurrence in 24 states. Trapping data from states and spatially referenced occurrence data (primary literature, unpublished reports, state survey efforts, museum records and casual observations) were also obtained. Verified records were scarce from most of the New England states. Maine reported a female with kittens in 1998, but there were few records prior to that. Between 1966 and 1998, there were 7 reported kills in the state. The Great Lakes states were much the same, with few verified records in the 19th and 20th centuries. Minnesota has several records of trapped lynx in the 1970s and 1980s. In the western states, Montana and Washington have documented reproducing populations, although there were no verified records west of the Cascades in Washington. In Idaho, there were 35 verified records between 1960 and 1991 and none since 1991. There were nine verified records in Wyoming between 1940 and 1957. Since then there have been two animals, a male and a female, radiocollared in the state. Records from the rest of the western states have been scarce.

Lynx Habitat

Lynx occur in mesic coniferous forests that have cold, snowy winters and provide a prey base of snowshoe hare. Vegetation types and elevations that provide lynx habitat are described as follows.

- **Northeastern U.S.:** Most lynx occurrences (88%) fell within Mixed Forest-Coniferous Forest-Tundra province; 77% of occurrences were associated with elevations of 250-500 m (820-2,460 ft) (McKelvey et al. 2000b). Lynx habitat includes coniferous and mixed coniferous/deciduous vegetation types dominated by spruce, balsam fir, pine, northern white cedar, hemlock, aspen, and paper birch.
- **Great Lakes states:** Most lynx occurrences (88%) fell within the Mixed Deciduous/Conifer Forest province (McKelvey et al 2000b). Lynx habitat includes boreal, coniferous, and mixed coniferous/deciduous vegetation types dominated by pine, balsam fir, black and white spruce, northern white cedar, tamarack, aspen, paper birch, conifer bogs and shrub swamps.
- **Western U.S.:** Most lynx occurrences (83%) were associated with Rocky Mountain Conifer Forest, and most (77%) were within the 1500-2000 m (4,920-6,560 ft) elevation zone (McKelvey et al 2000b). There is a gradient in the elevational distribution of lynx habitat from the northern to the southern Rocky Mountains, with lynx habitat occurring at 2,440-3,500 m (8,000-11,500 ft) in the southern Rockies. Primary vegetation that contributes to lynx habitat is lodgepole pine, subalpine fir, and Engelmann spruce (Aubry et al. 2000). In extreme northern Idaho, northeastern Washington, and northwestern Montana, cedar-hemlock habitat types may also be considered primary vegetation. In central Idaho, Douglas-fir on moist sites at higher elevations may also be considered primary vegetation. Secondary vegetation that, when interspersed within subalpine forests, may also contribute to lynx habitat, include cool, moist Douglas-fir, grand fir, western larch, and aspen forests. Dry forest types (e.g., ponderosa pine, climax lodgepole pine) do not provide lynx habitat.

Lynx appear to have a preference for gentle terrain when available (Apps 2000, McKelvey et al. 2000c). In rugged mountain ranges, lynx often occupy benches, plateaus, valleys, and gently rolling ridgetops (Koehler and Aubry 1994). This, along with the patchiness of prey resources, may explain their patchy distribution in the mountainous areas of the west.

Lynx are known to make long-range movements of 100 to 1,000 km (60 - 600 miles), particularly when dispersing in response to declines in prey populations (Mech 1980, Poole 1997). Shorter-distance movements may occur during periods of prey abundance as well. Maintaining connectivity between northern (Canadian) and southern habitats may be critical to the long-term persistence of lynx populations in the United States (McKelvey et al. 2000a).

Risk Factors—Rangewide

Risk Factors Affecting Lynx Productivity

At the southern periphery of its range, low recruitment may be typical of lynx populations because habitat conditions are marginal (Koehler 1990). When prey is scarce, kitten survival is low (Brand and Keith 1979, Carbyn and Patriquin 1983, Bailey et al. 1986).

Some timber management, fire suppression, and grazing practices may temporarily reduce prey populations, leading to low kitten survival. Conversion of native vegetation communities to forest types that are less suitable or unsuitable as lynx habitat may also decrease prey populations. Pre-commercial thinning results in a direct reduction of snowshoe hare habitat, at least in the short term (Sullivan and Sullivan 1988, Mowat et al. 2000, Ruggiero et al. 2000).

Road and trail access and recreational uses that result in snow compaction may allow ingress of coyotes into lynx habitat, thereby increasing competition for limited winter prey resources (Buskirk et al. 2000a).

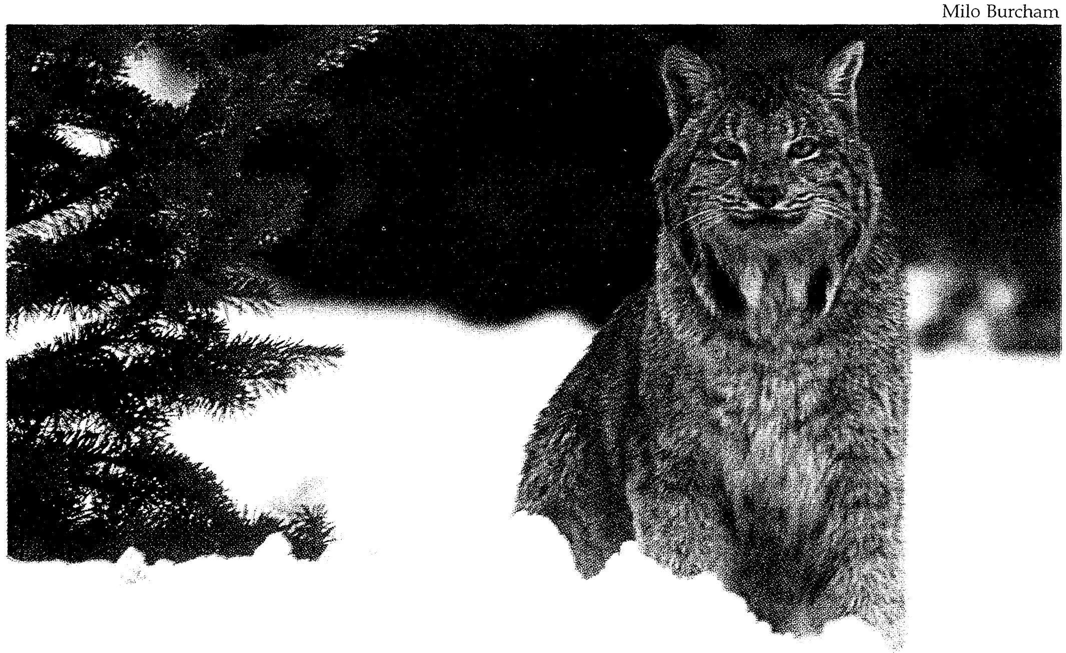
Risk Factors Affecting Mortality

All identified mortality factors apply range-wide. Descriptions of risk factors are further elaborated at the finer scales.

Risk Factors Affecting Movement

Highways and associated development within the right of way may impede movement by lynx. Private land development may impede movement by lynx.

Milo Burcham



Chapter 4

Lynx Geographic Areas: Descriptions and Risk Factors

For purposes of this analysis, we identified five lynx geographic areas: Cascade Mountains, Northern Rocky Mountains, Southern Rocky Mountains, Great Lakes, and Northeast (Fig. 1). Lynx geographic areas do not represent distinct lynx populations, or isolated subpopulations, or even currently occupied habitat. Each has unique ecosystems and management histories. Within these areas (refer to list of administrative units in Appendix A), lynx habitat will be mapped at a finer scale.

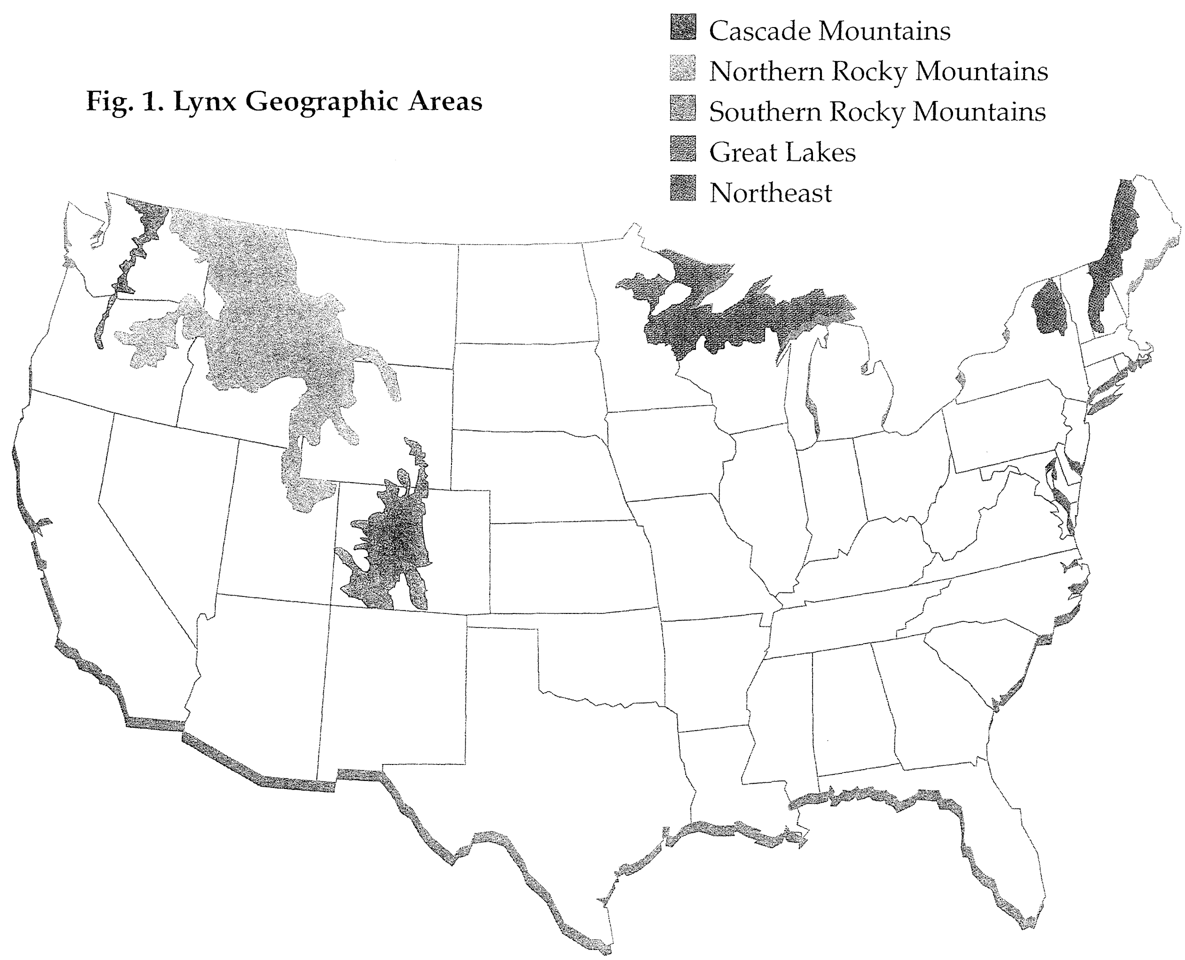


Fig. 1. Lynx Geographic Areas

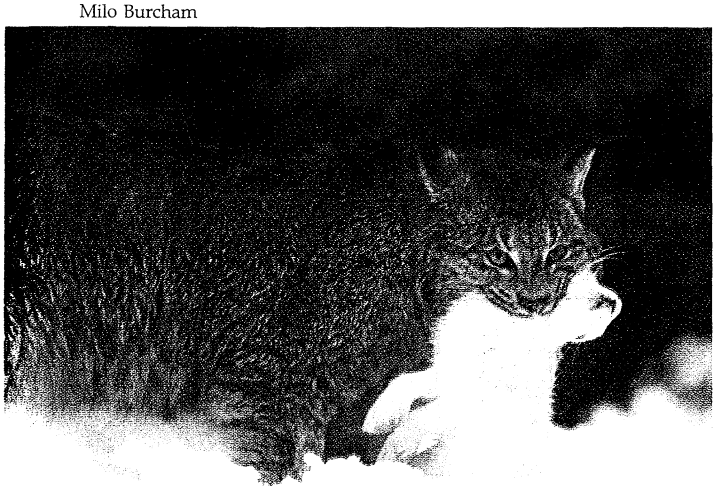
Cascade Mountains Geographic Area

Geographic Extent

Vegetation and landforms in the Cascade Mountains of Washington and Oregon have been described by Daubenmire and Daubenmire (1968), Franklin and Dyrness (1973), Demarchi (1994), McNab and Avers (1994), and Hann et al. (1997), among others. The Cascade Mountains Geographic Area is in the Cascade Mixed Forest - Coniferous Forest - Alpine Meadow province (McNab and Avers 1994). Three sections are described within this province: Oregon and Washington Coast Ranges, Western Cascades, and Eastern Cascades.

The Western Cascades section incorporates all habitats between the crest of the Cascade Mountains and Coast Ranges of Washington and Oregon, except the Puget Trough and Willamette Valley. Two primary landforms were described for this section: ancient slide complexes with deep weathering zones on relatively gentle terrain and steeply dissected debris slides that are associated with thin soils and resistant rock units. Elevations range from sea level to 4,300 m (>14,000 feet), although most of the area is between 600 m (2,000 feet) and 2,150 m (7,000 feet) elevation (McNab and Avers 1994).

Milo Burcham



Kuchler (1964) described the dominant potential vegetation of the Western Cascades section as silver fir-Douglas-fir forest with the second most dominant vegetation the fir-hemlock forest. Western spruce-fir forests are in the northern most portion of the Section. Pacific silver fir, mountain hemlock and subalpine fir vegetation series dominate the cryic regimes in this section (McNab and Avers 1994).

Primary disturbance regimes effecting vegetation in this section are fire, insects and disease, floods and windthrow (McNab and Avers 1994).

The Eastern Cascades section includes all vegetation types east of the crest of the Cascade Mountains in the Cascade Mountains Geographic Area. Volcanic peaks and glaciation have resulted in relatively steep eastern slopes. Many volcanic peaks are above the surrounding topography, some of which are still active. Volcanic ash originally covered the east slope. Elevations range from sea level to greater than 3,050 m (10,000 feet) (McNab and Avers 1994).

Natural disturbance as a result of fire is highly variable in the Eastern Cascades section. In the lower elevation ponderosa pine-lodgepole pine forests, mixed severity fires were common at 10-15 year intervals. Insect outbreaks in dense, overstocked stands and root rot were also common disturbance agents (McNab and Avers 1994).

Lynx Population Distribution

Museum records (McKelvey et al. 2000b) verify the presence of lynx in the Cascade Range of Oregon and Washington during historical times. However, lynx distribution was generally restricted to habitat occurring east of the Cascade Crest in northern Washington (Washington Department of Fish and Wildlife 1993). Current and historical records from the west side of the Cascade Crest in Washington, or in the Cascade

Range of Oregon are extremely rare; 12 verified records and 72 total records in Oregon (C. Lee USFWS pers. comm., Washington Department of Wildlife 1993, Koehler and Aubry 1994, McKelvey et al. 2000b). Lynx still occur in the north-central Cascades of Washington; Brittell et al. (1989), Koehler (1990), Rohrer (pers. comm.), and Skatrud (pers. comm.) have documented their continued occupancy of this area from 1980 through 1999 through capture and marking or with tracks and photographs.

During the summer of 1998, detection surveys for lynx using hair-snagging techniques and DNA analyses were initiated throughout the range of the northern spotted owl in Washington and Oregon as part of the Survey and Manage component of the Northwest Forest Plan. During the first year of operation, these surveys resulted in lynx detections at 14 different locations across a broad geographic area ranging from northern Washington (9) to central Oregon (5) (Weaver and Amato 1999). These findings contradict our current understanding of lynx distribution and abundance in this region, and species identifications for samples collected have not yet been confirmed. Hair-snagging surveys continued during the summer of 1999, across an expanded area that includes portions of the southern Oregon Cascades. Twelve survey sites (each with 125 sample points) using the national protocol method (McKelvey et al. 1999) and 16 blocks (16 square miles) each with 14 sample sites, using the Weaver method (Weaver and Amato 1999) were monitored in the Cascades; lynx were detected only on the Okanogan National Forest, in north central Washington. Sampling will continue in 2000 and 2001.

Lynx Habitat

Agee (2000) described western boreal forests as generally uniform in tree species composition: Engelmann spruce, subalpine fir, and lodgepole pine. In the Cascade Range, subalpine fir forests are the primary vegetation that may contribute to lynx habitat (McCord and Cardoza 1982, Koehler 1990, Apps 2000, Aubry et al. 2000a, McKelvey et al. 2000b). Lodgepole pine is frequently present as a seral species in this forest association. Cool, moist Douglas-fir, Pacific silver fir, grand fir, or western larch forests, where they are interspersed with subalpine fir forests, constitute secondary vegetation that may also contribute to lynx habitat.

Aubry et al. (2000a), Mowat et al. (2000) and McKelvey et al. (2000b) reported lynx to be absent or uncommon in wet, coastal forests of western North America. Habitat descriptions for the west side of the Cascade Range should include consideration of vegetation (both species and structure), snow, and topographic conditions that appear to provide suitable conditions for lynx and snowshoe hare.

Koehler and Aubry (1994) described lynx habitat as generally in areas of low topographic relief. Apps (2000) found selection for slope was significant among 3 of 6 radio-telemetered lynx in the southern Canadian Rocky Mountains. Of those 3 animals, 2 selected and 1 avoided slopes <20 percent during the summer, and slopes >40 percent were avoided by all three during winter. Slopes west of the Cascade crest generally are steeper than those east of the crest, especially in subalpine habitats used by lynx, suggesting lower habitat potential on the west side (Henderson et al. 1992).

The elevations of lynx habitats vary, depending on moisture patterns and temperatures. On the east side of the Cascade Mountains, subalpine fir plant associations are generally present above 1,220 m (4,000 feet) (Williams and Lillybridge 1983, Lillybridge et al. 1995). These vegetation types generally occur in areas with heavy winter snowfalls.

Risk Factors Specific to the Cascades

Risk Factors Affecting Lynx Productivity

Some timber management actions and fire suppression may influence habitat in a way that results in reduced prey populations, leading to low kitten survival. Practices that alter tree species distribution and abundance, especially in lodgepole pine communities, may be detrimental to lynx. Precommercial thinning reduces habitat quality for snowshoe hare and lynx, at least in the short term (Ruggiero et al. 2000b).

Road and trail access and recreational use that results in snow compaction can allow ingress of coyotes into lynx habitat, and increased competition (Buskirk et al. 2000a).

Risk Factors Affecting Mortality

Lynx trapping is currently not legal in Washington. In Oregon, lynx are not considered a furbearer, therefore are not covered by regulations for furbearers and can be legally taken. Trapping seasons exist for other carnivores such as bobcat and coyote, but most trapping for these species occurs outside the habitat of lynx.

In this geographic area, while the status of the bobcat population is currently unknown, the population of coyotes is thought to have increased. Historically, coyotes were extremely rare in the Cascades of Oregon and Washington. Coyote harvests in Washington increased from an average 362/year in the mid-1960's to an average of 16,250/year in the mid-1980's. The increase in the coyote population is thought to be coincident with the extirpation of wolves from Washington around 1930 (Buskirk et al. 2000a). Dispersing wolves occasionally occur in this area but pack activity has not been documented. Also, while there are no specific population data, it is thought that the mountain lion population has increased as well.

USDA Wildlife Services conducts predator control actions associated with livestock allotments, primarily targeted for coyotes, bobcats and mountain lion, on some forests in Washington and Oregon. No lynx have been reported taken during predator control activities recently. The effect of these practices on lynx in the Cascade Mountains is unknown.

One accidental lynx shooting occurred in October 1999 in the Washington Cascades. A lynx was shot by a licensed hunter, who mistook it for a bobcat (Harriet Allen, WDFW pers. comm. 1999). Prior to that incident, no illegal or accidental lynx shootings were reported in this geographic area within the last decade.

Highways may pose a threat of vehicular collision, although the risk appears to be minor.

Risk Factors Affecting Movement

A two-lane highway, a four-lane interstate highway, dams, a railroad, and associated human developments likely preclude movements between the Oregon and Washington Cascades. Historically, lynx may have moved across this area by crossing the Columbia River.

Four-lane highways such as I-90 may impede lynx movements within the Washington Cascades. Paved two-lane highways also have been shown to impede lynx movements in some areas (Apps 2000).

Northern Rocky Mountains Geographic Area

Geographic Extent

The Northern Rocky Mountains Geographic Area encompasses northern, central, and southeastern Idaho, western Montana on both sides of the Continental Divide, northeastern and southeastern Washington, northeastern Oregon, northeastern Utah, and western Wyoming. Landforms, climate, and vegetation across this large area are complex and highly variable.

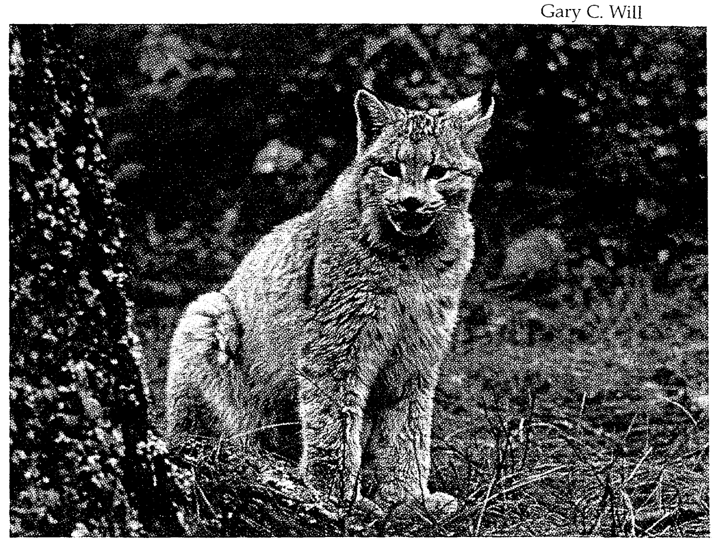
Within the current post-glacial period, climate in this area has been relatively stable for the past 1,700 to 2,000 years (Mack et al. 1983). Across the Northern Rocky Mountains Geographic Area, there are strong north-south and east-west gradients in climate. The northwestern portions have a cool temperate, maritime-influenced climate, while the eastern and southern portions have a cold continental climate (McNab and Avers 1994). As a result, vegetation varies from moist, dense conifer forests, to less productive forests with greater interspersion of grasslands and shrub lands. Koehler and Aubry (1994) suggest that there is a general pattern of decreasing habitat suitability for lynx with decreasing latitude in the Rocky Mountains.

The Northern Rocky Mountains Geographic Area intersects three ecological Provinces (McNab and Avers 1994, Bailey 1998). The following describes the characteristics of each Section within these Provinces.

Northern Rocky Mountain Province

- Okanogan Highlands Section (M333A): This Section includes northeastern Washington and southern Canada. Major rivers include the Columbia and Pend Oreille Rivers. Climate is maritime-influenced, with a strong east-west precipitation gradient. Elevations range from 420 - 2,225 m (1,375 - 7,300 feet).
- Flathead Valley Section (M333B): This Section includes northern Idaho and northwestern Montana, and adjoining areas in southern Canada. Major rivers include the Yaak and Kootenai Rivers. Climate is cool temperate with some maritime influence. Elevations range from 610 - 2,135 m (2,000 - 7,000 feet).
- Northern Rockies Section (M333C): This Section includes northwestern Montana, and adjoining areas in southern Canada. Major rivers include the North, Middle and South Forks of the Flathead River. Climate is cool temperate with minor maritime influence, and elevations range from 915 - 2,900 m (3,000 - 9,500 feet).

Gary C. Will

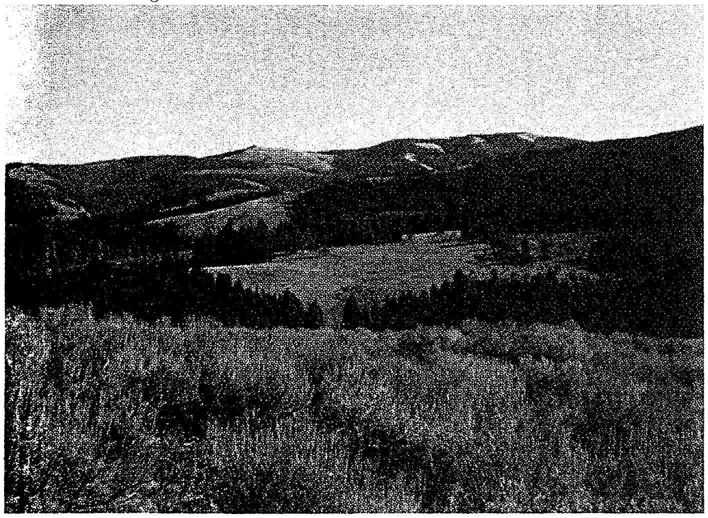


- Bitterroot Section (M333D): This Section lies in northern Idaho and northwestern Montana, south of the Flathead Valley Section. Major rivers are the lower Clark Fork and North Fork of the Clearwater. Climate is maritime influenced, cool, moist temperate. Elevations range from 365 - 2,135 m (1,200 - 7,000 feet).

Middle Rocky Mountain Province

- Idaho Batholith Section (M332A): This Section falls within central Idaho. Major rivers include the Salmon, Selway, and Payette Rivers. Climate is maritime influenced, cool temperate. Elevations range from 915 - 3,050 m (3,000 - 10,000 feet).
- Bitterroot Valley Section (M332B): This Section falls within western Montana. Major rivers include the Bitterroot and upper Clark Fork Rivers. Climate is cool temperate with some maritime influence. Elevations range from 760 - 2,440 m (2,500 - 8,000 feet), with peaks up to 3,050 m (10,000 feet).
- Rocky Mountain Front Section (M332C): This Section is located in Montana, east of the Continental Divide. Major rivers include the Two Medicine and Sun Rivers. Climate is cold continental, with severe chinook winds

Dick Wenger



Landscape mosaic

and dramatic winter temperature fluctuations common. Elevations range from 1,680 - 2,600 m (5,500 - 8,500 feet).

• Belt Mountains Section (M332D): This Section encompasses the Belt formation in Montana east of the Continental Divide. Major rivers include the Missouri and Smith Rivers. Climate is cold continental, with strong winds and winter temperature extremes common. Elevations range from 1,220 - 2,590 m (4,000 - 8,500 feet).

• Beaverhead Mountains Section (M332E): This Section encompasses southwestern Montana and portions of central Idaho. Major rivers include the Beaverhead, Lemhi, and Ruby Rivers. Climate is cold, dry continental. Elevations range from 1,220 - 3,600 m (4,000 - 12,000 feet) in the mountains.

• Challis Volcanic Section (M332F): This Section encompasses portions of central Idaho east of the Beaverhead Mountain Section. Major rivers include the Salmon, Wood, and Big Lost Rivers. Climate is cold continental, with mountains to the west producing a rain shadow effect. Elevations range from 1,220 - 3,600 m (4,000 - 11,800 feet).

• Blue Mountains Section (M332G): a wide plateau and moderately dissected mountains characterize This Section. A major feature near the eastern edge is the Snake River Canyon. Elevations range from 1,220 - 2,290 m (4,000 - 7,500 feet) in the mountainous portion.

Southern Rocky Mountain Province [Note that Southern Parks and Mountain Ranges (M331F), South-Central Highlands (M331G), North Central Highlands (M331H), and Northern Parks and Ranges (M331I) are not in this lynx geographic area.]

• Yellowstone Highlands Section (M331A): a wide plateau and moderately dissected mountains characterize This Section. Major rivers include the Yellowstone and Gallatin Rivers. Climate is cold, moist continental. Elevations range from 1,830 - 3,960 m (6,000 - 13,000 feet) in the mountains.

• Bighorn Mountains Section (M331B): a wide plateau and moderately dissected mountains characterize This Section. Major rivers include the Tongue, Shell, and Tensleep Rivers. Climate is cold continental with cold, dry winters. Elevations range from 1,220 - 3,960 m (4,000 - 13,000 feet).

• Overthrust Mountain Section (M331D): This Section lies within western Wyoming, southeastern Idaho, and north-central Utah. Rivers flow into the Great Basin or Snake River drainage, with a small area drained by the Colorado River. Climate is cold continental. Elevations range from 1,525 - 3,960 m (5,000 - 13,000 feet), with the Teton Range being the highest in this Section.

• Uinta Mountains Section (M331E): This Section lies within northeastern Utah and the southwest corner of Wyoming. Precipitation ranges from 200 - 890 mm (8 to 35 inches) annually. Elevations range from 1,830 - 3,960 m (6,000 - 13,000 feet).

• Wind River Mountains Section (M331J): This Section is located in western Wyoming. Climate is continental, with precipitation ranging from 375 - 2,550 mm (15 - 100 inches) annually. Elevations range from 1,830 - 3,960 m (6,000 - 13,000 feet).

Lynx Population Distribution

Montana: Lynx have been documented, historically and currently, throughout the Rocky Mountains of Montana, from the Canadian border through the Yellowstone area. Lynx presence has also been verified in the Big Belt, Little Belt and Crazy Mountains (Butts 1992, D. Godtel, USDA Forest Service, pers. comm. 1999). Trapping records indicate past lynx occupancy in the Big Snowy and Little Snowy Mountains and the Highwood Mountains (D. Godtel, pers. comm. 1999). Further survey or verification of current lynx presence should be done in the isolated mountain ranges, including the Big Snowy and Judith Mountains. There were restricted trapping seasons for lynx in Montana from 1991-1999 (quota of one each on the east and west sides of the Continental Divide annually). Lynx trapping is closed in Montana for the 1999-2000 season; however, up to 5 animals may be live-captured for translocation.

Idaho: Lynx presence has been well documented, historically and currently, throughout the Panhandle of Idaho. In 1998, a survey for lynx using hair-snagging techniques and DNA analyses was conducted in the Priest Lake, Bonners Ferry, and Sandpoint areas of northern Idaho. Lynx hair was collected at 5 separate locations across the survey area (Weaver 1999). Interviews of Idaho residents documented additional records of lynx in the Salmon, Upper Snake, and Bear River watersheds as well (Lewis and Wenger 1998). Other areas in Idaho that have consistent historical records over time include the Stanley Basin, the Henry's Lake/Island Park area, the Lemhi Range, and the upper Bear River watershed. The lynx is considered a species of special concern by the state of Idaho.

Wyoming: Lynx presence has been documented historically and currently in western Wyoming from the Yellowstone area through the Wyoming Range and Wind River Range, and in the Bighorn Mountains (McKelvey et al. 2000b). Recent reproduction has been documented in the Wyoming Range (Squires and Laurion 2000). [Note that the Medicine Bow Mountains are discussed in the Southern Rocky Mountains Geographic Area.] The lynx is considered a species of special concern by the state of Wyoming.

Northeastern Washington: Lynx occurrence, currently and historically, has been well documented in Washington, with the two primary areas being the Cascade Mountains and the northeastern corner of the state (McKelvey et al. 2000b). The lynx is considered threatened by the state of Washington.

Northeastern Oregon and Southeastern Washington: Lynx have been documented in the Blue Mountains and Wallowa Mountains (Butts 1992), but there are relatively few records of lynx in Oregon (McKelvey et al. 2000b). About half of the verified records are from the northeastern corner of Oregon. This area may be important in providing connectivity between Idaho and the Cascade Mountains Geographic Area, although the Snake River and Hells Canyon likely would impede lynx movements. The species is officially considered threatened by the state of Washington, and an infrequent and casual visitor by the state of Oregon.

Utah: There are records of lynx occurrence in the Uinta Range (Butts 1992, Lewis and Wenger 1998). A few records also exist from the Wasatch Range and the Manti La Sal (Laura Romin, pers. comm. 1999). However, it is unlikely that the La Sal or Abajo Mountains ever supported a resident lynx population, given the scarcity of records and the absence of snowshoe hares (memo from Janette Kaiser dated March 17, 1999). The last verified records of lynx from Utah were in 1977 for physical remains and 1982 for tracks (McKelvey et al. 2000b). The lynx has been protected from harvest since 1974, and is listed as a sensitive species by the state of Utah.

Nevada: The Jarbidge Mountains in Nevada, an isolated range just south of the Idaho border, may contain potential lynx habitat, but extensive surveys to determine lynx occurrence have not been conducted. Only 2 historical records exist from Nevada.

Lynx Habitat

Historical and current lynx records from this geographic area occur primarily in the Douglas-fir forest, spruce-fir forest, and fir-hemlock forest Potential Natural Vegetation types (Kuchler 1964, Pfister et al. 1977, Steele et al. 1981, Johnson and Simon 1987, Williams et al. 1995). A gradient in the elevation distribution of lynx habitat is apparent across the Northern Rocky Mountains Geographic Area. In the higher latitudes of northern Idaho and northwestern Montana west of the divide, lynx habitat generally occurs above 1,220 m (4,000 feet) (Koehler and Brittell 1990). Plant associations that may provide lynx habitat are found above 1,525 m (5,000 feet) in elevation in eastern Oregon (Johnson and Clausnitzer 1992), and above 1,980 m (6,500 feet) in Wyoming (Koehler 1990).

Fire has been a dominant influence historically in the northern Rocky Mountains (Gruell 1983, Barrett et al. 1997). Stand-replacing fires maintained a landscape mosaic that provided ideal snowshoe hare and lynx habitat (Koehler 1990). Non-lethal fires, avalanches, insects, and pathogens have also been important agents of disturbance, creating more structural diversity at a smaller scale.

Fire regimes in the Northern Rocky Mountains are extremely complex, reflecting great variation in climate, topography, vegetation, and productivity (Kilgore and Heinselman 1990). In general, the dominant regime in lynx habitat in pre-settlement times was long-interval (40-200 years), high severity, stand-replacing fire in continuous forests of lodgepole pine, spruce, and subalpine fir, often with smaller acreages subjected to non-lethal, low-severity fires in the intervals between stand-replacing fires (Fischer and Bradley 1987, Losensky 1993, Smith and Fischer 1997).

Aspen community types occur as scattered inclusions throughout all conifer habitat types, especially in central and southeastern Idaho, southern Montana, Utah, and Wyoming. Though common and widely distributed, aspen forests occupy a very small percentage of the total forested area. However, they do provide important habitat diversity and thus may contribute to the quality of lynx foraging habitat. Aspen/tall forb community types, especially those that include snowberry (Symphoricarpos alba), serviceberry, and chokecherry (Prunus virginiana) shrub understories, are very productive in terms of lynx prey. These communities are most prevalent in southeastern Idaho where they may provide good snowshoe hare habitat, especially where adequate aspen regeneration is occurring.

In areas that are naturally fragmented, high elevation shrub steppe habitats (especially high elevation sagebrush) that occur within the elevation ranges of forested lynx habitat may constitute an important component of lynx habitat.

Because the Northern Rocky Mountain Geographic Area encompasses a large and diverse region, the following presents descriptions of vegetation and elevation conditions that provide lynx habitat by state.

Montana: Lynx research has been conducted in the South Fork of the Flathead (Section M333C), Cabinet Mountains (Section M333D) and Garnet Mountains (Section M332B), and Seeley-Swan valley (Section M332B) (Koehler et al. 1979, Brainerd 1985, Smith 1984, Squires and Laurion 2000). In addition, research that may be applicable to Montana is in progress in southern British Columbia and Alberta (Apps 2000).

Most locations of two radio-collared lynx in the Bob Marshall Wilderness Area, South Fork of the Flathead River, were in dense lodgepole pine stands that resulted from a 1910 burn (Koehler et al. 1979). Within the burned area, 23 lynx locations were in lodgepole pine stands and 3 were in stands dominated by subalpine fir and Engelmann spruce. The remaining 3 locations were in mature Douglas-fir/western larch stringers along stream bottoms that escaped the 1910 burn. Snowshoe hares were also found to be most abundant in densely stocked stands of lodgepole pine, and ground tracking indicated that lynx activity was concentrated within areas of high hare activity.

In the Cabinet Mountain study area, 2 lynx were studied in the west fork of Fishtrap Creek, which has moderate, rolling topography in the lower reaches and steep alpine ridges in the headwaters (Brainerd 1985). Seven lynx were marked in the Garnet Range study areas. The Garnet Range is characterized by relatively moderate, rolling topography, with gentle to moderate slopes dissected by steep limestone canyons, mostly covered by coniferous forests. Habitat use by 5 lynx in these study areas was described as occurring in subalpine fir forest associations (Smith 1984).

The Seeley-Swan study area ranges in elevation from about 1,200 - 2,100 m (3,900 - 6,900 feet). Most lynx radiolocations have been in the mid elevation range of 1,300 - 1,800 m (4,260 - 5,900 feet), with a few locations up to 2,100 m (6,900 feet). Lynx generally occur in moist subalpine fir habitat types, above the dry ponderosa pine and Douglas-fir habitat types, and below the alpine zone (J. Squires, pers. comm. 1999).

Within the study area in southern British Columbia and Alberta, elevations range from 1,200 - 3,000 m (3,900 - 9,800 feet). Most lynx established home ranges at mid elevations between 1,550 - 1,850 m (5,050 - 6,070 feet), and with moderate to gentle slopes (<40%) (Apps 2000). Mid elevations in the study area are dominated by spruce-fir forests, with lodgepole pine as a seral species.

In summary, primary vegetation that may provide lynx habitat in Montana west of the Continental Divide is subalpine fir forest associations [habitat types], generally between 1,220 - 2,150 m (4,000 - 7,000 feet). Cover types may be mixed species composition (subalpine fir, lodgepole pine, Douglas-fir, grand fir, western larch, and hardwoods) as well as pure lodgepole pine stands (J. Squires, pers. comm. 1999). Moist Douglas-fir and moist grand fir habitat types, where they are intermixed with subalpine fir habitat types, constitute secondary vegetation that may provide habitat for lynx. In extreme northwestern Montana (Kootenai National Forest), primary vegetation may include cedar-hemlock habitat types intermixed with subalpine fir habitat types that receive heavy snow accumulation, but not moist Douglas-fir habitat types.

On the east side of the Continental Divide, elevation ranges of subalpine forests are higher, roughly between 1,650 - 2,400 m (5,500 - 8,000 feet). Subalpine fir forests are the primary vegetation, and intermixed Engelmann spruce and moist Douglas-fir habitat types where lodgepole pine is a major seral species are secondary vegetation that may contribute to lynx habitat.

Idaho: In general, lynx habitat in Idaho is the same as described for western Montana.

In northern Idaho, including the Priest Lake, Kootenai, Pend Oreille, Coeur d'Alene, and St. Joe Subbasins, western redcedar (Thuja plicata) and western hemlock (Tsuga heterophylla) habitat types support relatively high densities of snowshoe hares, and lynx appear to make regular use of these areas as documented by both historical and current lynx sightings. The western redcedar and western hemlock communities within this region are boreal in nature, with long winter periods and deep snowpack. These communities are highly productive habitats for both snowshoe hare and lynx at either end of the successional spectrum (T. Layser, pers. comm. 1999). In the Priest Lake Subbasin, and portions of the Kootenai and Pend Oreille Subbasins, western redcedar, hemlock, and moist grand fir habitat types are included as lynx habitat, generally down to 1,070 m (3,500 feet) but in some areas extending down to 914 m (3,000 feet). In the Coeur d'Alene and St. Joe Subbasins, cedar/hemlock habitat types generally above 1,220 m (4,000 feet) are considered lynx habitat only when in association with subalpine fir and spruce habitat types.

The subalpine fir series occurs at upper elevations throughout most of central Idaho (Steele et al. 1981). Large stands of fire-induced lodgepole pine commonly dominate much of this series and, especially when interspersed with unburned islands of subalpine fir, often provide very good quality lynx habitat. Undergrowth is variable and ranges from tall shrub layers of huckleberry (Vaccinium spp.) and menziesia (Menziesia ferruginea) to low, depauperate layers of grouse whortleberry (Vaccinium scoparium) or heartleaf arnica (Arnica cordifolia). Thus, the quality of lynx foraging habitat (i.e., snowshoe hare habitat) often varies greatly by habitat type. Engelmann spruce stands commonly occur along streams and valley bottoms where cool air drainage allows them to extend into the adjacent, lower elevation Douglas-fir communities. Habitat types within the series often occur on very wet sites and on steep northerly aspects where snow accumulates (Steele et al. 1981). Though a minor series, Engelmann spruce habitat types commonly provide good lynx travel corridors and denning habitat.

In central Idaho, lodgepole pine community types and habitat types are not widespread but do commonly appear on more gentle terrain, toe-slopes and valley bottoms wherever the species can dominate the site (Steele et al. 1981). Such stands usually grade into subalpine fir or Douglas-fir habitat types on adjacent steeper or higher slopes. Subsequent to disturbances such as fire, these lodgepole pine communities often provide good quality lynx foraging habitat.

Douglas-fir habitat types occur over the broadest range of environmental conditions of any conifer in central Idaho (Steele et al. 1981). Douglas-fir communities often extend from lower to upper timberline. The types of most importance to lynx include those where lodgepole pine is a seral species and moist habitat types that can produce dense understory shrubs.

Northeastern and southeastern Washington, northeastern Oregon: Primary vegetation that may contribute to lynx habitat is subalpine fir habitat types where lodgepole pine is a major seral species, generally between 1,250 - 2,000 m (4,100 - 6,600 feet). Moist grand fir and moist Douglas-fir habitat types, where they are intermixed with subalpine fir habitat types, constitute secondary vegetation that may also contribute to lynx habitat. In the Selkirk Mountains of extreme northeastern Washington, primary vegetation includes the cedar/hemlock habitat types as described above for northern Idaho.

Wyoming: Squires and Laurion (2000) described the study area in the Wyoming Range in which 2 lynx have been radio-collared. Topography is steep to rolling, with about 20% of the area being non-forested and about 10% riparian. Forest cover on drier sites is primarily homogeneous stands of lodgepole pine. About 10% of forest cover is aspen. Spruce-fir forests, which generally occur on north aspects, comprise about 20% of vegetation cover.

In Wyoming, primary vegetation that may contribute to lynx habitat includes subalpine fir, Engelmann spruce, and lodgepole pine forests at the higher elevations, generally 2,000 - 3,000 m (6,500 - 9,800 feet).

Utah: In the Uinta Range, Engelmann spruce, white fir, subalpine fir, and lodgepole pine forests at the higher elevations, 2,250 – 3,250 m (7,300 - 10,500 feet) are primary vegetation that may contribute to lynx habitat. Quaking aspen dominates over much of the landscape on mountain slopes, but snowshoe hares may use aspen stands much less than conifer stands in this area (Wolfe et al. 1982), probably because they lack dense understory cover (Hodges 2000b). Where they are intermixed with spruce-fir and lodgepole pine stands, aspen stands would constitute secondary vegetation that may contribute to lynx habitat.

Habitat Connectivity

Maintaining connectivity with Canada and between mountain ranges is an important consideration for the Northern Rocky Mountains Geographic Area. It is likely that the Northern Rocky Mountains Geographic Area and the Southern Rocky Mountains Geographic Area of Colorado and southern Wyoming are poorly connected. Lynx have been documented in at least 7 mountain ranges adjacent to the Snake River plain that are completely surrounded by shrub-steppe habitats. The Snake River plains are a large expanse of land in Idaho where native vegetation is dominated by shrubs and perennial bunch grasses. It is bisected by Interstates 15, 84, and 86 and extensive agricultural development. This scenario where connectivity must occur across large treeless expanses is not unique to Idaho and also includes mountain ranges in Montana, Wyoming, and Utah.

Shrub-steppe communities in central and southern Idaho, Wyoming, southeast Montana, and eastern Oregon may provide connectivity between adjacent mountain ranges. Along the Continental Divide, they may also provide an important north-south link between large patches of lynx habitat.

Risk Factors Specific to the Northern Rockies

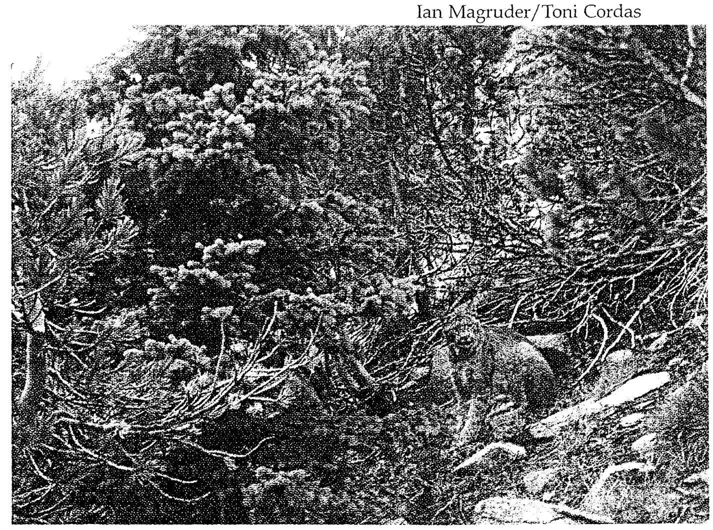
Risk Factors Affecting Lynx Productivity

In some areas, timber management and fire suppression have affected lynx habitat. Conversion or alteration of native vegetation communities in and adjacent to lynx habitat would decrease prey populations. Precommercial thinning has a direct negative effect on snowshoe hare habitat, at least in the short term.

Grazing use levels, by livestock and/or wild ungulates, may increase competition for forage resources with lynx prey. By changing native plant communities, such as aspen and high elevation riparian willow, grazing can degrade snowshoe hare habitat. Domestic livestock grazing is common in lynx habitats throughout the southern portions of this geographic area.

Road and trail access and recreational use that results in snow compaction may allow ingress of coyotes into lynx habitat, and increased competition for prey (Buskirk et al. 2000). New road construction is occurring at a much slower rate now than in recent decades. However, road densities may be high in some areas, and winter recreation use is increasing significantly in this geographic area.

Ian Magruder/Toni Cordas



Risk Factors Affecting Mortality

The lynx trapping season is closed in Montana for the 1999-2000 season. Occasionally, lynx are incidentally trapped, especially in Montana, Idaho, and Wyoming during the trapping seasons for other carnivores, particularly bobcat and wolverine (Squires and Laurion 2000). For example, bobcat trappers incidentally trapped 2 lynx in Idaho in 1991. In Montana during the winter of 1997/98, at least 3 lynx were captured by wolverine trappers and subsequently radio-collared for research (J. Squires, Univ. of Montana, pers. comm. 1999). Incidentally trapped lynx can be released alive, but the likelihood of injury may be high, depending on the type of trap and frequency of trap checking, and some may perish.

Predator control activities on federal lands are commonly conducted throughout this geographic area, but the level of activity is currently lower than historical levels. Such efforts are aimed specifically at the offending animal or target species and take place outside of lynx habitats, in lower elevation rangelands. Since the ban on poisons such as 1080, predator control activities on federal lands conducted by USDA Wildlife Services probably have a low potential to impact lynx. Predator control activities on private lands, though not as closely controlled as on federal lands, generally occur outside of, but may be within or adjacent to, lynx habitats.

Though uncommon, lynx have been trapped or shot legally, illegally, and incidentally throughout this geographic area.

Mountain lion numbers are currently believed to be high throughout the Northern Rocky Mountains Geographic Area. Idaho, Utah and Montana have recently liberalized their mountain lion hunting seasons. In northwestern Montana, the 1999-2000 lion season regulations will be modified to more moderate harvest levels, due to very successful harvest results in 1998-1999. Wolf packs are now well established in Montana, Idaho and the Yellowstone area. It is possible that the higher population numbers of wolves may increase the potential for predation on lynx, although the risk is probably low. Wolves may also reduce coyote populations, thereby reducing the potential for coyote competition with lynx. Ongoing studies in Montana and Wyoming may yield information concerning this mortality factor.

Highways such as I-90, I-15, US-2, US-12, and US-93 may pose a threat of lynx/vehicle collisions. These highways pass through occupied lynx habitats and potential landscape linkages, and thus may affect both resident and dispersing individuals.

Risk Factors Affecting Movement

Highways and associated development within the right of way may affect movements by lynx. In Montana, I-90, I-15, Highway 93, and Highway 2 could discourage lynx movement. State Highway 83 bisects lynx habitat in the Swan valley, although radio-collared lynx are known to cross this highway (Squires and Laurion 2000). In Idaho, I-90, I-15, Highway 2 and Highway 93 may impede movement; Highways 12 and 95, and State Highways 55 and 75 intersect lynx habitats. Interstate 84 crosses the Blue Mountains of southeastern Washington and northeastern Oregon. In Utah, I-80 may impede movement between the Wasatch and Uinta Ranges. In Wyoming, highways in the Yellowstone area may impede movement due to their high traffic volumes; Highway 14 may impede movement in the Bighorn Range, and Highway 26 and Highway 189 may impede movement in the Wind River and Wyoming Ranges.

Private land development, especially along road corridors in mountain valleys, may fragment habitat and impede movement by lynx.

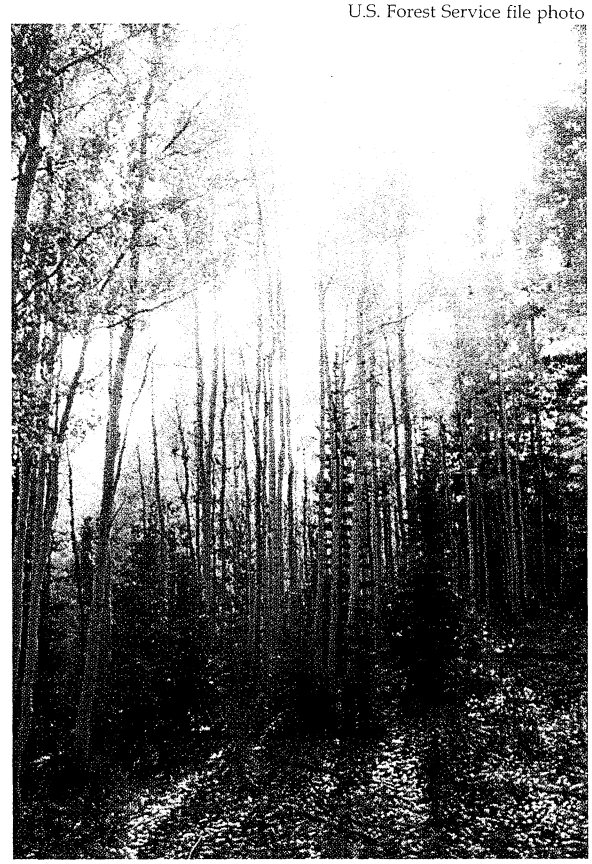
Southern Rocky Mountains Geographic Area

Geographic Extent

The Southern Rocky Mountains Geographic Area encompasses the mountainous regions of Colorado, south-central Wyoming, and north-central New Mexico. The Southern Rockies are isolated from the rest of the Rocky Mountain chain by vast sagebrush and desert shrub communities in the Wyoming Basin and Red Desert in southern and central Wyoming, and the arid Green and Colorado River plateaus in western Colorado and eastern Utah.

Throughout much of the Pleistocene epoch, the Southern Rockies appear to have been connected with the rest of the Rocky Mountains through continuous forested habitats, across what are now open shrub steppe communities (Armstrong 1975). Although the continental ice sheets of the Pleistocene never reached Colorado, the climate of the Southern Rockies in that period was substantially cooler. Summer mean temperatures were estimated to be some 16 degrees F cooler, resulting in extensive alpine valley glaciation, high altitude ice caps, and a lowering of the life zones some 900-1,220 m (3,000-4,000 feet) from their current elevation limits. This would have lowered the spruce-fir-lodgepole pine forest to 1,500-2,150 m (5,000-7,000 feet) in elevation, encompassing much of the area between the Southern Rockies and the rest of the Rocky Mountain chain (Armstrong 1975). Sometime within the last 15,000 years, it appears the climate began a general trend of warming and drying, causing a northward retreat of the boreal forest and the raising of mountainous life zones to their current elevation limits (Armstrong 1972). It was during this interval that the Southern Rockies became ecologically separated from the rest of the Rocky Mountains, isolating its remnant high-elevation boreal forests and

U.S. Forest Service file photo



Aspens

the species characteristic of these forests (Armstrong 1975, Fitzgerald et al. 1994). The climatic warming and drying of the altithermal period of 4,000-6,500 years ago, during which the climate may have reached its thermal maximum (Oosting 1956), produced the elevation dependent vegetation types we find today in the Southern Rockies (Armstrong 1972). Based on pollen studies by Pennak (1963), mountainous vegetation communities have remained relatively stable now for the past 3,000 years.

The Southern Rocky Mountains Geographic Area falls within the Southern Rocky Mountain Province (McNab and Avers 1994, Bailey et al. 1994), and includes the following sections:

- Southern Parks and Mountain Ranges (M331F)
- South-Central Highlands (M331G)
- North Central Highlands and Rocky Mountain (M331H)
- Northern Parks and Ranges (M331I)

Lynx Population Distribution

Until recently, it was generally assumed that the lynx was an indigenous but uncommon species in the Southern Rocky Mountain Geographic Area. However, records are coming to light that paint a different picture. Both Allen (1874) and Cary (1911) indicate that lynx may have been relatively common in Colorado, at least near or prior to the turn of the century. Recently discovered are cumulative records of predatory animals taken on the Routt National Forest in northern Colorado between the years of 1914 and 1922. Unlike many trapping records, numbers for bobcat and lynx are separated. Numbers of lynx taken on the Routt National Forest were 83 in 1914 and 1915, and 210 in 1916. Articles from the Jackson County Star (January 24 and February 21, 1924) reported predators taken at trap and poison stations in Colorado by the Federal Bureau of Biological Survey during 1923 and January 1924. Among the take were 309 bobcats and 103 lynx (as reported by Stanley P. Young).

Records of lynx occurrence are distributed throughout mountainous areas of Colorado. The southernmost record is from the southern San Juans (Conejos County), one mile from the New Mexico border. Although no records exist from New Mexico, suitable habitat extends into north-central New Mexico along the Sangre de Cristo mountain range and, especially, in the San Juan Mountains. Only a few records are known from the far northern parts of the Southern Rocky Mountain Geographic Area in south-central Wyoming. A single record (1856) is available from the Medicine Bow Range (Reeve et al. 1986) and in 1963 a lynx was taken from the Laramie Range, 50 miles east of the 1856 record.

In 1969, three lynx specimens were taken in adjacent counties in the central core of the Southern Rockies. One was shot along the Fryingpan River in Pitkin County, another on Vail Mountain (Eagle County), and a third was trapped in sagebrush habitat near 2,900 m (9,500 feet) elevation south of Leadville in Lake County (G. Byrne 1998, unpubl. data). In 1972, a lynx was trapped on Guanella Pass and another caught in a snowslide east of Bakerville, both in Clear Creek County. During the 1973-74 winter, a pair of lynx was illegally trapped within Vail Ski Area boundaries (Thompson and Halfpenny 1989). No lynx specimens are available since those last illegal takes. However, it should be recognized that the State of Colorado made it illegal to take lynx in 1971.

Despite the lack of recent specimens, evidence indicates lynx have persisted to the present, but are rare in the ecosystem. A statewide lynx verification program conducted from 1978-80 by the Colorado Division of Wildlife (CDOW) concluded that viable but low-density lynx populations persisted in Eagle, Pitkin, Lake, and Clear Creek counties, with evidence of lynx occurrence in Grand and Park counties (Halfpenny and Miller 1981, Halfpenny et al. 1982). All of these Colorado counties are in the central part of the ecosystem. Lack of evidence from other portions of the geographic area was likely a consequence of lack of survey effort.

Since then, CDOW has conducted several surveys, with little success. While failing to confirm lynx presence, they did locate several sets of possible lynx tracks. Although these surveys have not provided the systematic statewide coverage and intensity necessary to make conclusions about population persistence or numbers (large tracts of terrain have never been surveyed), the level of effort has enabled us to conclude that lynx are apparently rare in the Southern Rocky Mountain Geographic Area. Still, evidence of persistence continues to surface.

Thompson and Halfpenny (1989) confirmed lynx in the vicinity of Vail Ski Area during the winter of 1988-89 as part of studies conducted by Vail Associates for the Category III expansion. Verification resulted from a combination of carefully evaluated tracks, further corroborated with hair and scat samples, ruling out any potential confusion with bobcat or mountain lion. Given the short duration and limited areal extent of these surveys, often in unfavorable tracking conditions, the evidence of lynx activity generated must be considered substantial. They stated in their 1989 report, "There is no question that lynx exist at Vail Ski Area and in the surrounding mountains." Follow-up work by CDOW in 1990 and 1991 led to the discovery of additional lynx tracks. Photographs of one set of tracks characteristically going from tree well to tree well are on file, with both pattern and size indicating lynx (G. Byrne, CDOW, unpubl. data 1998). No work has been done in the area since that time.

In 1991, Thompson and Halfpenny also confirmed two sets of lynx tracks at a proposed ski area site south of Wolf Creek Pass in the eastern San Juan Mountains (Thompson and Halfpenny 1991, Andrews 1992). They believed the pair was probably a female and her kitten, evidencing reproduction.

Since the 1991 track discoveries near Vail and in the San Juans, CDOW has recorded a number of lynx sightings or track locations that they rate as probable lynx, three of which were documented by CDOW biologists. Carney (1993) located lynx tracks along the east side of the Gore Range in Summit County. Tom Beck, a CDOW carnivore researcher, found a set of lynx tracks in the Dolores River drainage in the west San Juans of Montezuma County in 1993. A CDOW Area Wildlife Manager observed a lynx in the southern Sangre de Cristos of Costilla County, also in 1993. Two additional sightings and one set of tracks rated as probable came from Eagle County and another set of tracks was located in Larimer County north of Rocky Mountain National Park. In 1997, tracks believed to be those of lynx were found and photographed in the Tennessee Creek drainage on the border of Lake and Eagle Counties, an area where possible lynx tracks were located just a few years earlier. These photographs closely match those taken of tracks left by lynx recently released into the San Juan Mountains and have been rated as probable lynx in the official state database.

Other recent credible reports come from Boreas Pass on the border of Summit and Park Counties (1995), as well as the Vail vicinity, the Flattops of northwestern Colorado, and Rocky Mountain National Park, all in 1998. Most recently, CDOW trackers following radio-collared lynx transplanted into the San Juan Mountains located a several-day-old lynx trail they believed to be that of a native lynx. The lynx being tracked was the first of the transplanted lynx to enter that drainage and the other set was believed too old to belong to the radio-collared lynx (G. Byrne and T. Shenk, CDOW, pers. comm 1999.).

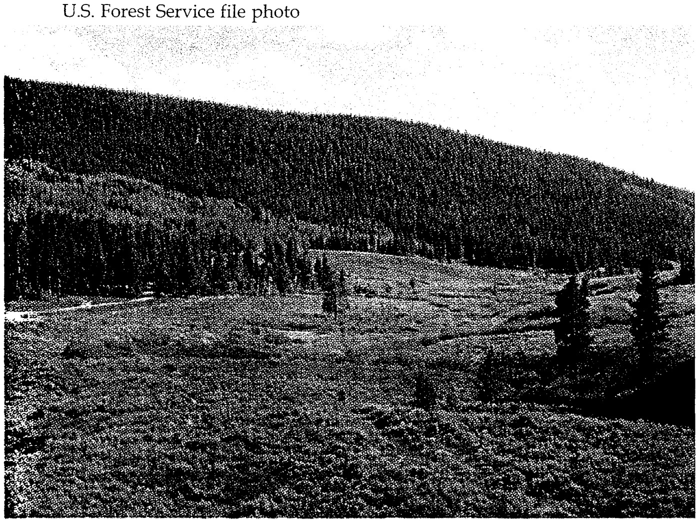
Although lynx appear to persist in the Southern Rocky Mountain Geographic Area, the population has failed to rebound in this ecosystem despite the removal of certain key suppressing factors, including commercial trapping and indiscriminate predator control. Biologists in Colorado have concluded that this extant lynx population is too small to be self-sustaining or capable of naturally rebounding to self-sustaining levels. Without recovery efforts, it is therefore assumed to be trending toward extinction. In 1999, CDOW initiated a recovery program intended to augment any existing populations with transplants from Canada and Alaska and re-establish a self-sustaining breeding population throughout the Southern

Rockies. A total of 96 animals were transplanted into the San Juan Mountains during 1999 and 2000. At the time pf printing this document, approximately 70 surviving transplanted lynx are establishing in the Southern Rockies. Of these, a majority have established or appear to be establishing resident territories in the San Juan Mountains. Other individuals have taken up residence as far east as Cuchara Pass in Huerfano County, and as far north as Rocky Mountain National Park. While most animals transplanted in 1999 have settled down, some 2000 transplants continue to explore the Southern Rockies. Eventually, it is assumed and hoped that lynx will reestablish in all portions of the Southern Rockies, consistent with historical distribution patterns.

Lynx Habitat

Lynx habitat in the Southern Rockies is likely found within the subalpine and upper montane forest zones, typically between 2,450 - 3,650 m (8,000 and 12,000 feet) in elevation. Depending on latitude and moisture gradients, however, the lower range of suitable lynx habitat may begin at lower or higher elevations. At the upper elevations of the subalpine, forests are typically dominated by subalpine fir and Engelmann spruce. As the subalpine transitions to the upper montane, spruce-fir forests begin to give way to a predominance of lodgepole pine, aspen, or mixed stands of pine, aspen, and spruce. Englemann spruce may retain dominance on cooler, more mesic mid elevation sites, intermixed with aspen, lodgepole pine, and Douglas fir. Lodgepole pine reaches its southern limits in the central parts of the ecosystem, while southwestern white fir first makes its appearance in the San Juan Mountains.

U.S. Forest Service file photo



Sagebrush interpersed with forest

The lower montane zone is dominated by ponderosa pine and Douglas-fir, with pine typically dominating on lower, drier, more exposed sites, and Douglas-fir occurring on moister and more sheltered sites. Although this forest zone is below lynx habitat, montane forests likely are important as connective habitat where they may facilitate lynx dispersal and movements between blocks of lynx habitat, and may provide some foraging opportunities during those movements. It is not yet known how lynx naturally use the habitat types of the Southern Rocky Mountain ecosystem.

Because of latitude, lynx habitat in the Southern Rockies is naturally fragmented, a function of elevation, aspect, and local moisture regimes. The high alpine tundra environments and lower, mostly open valleys typically separate subalpine and upper montane forests. Drier south- and west-facing slopes may also break up the continuity of cooler, mesic high-elevation forests that are believed to constitute primary vegetation contributing to lynx habitat.

Lynx habitat should be thought of in terms of a habitat mosaic within these forest landscapes, rather than as simple vegetation types. Spruce-fir, lodgepole pine, white fir, aspen, and mesic Douglas-fir may all provide foraging and/or denning habitat for lynx. Also potentially important in many parts of the Southern Rockies are the high elevation sagebrush and mountain shrub communities found adjacent to or intermixed with forested communities, affording potentially important alternative prey resources. Likewise, riparian and wetland shrub communities (for example, willow, alder, serviceberry) found in valleys, drainages, wet meadows, and moist timberline locations may support important prey resources (Noss and Cooperrider 1994, C. Apps pers. comm. 1998, Shenk pers. comm. 1999). Lynx transplanted to Colorado in 1999 are frequently located in well developed riparian and valley wetland shrub habitats of the upper montane and subalpine zones (Shenk pers. comm. 1999). The ecotones formed by the integration of these various vegetation communities may offer some of the richest foraging opportunities for lynx.

Foraging habitat for lynx in the Southern Rocky Mountains Geographic Area includes all of the vegetation community types discussed above. While most studies (Koehler 1990, Koehler et al. 1979, Weaver 1993, Koehler and Aubry 1994) have found that densely regenerating forests typically produce the highest densities of snowshoe hare, there have been some seemingly conflicting findings from more southern ranges. On the Big Horn National Forest of Wyoming, Beauvais (1997) found that snowshoe hares had a strong affinity for the higher elevation mature to late-successional spruce-fir forests. Furthermore, hares were out-competed by other species in early successional stages (less than 15 years of age) and these altered conditions probably were not providing hare habitat. Dolbeer and Clark (1975) in Colorado similarly found the highest densities of snowshoe hare in mature and late-successional spruce-fir forests. This study was, however, conducted in a very limited area, and did not sample natural or man-made regeneration units (15 to 40 years of age) to compare hare densities with those they reported for mature and late-successional spruce-fir forests.

It remains unclear what role early-successional forests play in providing quality lynx foraging habitat in the Southern Rocky Mountain Geographic Area. Fire exclusion in this century has led to the maturation of many lodgepole pine forests into highly stocked, even-aged stands that do not now provide the dense ground- and snow-level cover and forage necessary to support higher densities of snowshoe hare. While these stands have a high density of tree boles, their crowns have lifted far above the reach of hares even in the deepest snowpacks. At the same time, the high dense canopy limits light penetration, contributing to a depauperate understory. Consequently, these stand types have low habitat value for snowshoe hare and other small mammal prey species, and consequently lynx. Because of their structure, mature and late-successional spruce-fir forests, by contrast, provide these characteristics and are, therefore, far superior to mature lodgepole pine. Mature and late successional spruce-fir forests are also excellent producers of red squirrels, an important alternate prey species for lynx (Obbard 1987).

Conifer-aspen forests, particularly those with dense regeneration or with an extensive shrub and woody debris understory component, may be important for snowshoe hares and other prey species. While extensive stands of pure aspen may not provide quality hare habitat due to deficiencies in winter habitat characteristics, when intermixed with spruce-fir or young lodgepole pine stands, aspen (especially younger stands) may substantially contribute to prey productivity. Regenerating burns are often quite productive because of the mixed coniferous/deciduous species composition, multiple age classes, shrub layer, dense herbaceous layer, and extensive downed woody debris. These conditions provide excellent habitat for snowshoe hare and other prey species.

Sagebrush communities are found in many high elevation drainages, valleys, basins and benches between and adjacent to subalpine and upper montane forests. When sagebrush communities intergrade with or are proximal to primary coniferous and conifer/aspen habitats, they may provide important alternate prey resources for lynx. White-tailed jackrabbits are found in sagebrush communities at the highest elevations, as well as in the sagebrush-forest ecotones, providing an excellent prey resource for lynx in or near forest cover. Mountain cottontail, Wyoming ground squirrels, and grouse are also locally abundant in these habitat types. Large or medium willow/alder carrs, beaver pond complexes, and shrub dominated riparian communities also provide important habitat for snowshoe hare, grouse, ptarmigan (winter), and other prey species that may be utilized by lynx. The ecotones and edges produced by these intermixed habitats may be among the most productive foraging sites for lynx in the Southern Rocky Mountains Geographic Area.

Many parts of the Southern Rockies currently have a shortage of regenerating forest (particularly lodgepole pine stands). Consequently, in the short term it is important to protect and encourage habitats that now support moderate to high snowshoe hare populations and those which are developing towards quality snowshoe hare habitat. It is equally important to protect and encourage those habitats that are good producers of alternative prey, such as red squirrels, grouse, and other lagomorph species. In those conifer (especially lodgepole pine) and mixed conifer-aspen stands that are regenerated, encourage development of horizontal cover at ground through maximum snow depth levels. Shrub and woody debris components should be maintained and even increased where understory cover is deficient. In the absence of widespread regenerating forest stands, mature and late-successional spruce-fir forests may constitute some of the most important habitat for lynx. These stands not only provide components necessary for denning habitat, but also produce red squirrels, grouse, and snowshoe hare. Although these forest types may support a lower density of hares than do densely regenerating stands, they also likely provide stable populations of both hares and red squirrels over time (Keith and Surrendi 1971, Dolbeer and Clark 1975, Fox 1978, Conroy et al. 1979, Wolfe et al. 1982, Parker et al. 1983, Litvaitis et al. 1985, Bailey et al. 1986, Monthey 1986, Koehler 1990 and 1991, Koehler and Brittell 1990, Beauvais 1997). Consequently, manipulation of spruce-fir forests should probably be undertaken with great caution, especially until large areas of lodgepole pine can be converted into densely regenerating stands and begin to support strong snowshoe hare production.

It may be desirable to reintroduce fire and silvicultural treatments into mature lodgepole pine forests (and white fir forests where they no longer provide suitable hare habitat) to increase quality snowshoe hare habitat in the Southern Rockies. Because this forest type currently provides little habitat value for lynx, the risk of such manipulation is low, while the long-term benefits (15-40 years) are potentially great. In planning such treatments, however, it should be recognized that some lodgepole pine stands in the Southern Rocky Mountain Geographic Area are on dry sites with thin soils that may have limited potential for providing quality hare habitat. The long-term strategy across the forested landscape should be to recreate, to the extent possible, the mosaic of young, regenerating, mature, and late-successional forests typical of naturally operating disturbance regimes.

Fire, insect and disease processes have shaped vegetation patterns. Natural fire regimes in subalpine fir-spruce forests of the Southern Rocky Mountains are extremely complex, reflecting great variation due to climate, topography, elevation, vegetation, and site productivity. Because of the high elevations and higher moisture gradients of the subalpine zone, stand replacement events occur only rarely on a given site, perhaps every 250 to 500 years. Such events occur with increasing frequency at decreasing elevations. In warmer and drier montane zones, extreme fire behavior often results in stand replacement events. Here too, small diameter, highly stocked lodgepole pine stands create a fuel load favorable to major fire events. Stand-replacing fires may occur every 100 to 150 years in the montane zone, while surface fires of low to moderate-intensity occur relatively frequently (return intervals of 5 to 60 years).

DeLong (1998) reported that in boreal forests of British Columbia, 40 to 60% of burned areas occurred in patches greater than 1,000 ha (2,500 acres), and 60 to 85% in patches greater than 250 ha (600 acres) in size. Smaller acreages often are subjected to low-intensity surface fires during the intervals between stand-replacing events.

Denning habitat in the Southern Rockies is likely to occur most often in late-successional spruce-fir forest with a substantial amount of large diameter woody debris on the forest floor, frequently found on north to northeast exposures. Weaver (1993) noted that selection of den sites on cooler exposures probably relates to thermoregulation, while the forest floor structure provides adequate protection for kittens. Although late successional spruce-fir forests most often provide these characteristics, it is likely that forest floor structure, and perhaps exposure, is more important than age class of the forest stand. Younger forests may, in some cases, provide similar characteristics. Fires, blowdowns, and even certain timber harvesting practices can leave considerable stacked and jackstrawed large-diameter woody debris under young forest canopies, providing excellent denning potential. For denning habitat to be functional, it must be in or adjacent to large areas of quality foraging habitat. Because lynx may move their kittens frequently in the first few months, denning habitat should provide multiple quality den site options to the female.

Landscape Connectivity

McKelvey et al. (2000a) stated that "fragmented forest cover types, high vagility of lynx, and linkages in population dynamics suggest that lynx in the contiguous United States are arranged as metapopulations. Metapopulation stability depends on not only habitat quality but also dispersal rates between habitat islands. Models indicate that dispersal rates between habitat islands should sharply decrease as the islands become smaller and more distant and the risks associated with crossing between islands increase." Colorado and Utah are separated from the larger boreal forests in Wyoming by at least 100 km (60 mi) and may be effectively isolated (McKelvey et al. 2000a, Halfpenny et al. 1982).

Human activities that change vegetation patterns of the natural landscape affect ecological processes (competition, dispersal and predation) in various ways (Wilcove 1985). Goodrich and Buskirk (1995) noted that generalist species, such as coyotes and great-horned owls, are strongly linked to human-dominated vegetation mosaics where fragmentation and competition provide the environments needed by these generalist species. Although the magnitude of these effects is poorly understood, it is clear that the function and structure of these animal communities can be altered (Wilcove et al. 1986, Yahner 1988, Oehler and Litvaitis 1996).

Building residences and roads in and through lynx habitat may exert potentially negative influences on lynx by altering and modifying existing habitats, and by direct disturbance through recreation or travel in areas inhabited by lynx (Mowat et al. 2000).

O'Donoghue et al. (1998) reported that lynx and snowshoe hare used habitats with the densest vegetative cover during cyclic declines, while both were documented using more open habitats when hares were abundant. Several authors (Murray et al. 1994, Poole et al. 1996, Roe et al. 1999) have reported lynx selecting against openings such as water and open meadows, although use of terrestrial openings was always detected. Lynx may cross openings such as farmland during dispersal (Roe et al. 1999). In fact, during the 1963 irruption of lynx in Canada, lynx were documented in several states where lynx habitat is non-existent (Adams 1963, Gunderson 1978). Poole and Mowat reported observing lynx crossing several hundred meter wide openings, frozen lakes and rivers greater than 1 km wide during their investigations in the Northwest Territories.

Apps (2000) reported in his study in Banff National Park that landscape features may also influence dispersal, and in high mountainous terrain, movements can be expected to align with major valleys. This would be a quite different scenario at the southern extent of the lynx range in the United States, where many of the major valleys are dominated by sagebrush, oakbrush, or towns and resort communities. On the other hand, snow conditions in the southerly habitats may undergo more winter thaws, with subsequent formation of crusts, then snow in the taiga (Buskirk et al. 2000). Crusted snow conditions would tend to remove or reduce the competitive edge held by deep snow adapted lynx. Lynx and snowshoe hare habitats are more prone to a metapopulation structure in the western forests due to fragmented landscapes and heterogeneous distribution of topographic, climatic and vegetative conditions (Buskirk et al. 2000). This condition is further exacerbated by the presumably greater human caused fragmentation of lynx habitat in the south.

What little is known about lynx populations in the contiguous United States indicates that the subpopulations are not large. Until more is know about the current distribution and size of these small subpopulations, it is unwise to assume they can be reduced or further isolated without increasing the risk of loss of viability (McKelvey et al. 2000a).

McKelvey et al. (2000a) indicate that we know very little about the degree of connectivity or its role in the viability of lynx, but assume that connectivity plays an important role. Alpine tundra, open valleys, shrubland communities and dry southern and western exposures naturally fragment lynx habitat within the subalpine and montane forests of the Southern Rocky Mountains. Because of the southerly latitude, spruce-fir, lodgepole pine, and mixed aspen-conifer forests constituting primary vegetation are typically found in elevational bands along the flanks of mountain ranges, or on the summits of broad, high plateaus. Although the primary vegetation is fragmented, it remains generally interconnected through the numerous mountain chains and intervening lower elevation forests and shrublands. In those circumstances where large landforms are more isolated, they still typically occur within 40 km (24 miles) of other suitable habitat (McKelvey et al. 2000b). This distribution maintains the potential for lynx movement from one patch to another through non-forest environments.

Because of the fragmented nature of the landscape, there are inherently important natural topographic features and vegetation communities that link these fragmented subalpine forested landscapes together, providing for dispersal movements and interchange among individuals and subpopulations of lynx. Landscape connectivity may take the form of narrow forested mountain ridges or plateaus connecting more extensive mountain forest habitats. Wooded riparian communities may provide travel cover across open valley floors between mountain ranges, or lower elevation ponderosa pine, pinyon-juniper woodlands or shrublands that separate high elevation spruce-fir forests.

The role that sagebrush, foothill shrublands, and lower elevation pine woodlands play as elements of lynx habitat is not entirely clear. McKelvey et al. (2000b) reported that most lynx records across North America fell within cool, coniferous forests. Of 349 records from non-conifer types, 79 percent were within 10 km (6 miles) of spruce-fir forests. Shrub steppe communities, especially where proximate to subalpine forested habitats, provide alternate lynx prey (Squires and Laurion 2000). It is anticipated that where sagebrush communities are proximal to forest habitats, they may also prove valuable to lynx in the Southern Rockies.

Ian Magruder/Toni Cordas

Since the mid- to late 1800's, human actions have continually eroded forested landscape linkages in the Southern Rocky Mountains Geographic Area. Beginning in the 1860's through much of the latter half of the 19th century, large-scale alteration of the natural landscape resulted from the rush to extract the rich deposits of gold, silver, and other metals in portions of the Southern Rockies. A huge demand for timbers, construction materials, and smelter and heating fuels resulted in the massive cutting of forests around mining centers. Human-induced and lightning-caused fires burned over large areas and decades of phytotoxic smelter emissions killed or precluded the regeneration of forests around these centers. The effects of mining and large-scale logging are still evident today across much of the landscape. While many cut-over areas have recovered to varying degrees, some high elevation forests still remain poorly timbered. Large-scale clear-cutting continued into the middle of the twentieth century, while forest fire suppression became standard policy early in this century, leading to an increasingly mature and less productive forest landscape. The developing ski industry, a growing and affluent population, and telecommuting capabilities have converged to spur rapid growth in some mountain valleys. Transportation corridors have been, and continue to be, modified and expanded to handle increasing volumes of traffic and speeds, altering historical movement patterns of wide-ranging species and creating barriers to movement. These and other factors, both historical and current, have combined to eliminate or degrade many landscape linkages.

Human population growth has occurred in a highly clumped pattern, leaving extensive wilderness and lightly developed backcountry. While the ecosystem remains largely interconnected at this time, ongoing development and other activities continue to pressure those linkages. Some are now tenuous and in urgent need of protection; others will be at risk in the future. Sustaining wide-ranging carnivores, including the lynx, in this ecosystem may ultimately depend on the interconnection of large blocks of suitable habitat. An interconnected ecosystem is essential to maintain the ability of subpopulations to expand and colonize new habitats, to recolonize areas where subpopulations have been locally extirpated or to provide population support to declining populations, to allow individuals to find mates among neighboring subpopulations, and to effect dispersal and genetic interchange (Noss and Cooperrider 1994).

Risk Factors Specific to the Southern Rockies

Risk Factors Affecting Lynx Productivity

Fire exclusion in the Southern Rockies has created homogeneous forests of mature lodgepole pine, aspen, Douglas-fir, and ponderosa pine (Veblen et al. 1998) lacking a forest understory of shrubs and seedlings important to snowshoe hares. Early successional conditions created and maintained by fire and other finer-scale disturbance agents (wind, insect, ungulate browsing, avalanches etc.) generally occurred in different patterns than those created by timber management (Veblen et al. 1998). These changes have likely reduced habitat quality and quantity for lynx and lynx prey.

Grazing, in conjunction with increasing elk populations, may have resulted in increased competition for forage resources with lynx prey. By changing native plant communities, such as aspen and high elevation riparian willow, grazing can degrade snowshoe hare habitat. Domestic livestock grazing is common in lynx habitats throughout this geographic area.

Recreational uses or activities that create compacted snow conditions may reduce the competitive advantage that lynx have in deep snow environments. Ski areas and four-season developments can reduce the availability of lynx habitat within localized areas. Development of facilities can result in the loss of lynx habitat and contribute to the overall fragmentation of the landscape. Depending on how developed the ski or resort area is, it may also influence the distribution or abundance of prey resources within the development area.

U.S. Forest Service file photo

Snow tracks

Risk Factors Affecting Mortality

Leg-hold trapping is currently illegal under the state constitution of Colorado as a means of predator control or commercial trapping. However, if a landowner can prove that all other non-lethal methods have been ineffective, a 30-day exemption might be granted for depredation cases. Consequently, trapping effects are probably very reduced from historical times in Colorado, but still may be a minor risk during trapping seasons in southern Wyoming, Utah, and northern New Mexico.

Predator control activities on federal lands, including coyote shooting or trapping, are common throughout most of this geographic area, mostly related to the grazing of domestic sheep. Incidental capture of lynx is a possible risk factor. Although the majority of sheep grazing occurs on arid rangelands, some grazing does occur during summer at the higher elevations, especially in south-central Colorado.

There are very few records of lynx being shot in the Southern Rocky Mountains Geographic Area. None have been reported in the past several decades, except for the animals taken in 1969 on the south side of Vail Mountain. Recently, one of the translocated lynx was found dead of a gunshot wound near the release site. The Colorado Division of Wildlife has not been able to determine whether the shooting was accidental (G. Byrne, CDOW pers. comm. 1999).

Increased predation on lynx could occur due to the current abundance of mountain lion, bobcat and coyote populations in this geographic area. Wolves are not known to be present in this area.

Vehicular collisions are a potential mortality factor, given the high speed and traffic volumes of highways that pass through lynx habitat, such as I-70, I-80, US 50 and US 160. Brocke et al. (1990) suggested that translocated animals might be more vulnerable to this form of mortality than resident lynx. Two recently translocated lynx were killed on Colorado's highways. Two other translocated lynx in Colorado have been recently documented crossing interstate highways. One of the lynx crossed I-70 in the general vicinity of the Wolcot Junction, and the other lynx somewhere between the town of Vail and the Eisenhower Tunnel (G. Byrne pers. comm. 1999). The latter individual also crossed I-80 before being killed in Nebraska.

<u>Risk Factors Affecting Movement</u>

Urban expansion and development has further fragmented an already patchy distribution of lynx habitat. Valley floor development continually erodes the amount of non-forest habitats within 40 km (24 miles) of lynx habitat. The expansion of homes and some municipal facilities up mountain slopes, into forests of aspen, lodgepole pine, and to a lesser degree spruce-fir, adds to the fragmentation of a naturally fragmented landscape. The cumulative effect of private land development and expansion of rccreational facilities in and adjacent to lynx habitat may reduce the ability of lynx to move throughout their home range, or interact with other individuals in the the larger subpopulation.

As ski areas are developed, they add to the overall fragmentation of the landscape in the Southern Rocky Mountains. If these developed areas occur jointly with (back to back ski areas) or abut the expansion occurring on private land, then there is a higher likelihood that lynx will have a more difficult time moving across these portions of the Southern Rocky Mountain landscape. Although lynx have been documented inhabiting ski areas in Canada (Roe et al. 1999), most observations have been within forest cover and away from base area developments and parking facilities (Roe et al. 1999). As noted by Buskirk et al. (2000a), lynx and snowshoe hare habitats are more prone to a metapopulation strucuture in western forests due to fragmented landscapes and heterogeneous distribution of topographic, climatic and vegetative conditions. This condition is further exacerbated by the presumably greater human caused fragmentation of lynx habitat in the south (Buskirk et al. 2000a). What little is known about lynx populations in the contiguous United States indicates that the subpopulations are not large. Until more is know about the current distribution and size of these small subpopulations, it is unwise to assume they can be reduced or further isolated without increasing the risk (McKelvey et al. 2000a).

Highways and their continued expansion into mountain towns and resorts increase the amount of fragmentation occurring in these long, linear landscapes. This fragmentation effect further erodes the potential for lynx to effectively cross some of these potential barriers. So far, the lynx translocation effort in Colorado has documented two lynx highway fatilities (I-70 and highway 24) and two successful crossings of lynx across I-70.

Great Lakes Geographic Area

Geographic Extent

The Great Lakes Geographic Area encompasses northeastern and north-central Minnesota, northern Wisconsin, and the Upper Peninsula and northern portions of Michigan. This area largely falls within the western portions of the Laurentian Mixed Forest Province (McNab and Avers 1994). Most of this province has low relief with rolling hills occurring in many areas. Glacial features such as lakes, poorly drained depressions, moraine hills, drumlins, eskers, and outwash plains are typical of the area. Elevations range to 730 m (2,400 feet).

Climate in the area produces moderately long and somewhat severe winters, with snowfall remaining on the ground all winter. The forest vegetation of this ecoprovince is transitional between the boreal forests of the north and the broadleaf deciduous forests to the south. Forested stands vary from mixtures of conifers (pine, spruce, fir, cedar) and hardwoods (birch (Betula spp.), maple (Acer spp.), beech (Fagus grandifolia), basswood (Tilia spp.)) to pure stands of conifer or hardwood species (Bailey 1995).

That portion of the Laurentian Mixed Forest Province that comprises the Great Lakes Geographic Area is composed of several ecological subdivisions, or Sections, as described by McNab and Avers (1994). The Sections included are the Northern Great Lakes, Southern Superior Uplands, Western Superior, Northern Superior Uplands, Northern Minnesota and Ontario, and Northern Minnesota Drift and Lake Plains.

Northern Great Lakes Section (212H): This Section extends across the northern one-third of the "mitten" portion of Michigan, the eastern half of the Michigan Upper Peninsula and northeastern Wisconsin. The potential natural vegetation types occurring on this Section include northern hardwoods forest, northern hardwood-fir forest, Great Lakes pine forest, conifer bog, and elm-ash forest.

Southern Superior Uplands Section (212J): This Section covers most of the northern half of Wisconsin and the western half of the upper peninsula of Michigan. Potential natural vegetation types occurring on this Section include maple-beech-birch forest, aspen-birch forest, and spruce-fir forest.

Western Superior Section (212K): This Section includes portions of northwestern Wisconsin and east-central Minnesota. Potential natural vegetation types occurring on this Section include Great Lakes pine forest, Great Lakes spruce-fir forest, and maple-basswood forest.

Northern Superior Uplands Section (212L): The Northern Superior Uplands encompass the "arrowhead" region of northeastern Minnesota. Potential natural vegetation types occurring on this Section include Great Lakes pine forest and Great Lakes spruce-fir forest.

Northern Minnesota and Ontario Section (212M): This Section occurs along the U.S.-Canada border in north-central Minnesota. Potential natural vegetation types occurring here include conifer bog, Great Lakes spruce-fir forest, and Great Lakes pine forest.

Northern Minnesota Drift and Lake Plains Section (212N): This Section extends across much of north-central Minnesota south of the Northern Minnesota and Ontario Section. Potential natural vegetation types occurring here include Great Lakes pine forest, Great Lakes spruce-fir forest, and conifer bog.

Lynx Population Distribution

Overall, lynx population status in the Great Lakes Geographic Area is uncertain. The U.S. Fish and Wildlife Service concluded that a very small resident population may possibly exist in Minnesota, but acknowledged that population information is fragmentary and largely anecdotal in nature (U.S. Fish and Wildlife Service 1998). McKelvey et al. (2000b) analyzed historical information for the Lake States, and found that the large numbers of lynx records, particularly from the 1960's and 1970's, are highly correlated with lynx population peaks in Canada, and not with local cycles of hare abundance. While this does not rule out the existence of local populations, the data do indicate that recent patterns of lynx occurrence in this region are at least partially Canadian in origin (McKelvey et al. 2000b). Individual animals are irregularly recorded in Wisconsin and Michigan's upper peninsula. Lynx population levels immediately north of the border in Canada are reported be lower now than historical levels (Alvo 1998), which may affect population recovery efforts in this part of the U.S.

In the past, lynx populations in the Great Lakes area were regularly supplemented by dispersing lynx from Canada (Harger 1965, M. DonCarlos, in litt. 1994), but the number of immigrating animals has declined considerably over the numbers observed in the 1960's and 1970's (McKelvey et. al. 2000b). As the amount of lynx habitat in this region may be insufficient to support an isolated population, maintaining connectivity with lynx habitats in Canada may be important (McKelvey et al. 2000b).

Lynx Habitat

Lynx habitat in the Great Lakes Geographic Area is imbedded within the ecotone between boreal and mixed deciduous forests. In the Great Lakes states, lynx habitat consists of boreal spruce-fir forests, aspen, pine and mixtures of upland conifer and hardwood, interspersed with lowland conifer and shrub swamps and bogs, in those areas where snow accumulation and condition may limit travel of competing species.

Some forest habitats are primarily coniferous, others are primarily deciduous, and many are mixtures of both coniferous and deciduous trees. Similarly, some forested habitats contain one or few species, while others contain many species. Conifer species include white and black spruce; balsam fir; northern white cedar; jack, white and red pine; hemlock and tamarack. Deciduous species include aspen, paper birch, and mixtures of northern hardwoods and lowland hardwoods. Large stands of essentially pure northern hardwoods are not considered lynx habitat. Of the non-forested types, shrub swamps and conifer bogs are generally considered lynx habitat. Shrub swamps consist mainly of alder or willow. Bogs typically have components of black spruce, tamarack or other lowland conifers.

Snowshoe hare habitat consists primarily of all lowland shrub and conifer bogs, and the sapling and older sawlog stands, rather than the early regenerating or pole-sized stands. Sapling-sized aspen adjacent to conifer cover also provides snowshoe hare habitat. Conifer bogs or lowland conifer forests may serve as refugia for hare during low points in their cycle. Red squirrels are associated with forested stands that contain conifers of cone bearing age. Small, permanent upland openings would probably also be used by lynx for foraging.

Lynx denning habitat is suspected to be associated more with structural components of forests, such as blowdown, deadfalls and root wads, rather than forest cover type, based on studies in other geographic areas.

In addition to climatic and topographic influences, a variety of disturbance factors created and maintained forest composition and successional patterns, which provided landscape mosaics of suitable lynx habitat. These disturbance factors included fire, insects and wind. Pre-settlement forests in this area had three distinct fire regimes (Kilgore and Heinselman 1990):

1. Jack pine and spruce-fir forest with very large (sometimes >250,000 acres) stand-

replacement crown fires or severe surface fires, every 50 to 100 years in the west and 80 to 250 years in the east;

2. Red pine and white pine forests with combinations of moderate intensity surface fires at 20 to 40 year intervals, with more intense crown fires at 150 to 300 year intervals, and

3. Mixed aspen-birch-conifer forests with high-intensity surface or crown fires.

Larger blowdowns due to windshear and tornadoes occurred infrequently, but often caused extensive localized disturbance. Insect infestations such as those caused by spruce budworm contributed to large areas of tree mortality, and may have created conditions conducive to large fires.

These major disturbance events created diverse, early successional forests that provided habitats preferred by snowshoe hare, and thus important foraging areas for lynx. The less intense, more frequent ground fires were an important factor in maintaining the conifer understory component throughout much of this area. Smaller, localized wind events and insect infestations likely created concentrations of downed logs, which can provide suitable denning habitat for lynx.

Sites in this geographic area where the best lynx habitat is found include the Voyageurs National Park and Boundary Waters Canoe Area Wilderness (Minnesota), and Quetico Provincial Park (Ontario). Wisconsin and Michigan currently suffer from a lack of connectivity with Minnesota and Ontario, and may have limitations of size, fragmentation and current vegetation composition. Of these two states, the largest areas of contiguous habitat occur on the Ottawa and Hiawatha National Forests and associated state forests in Michigan.

Approximately 41 percent of lynx habitat in this geographic area is in public or tribal ownership (John Wright, unpubl. data from Great Lakes Ecological Assessment).

Risk Factors Specific to the Great Lakes

Risk Factors Affecting Lynx Productivity

The forest that resulted from the early logging and wildfires replaced most of the mature and old growth conifer and mixed conifer-hardwood forests with early successional mixtures of aspen, birch, mixed hardwoods, spruce and fir. Much of the timber management that followed has emphasized pulpwood production by maintaining much of the early successional aspen, and converting mixed stands with pine plantations. Most mixed northern hardwood forests have been managed toward sawtimber production.

These timber management practices also resulted in conditions that favored lynx competitors such as coyote and/or bobcats. It has probably reduced denning habitat, while increasing habitat for lynx prey in some areas.

Loss of habitat due to conversion to agriculture has occurred across significant areas within historical lynx range in northern Wisconsin, central Minnesota, and upper Michigan. Portions of this area remain in a non-forested condition. More recently, human encroachment in the form of summer homes and cabins has occurred in this region.

The significant decline of fire as a large-scale disturbance agent may have reduced habitat quality and quantity for lynx in some portions of this geographic area, as compared with historical conditions. The composition and spatial distribution of early successional habitats and the composition and structure of the mature forests of today are considerably different from those formed by the disturbances that occurred prior to European settlement (Agee 2000).

In contrast to the western U.S., snow depth probably does not limit the distribution of bobcats and coyotes within the more southerly portions of the Great Lakes Geographic Area. Deep snow accumulation occurs in northeastern Minnesota, extreme northern Wisconsin, and the Upper Peninsula of Michigan. Within portions of this area, extensive road and trail systems are in place, and current winter use may facilitate coyote and bobcat movement. A possible exception to this situation occurs within the Boundary Waters Canoe Area Wilderness and other northern portions of the Superior National Forest in northeast Minnesota. In this area, the combination of snow depth and a lack of trails and roads may allow the lynx to retain a competitive advantage.

Risk Factors Affecting Mortality

Lynx trapping is currently not legal within the Great Lakes Geographic Area. Trapping seasons do exist, however, for other carnivores such as bobcat and coyote. Therefore, some potential for incidental trapping does exist, though none have been reported in recent years.

Wolf numbers have increased substantially in this geographic area in the last decade (Wydeven et al. 1999, Michigan Dept. Nat. Res. in litt. 1994, Minnesota Dept. Nat. Res. in litt. 1994). Consequently, coyote numbers have noticeably declined within occupied wolf range. Changes have not been noted in bobcat or red fox populations. Decreasing coyote numbers probably result in less competition with lynx for preferred prey such as snowshoe hares. Although wolves may pose some risk of predation to lynx, they have always persisted in the extreme northern Minnesota region and coexisted with lynx. Wolf density in the extreme northern Minnesota region has not appreciably increased from historical levels (D. Mech, pers. comm. 1999).

Predator control activities are essentially non-existent on federal lands as no livestock grazing occurs there. Some predator control occurs on private lands but does not appear to be a factor of concern in this geographic area.

Incidental or illegal shooting could be a minor concern in this geographic area. Of the 7 reported lynx mortalities in the last 15 years in this geographic area, 3 were due to vehicle collisions, 2 due to shootings, 1 from trapping, and 1 unknown (Wydeven 1998, Michigan Department of Natural Resources, in. litt. 1994, Minnesota Department of Natural Resources in litt. 1994, Paul Burke pers. comm. 1998).

Due to relatively high road and highway densities, mortality due to vehicle collisions may be an important risk factor within this geographic area. A number of high volume highways traverse this geographic area.

Risk Factors Affecting Movement

Conversion to agriculture may have decreased connectivity of habitat in northern Wisconsin and central and eastern Upper Michigan. Conversion to forest types less suitable for lynx may also have limited dispersal within this geographic area.

Dispersal of animals from southern Ontario into eastern Upper Michigan is currently inhibited by the extended Great Lakes shipping season, limiting opportunities for crossing on the ice of the St. Mary's River. The fragmentation of lynx habitat in southern Ontario by agricultural conversion has also resulted in a lower number of animals likely to disperse through this area.

Highways are probably an important factor limiting dispersal both into and within the geographic area. Several major highway corridors may impede dispersal into northern Wisconsin and the western portion of upper Michigan.

Northeast Geographic Area

Geographic Extent

The Northeast Geographic Area encompasses western Maine, central and northern New Hampshire, Vermont, the northeastern portion of New York, small portions in northwestern Massachusetts, and the very northeastern corner of Pennsylvania. This area largely falls within the Adirondack-New England Mixed Forest - Coniferous Forest - Alpine Meadow Province (McNab and Avers 1994). This province is composed of subdued glaciated mountains and maturely dissected plateaus of mountainous topography. Any glacially broadened valleys have glacial outwash deposits and contain numerous swamps and lakes. Elevations range from 150 - 1,220 m (500 - 4,000 feet) with a few isolated peaks higher than 1,525 m (5,000 feet).

The climate in the area is characterized by warm summers. Winters can be severely cold, but less so near the ocean. Average annual snowfall is more than 250 cm (100 inches). The forest vegetation of this ecoprovince is transitional between the boreal forests of the north and the deciduous forests to the south. Growth form and species are similar to those found to the north, but red spruce (Picea rubens) tends to replace white spruce. Valleys contain a hardwood forest with the principal tree species being sugar maple (Acer saccharum), yellow birch (Betula alleghaniensis), and beech, with a mixture of hemlock. Low mountain slopes support a mixed forest of spruce, fir, maple, beech, and birch. Above the mixed-forest zone lie pure stands of balsam fir and red spruce. Alpine meadows exist above timberline (Bailey 1995).

The Adirondack- New England Mixed Forest - Coniferous Forest - Alpine Meadow Province is composed of several ecological subdivisions, or Sections, as described by McNab and Avers (1994). These include the White Mountains Section, the New England Piedmont Section, the Green, Taconic, Berkshire Mountains Section, the Adirondack Highlands Section, and the Catskill Mountains Section.

White Mountains Section (M212A): This Section extends across the western one-half of Maine from north to south and the northeastern corners of New Hampshire and Vermont. The potential natural vegetation types occurring on this Section include northern hardwoods forest, northern hardwood-spruce forest, and northeastern spruce-fir forest (Kuchler 1964).

New England Piedmont Section (M212B): This Section covers much of the western half of New Hampshire, the northeastern one-third of Vermont, and small portions of north-central Massachusetts. Potential natural vegetation types occurring on this Section include northern hardwood forest and northern hardwood-spruce forest.

Green, Taconic, Berkshire Mountains Section (M212C): This Section covers most of the remainder of Vermont with the exception of the northwestern corner. It also reaches into western Massachusetts and east-central New York. Potential natural vegetation types occurring on this Section include northern hardwoods forest, northern hardwood-spruce forest, and northeastern spruce-fir forest.

Adirondack Highlands Section (M212D): This Section covers the Adirondack Mountains in northern New York. Potential natural vegetation types occurring on this Section include northern hardwood-spruce forest and northeastern spruce-fir forest.

Catskill Mountains Section (M212E): This Section occurs in southeastern New York and extends to the Pennsylvania border. Potential natural vegetation types occurring here include northern hardwood forest and northern hardwood-spruce forest.

Lynx Population Distribution

Although lynx are considered to have been historically resident within Maine, New Hampshire, Vermont, and New York, their current distribution in the Northeastern Geographic Area is now thought to be limited to Maine (U.S. Fish and Wildlife

Service 1998). Anecdotal information suggests that the species was breeding in Maine in the 1960's and 1970's (McKelvey et al. 2000b), and breeding was confirmed in 1999 when a radio-collared female produced two kittens (U.S. Fish and Wildlife Service in Litt. 1999). With the exception of Maine, recent records from the northeast are rare (McKelvey et al. 2000b).

Isolation of suitable habitat and limited connectivity with Canada apparently continue to be important factors in the low numbers of lynx in this region (Litvaitis et al. 1991, McKelvey et al. 2000b). The majority of the lynx habitat in this geographic area occurs on private land, ranging from small residential lots to large industrial ownerships (Harper et al. 1990).

Northeastern lynx habitat consists of forest vegetation that is transitional between the boreal forests of the north and the deciduous forests to the south. This habitat is similar to, and was formerly contiguous with, forested areas in southern Canada. Growth form and species are similar to those found to the north, but red spruce tends to replace white spruce.

Transient or dispersing lynx from the north may have periodically supplemented resident populations (Litvaitis et al. 1991). However, lynx populations in southern Canada have also experienced declines in recent decades, and are considered extirpated from the Upper St. Lawrence Valley (Alvo 1998). Due to the small and isolated nature of existing populations, maintaining and enhancing connectivity with occupied lynx habitats in Canada may be critical to the conservation of lynx in the northeastern U.S.

Lynx Habitat

Lynx habitat within the New England Geographic Area occurs in a mostly contiguous block of forest in the ecotone between the boreal and deciduous forest, primarily associated with northern spruce-fir forest and northern hardwood-spruce forest communities (higher elevations in the mountainous areas), in those areas where snow accumulation and condition may limit travel of competing species.

The conifer trees associated with forests of this area are red spruce, balsam fir, northern white cedar, eastern white pine (Pinus strobus), and hemlock. Hardwood species include northern hardwoods, aspen, and paper birch. The edges rather than the interior of large stands of essentially pure deciduous species are considered lynx habitat.

The mountainous krummholz zone provides foraging habitat for snowshoe hare (Clay Grove, pers. comm. 1999). Other foraging habitat containing hare are those forested stands in the younger and older ages that contain dense tree or shrub components. Regenerating stands in the earlier stages, and mid-aged stands are less suitable as foraging habitat for hare. Forested stands that contain conifers of cone-bearing age provide habitat for red squirrels and other alternate prey species. Denning habitat is associated more with structural components of forests, such as blowdown, deadfalls and root wads, rather than tree species.

Beyond climatic and topographic influences, the primary disturbance factors which created and maintained forest composition and successional patterns in this geographic area were wind, insects, disease, and fire.

Large blowdown disturbances resulting from hurricane winds and other severe weather events, such as ice and wind storms, contributed significantly to the early successional forest patterns in this region. Higher elevation forests are often characterized by an even-aged wind-throw phenomenon known as fir-waves. Insect and disease disturbances resulting from a variety of agents including spruce budworm, spruce beetle, beech bark disease, and sugar maple defoliators were also important factors affecting forest landscape patterns (McNab and Avers 1994).

These major disturbance events created diverse, early successional forests that provided habitats preferred by snowshoe hare, and thus important foraging areas for lynx. Red spruce and balsam fir are important components in snowshoe hare habitat. Smaller, localized wind events, disease outbreaks, and insect infestations likely created concentrations of downed logs, which provide suitable denning habitat for lynx. Denning habitat also could occur on or near the krummholz zone in this geographic area.

Fire is not a significant disturbance regime in this geographic area. Fire occurred more frequently in southern portions but becomes increasingly infrequent on more northern inland sites (McNab and Avers 1994). The typical fire regime for this part of the country was infrequent surface fires in the dormant season in the hardwood forests, and slightly more frequent but long-interval fires in some conifer forests (Kilgore and Heinselman 1990).

Due to forest fragmentation, land ownership patterns, and barriers to connectivity, there are relatively few areas that may be capable of supporting a lynx population. One of the only large contiguous blocks of forested land within lynx habitat is located in northwestern Maine. However, this area is largely in private ownership, with the majority of these being industrial landowners. Other lynx habitat within the geographic area is either quite small or cut off from possible immigration of lynx from occupied habitats.

Risk Factors Specific to Northeast

<u>Risk Factors Affecting Lynx Productivity</u>

Past timber management and other land uses have resulted in the loss of 75% of the spruce-fir forest cover from the White Mountain National Forest (J. Lanier, pers. comm. 1999). As a result of logging and land clearing on the White Mountain and Green Mountain National Forests at the turn of the century, many areas that were once predominantly softwood conifers regenerated to and were replaced by hardwoods. Remaining coniferous forest in the White Mountain and Green Mountain National Forests are in a mature condition in much of the potential lynx habitat. These mature conifer forests are now being regenerated, increasing the amounts of early successional stages (seedling and sapling stands). These activities are improving snowshoe hare habitat. Although hardwood forests do not typically supply adequate cover for snowshoe hares (Monthey 1986), many of the hardwood stands found on the White Mountain and Green Mountain National Forests have a conifer understory component.

In some areas within this geographic area, large tracts of coniferous forest were harvested to reduce the incidence of spruce budworm. This greatly simplified the forested landscape and did not provide the mosaic of forest stands necessary for lynx and snowshoe hare.

Although forested habitat has increased in recent decades and snowshoe hare populations appear to provide an adequate prey base, there is no evidence that lynx populations have responded on national forest lands.

Some potential for competition with other predators exists. Coyote numbers have increased dramatically in New England in the past few decades (Buskirk et al. 2000a). However, most lynx habitats occur in areas of high snow accumulation, which effectively precludes most winter coyote presence. This is especially true since the mountainous areas have very few roads or groomed winter recreation trails to attract competitors such as coyotes. The exception to this is some roading of spruce/fir habitats on private lands.

Risk Factors Affecting Mortality

Lynx trapping is currently illegal in the Northeastern Geographic Area. Trapping of other carnivores such as coyote, bobcat, marten and fisher is allowed, but no reports of incidentally trapped lynx have occurred within the past decade. Potential for incidental trapping exists but is considered very minimal.

Predation on lynx is unknown but is not considered to be a significant factor. Coyotes have recently expanded their range and become well established throughout the Northeast Geographic Area (J. Lanier, pers. comm. 1999). Coincidentally, bobcat numbers have declined but fox, marten, and fisher populations appear relatively stable (J. Lanier, pers. comm. 1999). Wolves are occasionally present in northern Maine but packs are apparently not established in this geographic area at present.

There are no domestic livestock grazing allotments on federal or state lands in this geographic area. Consequently, predator control activities are essentially limited to private lands and are not considered to be an important factor.

Though few records of incidental shootings exist, one radio-collared lynx that had been released in the Adirondack Mountains of New York during the 1980s was killed in a farmer's chicken coop in New Hampshire approximately 10 years ago (J. Lanier, pers. comm. 1999).

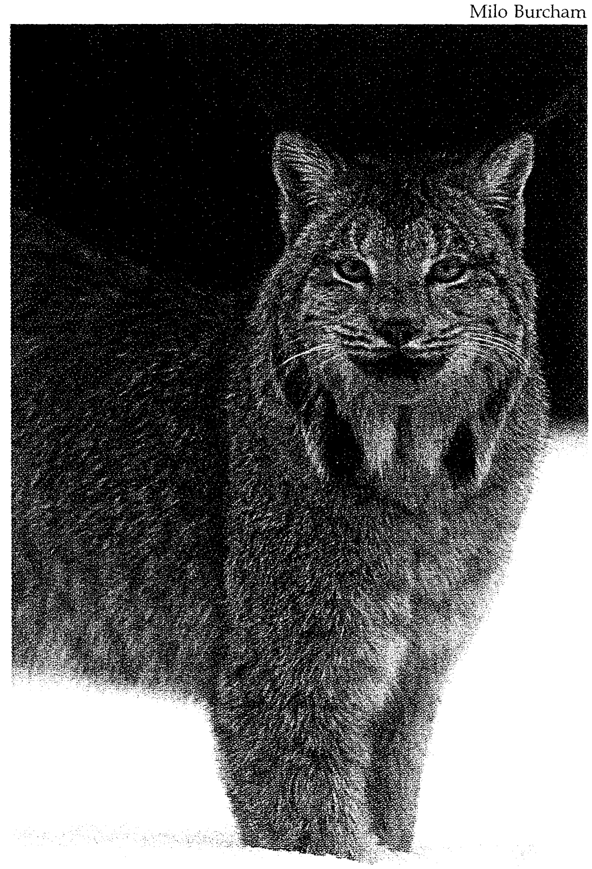
Highway mortality records indicate one road-killed lynx in New Hampshire in the last five years (J. Lanier, pers. comm. 1999). In the Adirondack Mountains of New York, an attempt to reintroduce lynx was unsuccessful; 18 of 37 mortalities of translocated animals were attributed to road kills (Brocke et al. 1990). A number of high volume highways traverse this geographic area.

Risk Factors Affecting Movement

Paved roads with high-volume traffic, non-forested agricultural lands, or other intervening areas of unsuitable habitat impede re-occupation of potentially suitable habitats in this geographic area, especially those in New York, New Hampshire, and Vermont.

Agricultural conversion and/or urban development in southern Canada may be an additional hindrance to connectivity with the north. The St. Lawrence River is now a major shipping lane and crossings are unlikely. Lynx from a resident population in a Quebec reserve south of the St. Lawrence and animals from occupied habitat in New Brunswick should be able to immigrate into Maine.

Milo Burcham



Planning Area Description and Risk Factors

A Planning Area is not a biological scale of particular relevance to lynx, but rather is the scale at which broad programmatic planning direction is developed. Consultation under the Endangered Species Act is conducted by federal agencies for both programmatic and project planning. In this section, we have specifically identified risk factors related to lynx management for which programmatic management direction should be developed. Recommended conservation measures (found in Chapter 7) have also been sorted into those applicable at the programmatic and project levels.

Geographic Extent

Programmatic plans provide broad direction for management activities by establishing goals, objectives, desired future condition statements, standards, guidelines, and land allocations. Examples of programmatic plans are regional guides and forest land and resource management plans, as required under the National Forest Management Act; Resource Management Plans, as required under the Federal Lands and Policy Management Act; and General Management Plans for individual National Parks.

Lynx Population and Habitat Distribution

In Appendix A, the national forests, BLM field offices, national parks, and wildlife refuges that should develop or refine maps of known lynx occurrence and potential lynx habitat are identified.

There is substantial uncertainty as to the historical distribution and status of lynx in some areas, particularly Wisconsin, Michigan, New York, Vermont, southeastern Washington, northeastern Oregon, the Oregon Cascades, central and southern Idaho, and Utah (McKelvey et al. 2000b). Surveys designed to detect lynx presence should be emphasized in these areas.

Risk Factors Specific to Planning Areas

Risk Factors Affecting Lynx Productivity

Timber management activities occur throughout the range of lynx in the conterminous United States and directly affect the quality and quantity of available habitats for this species. Timber harvest levels established in the various programmatic plans must be consistent with objectives for maintaining lynx habitat, especially to provide for denning and foraging requirements.

Reduction of large diameter woody debris may affect the survival of lynx kittens and the availability of lynx prey, including snowshoe hares and red squirrels. Programmatic plans should be reviewed to determine whether or not they will provide adequate down woody material necessary for lynx denning habitat. As such plans are updated, they should be adjusted to fully integrate retention objectives for large diameter woody debris, in the context of natural disturbance processes.

Pre-commercial thinning reduces the quality and quantity of snowshoe hare foraging habitat and escape cover. Pre-commercial thinning programs have traditionally been applied to large areas of regenerating forests, after human-caused or natural disturbances, as stands approach or reach optimum conditions for snowshoe hares.

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Den site

Fire exclusion may alter the natural mosaic of forest successional stages necessary for maintaining snowshoe hare habitat across landscapes over time. Current federal fire management policy requires suppression of wildfires in the absence of approved prescribed fire plans, and such plans have not yet been completed on many land management units. In addition, certain management area prescriptions in many forest plans and resource management plans may preclude the use of fire. This limits the use of fire to help perpetuate vegetation conditions that favor lynx and snowshoe hares.

Livestock grazing in important lynx prey habitats such as riparian areas, aspen stands and high-elevation willow communities may reduce available forage for snowshoe hares. Programmatic plans should be reviewed to ensure that the areas where livestock grazing is permissible, the allowable number of animal unit months (AUMs), and grazing use levels or standards are compatible with maintaining adequate lynx prey.

Human presence in lynx denning habitat during the May through August period may be detrimental to lynx. In winter, human presence on forest roads and trails that results in snow compaction may provide lynx competitors such as coyotes, cougars, bobcats and wolves access into lynx habitat. Travel plans should be reviewed to determine if opportunities exist to reduce access to important lynx habitats.

Mineral prospecting and extracting activities may affect important lynx habitats or linkage areas. As programmatic plans are updated or revised, such areas should be evaluated to determine if withdrawal from mineral leasing is warranted.

Risk Factors Affecting Mortality

Outside of Colorado and the national parks, regulated trapping seasons occur in all planning areas. Incidental trapping of lynx, though uncommon in most areas, could be a factor of concern in areas that encompass known lynx population centers, or those attempting to reestablish lynx populations.

Relationships between lynx and potential predators and competitors are poorly understood. On a planning area scale, motorized and non-motorized access during the winter may affect levels of predation on lynx and competition for snowshoe hares. The increase in groomed or packed snow trails or areas into deep snow conditions may provide access for lynx predators/competitors. Some types of vegetation management can result in habitat conditions that favor or discourage use by potential lynx predators.

Predator control activities occurring within lynx habitat on federally administered lands may pose a risk to lynx. Programmatic planning provides the opportunity to affect this risk factor through management direction (standards and guidelines), and through management direction in allotment management plans/annual operating plans. Since predator control activities are area and species specific, or often may target a specific offending animal, this risk factor may be very manageable on a planning area basis.

Illegal or accidental (i.e. mistaken identity) shootings of lynx, though uncommon, may be a concern in planning areas known to contain occupied lynx habitat.

Highway segments that cross the planning area and have experienced significant wildlife mortality due to vehicular collisions should be identified. Key linkage areas should be identified to integrate into planning at this scale.

Risk Factors Affecting Movement

Assessments of habitat connectivity and possible barriers are best done at broader scales, such as the planning unit or larger. Key linkage areas are especially important in the southern portions of lynx range. Such areas should be identified and appropriate management objectives and direction established in programmatic plans.

Home Range Description and Risk Factors

Geographic Extent

In the lower 48 states, lynx habitat quality is believed to be lower than in northern boreal forests, due to lower prey densities and inherent habitat patchiness (Koehler and Aubry 1994). Lynx in the southern portion of their range may include areas used primarily for traveling between hunting sites (Koehler and Brittell 1990), which could increase home range size. Therefore, a gradient in home range size may occur in the U.S., with largest home range size occurring in the patchy habitats of Colorado. However, our premise that increases in home range sizes occur in more southern regions is speculative. Lynx home range studies in southern regions have varied in design, implementation, and analysis (Aubry et al. 2000). Differences in habitat quality, sex, age and reproductive status of study animals, duration of study, available prey resources, along with small sample sizes, limit the usefulness of a direct comparison of results. The following paragraphs summarize home range information.

Aubry et al. (2000) provided a compilation of annual mean home range sizes for lynx. In general, lynx home ranges in southern boreal forests were large compared to those reported from the taiga during times of high snowshoe hare densities. The mean home range for male lynx was about 151 km^2 (58 mi^2) in southern boreal forests and 62 km^2 (24 mi^2) on the taiga during high hare densities, and for females were 72 km^2 (28 mi^2) and 30 km^2 (12 mi^2) for the south and taiga during high hare densities, respectively. However, the relationship was not as

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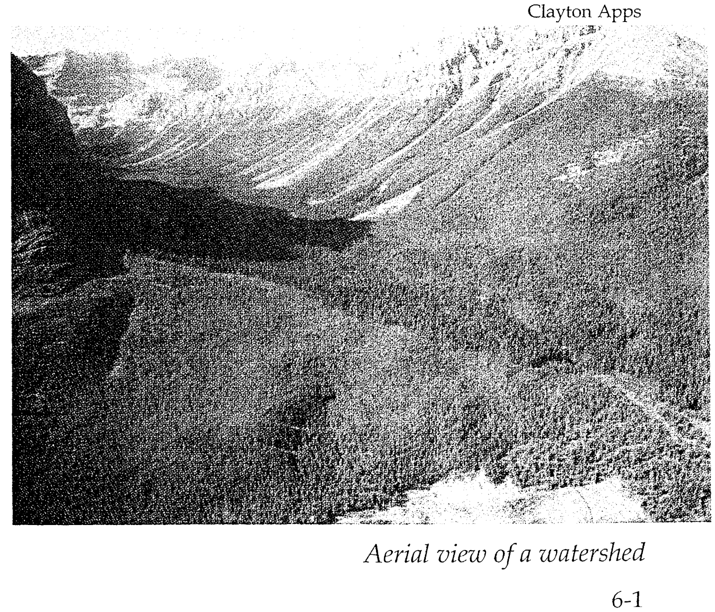


Aerial view of a watershed

strong during periods of low hare densities.

Squires and Laurion (2000) reported that their findings generally support the contention that lynx in more southern regions have large home ranges. In Montana, the annual 95% minimum convex polygon (MCP) average home range size for males was 238 km^2 (92 mi^2) and 115 km^2 (44 mi^2) for females. In west-central Wyoming, average annual home range estimates for one male and one female lynx were 110 km^2 (42 mi^2) and 90 km^2 (35 mi^2) respectively. In southwestern Alberta and southeastern British Columbia, Canada, mean annual home range for 3 male lynx was 277 km^2 (107 mi^2) and for 3 females was 135 km^2 (52 mi^2) (Apps 2000).

The following home range estimates from the lower 48 states are based on 100% MCP estimates. In northcentral Washington, the mean annual home range size of 5 males was 69 km^2 (27 mi^2) and 39 km^2 (15 mi^2) for 2 females (Koehler 1990). In Montana, annual home ranges of 6 males averaged 122 km^2 (47 mi^2) and for 4 females averaged 43 km^2 (17 mi^2) (Brainerd 1985).

We recommend that Lynx Analysis Units (LAUs) be identified for all areas with lynx habitat. LAUs are not intended to depict actual lynx home ranges, but are intended to provide analysis units of the appropriate scale with which to begin the analysis of potential direct and indirect effects of projects or activities on individual lynx, and to monitor habitat changes.

Lynx Population Distribution

LAUs should approximate the size of a female's annual home range and encompass all seasonal habitats. LAUs will also likely contain areas of non-lynx habitat, such as lower elevation drier sites, especially in mountainous regions. Generally, lynx conservation measures apply only to lynx habitat within LAUs, although considerations related to connectivity may be appropriate for other areas.

The spatial arrangement of LAUs should be evaluated. Some minimum number of contiguous LAUs will be necessary to provide the amount and distribution of habitat required to manage for viable lynx populations. Each planning unit should evaluate those areas with more or less discontiguous patches of lynx habitat to determine the potential for lynx management. A single LAU, isolated from other blocks of lynx habitat, is unlikely to be effective in providing lynx habitat in sufficient amounts to maintain or increase lynx numbers.

Lynx Habitat

In the lower 48 states, lynx habitat quality is believed to be lower than in northern boreal forests, due to lower prey densities and inherent habitat patchiness (Koehler and Aubry 1994). Large home range sizes documented in Washington (Koehler 1990), Montana (Koehler et al. 1979, Brainerd 1985, Smith 1986), and Minnesota (Mech 1980) indicated that lynx were required to travel extensively to locate sufficient prey resources.

Therefore, we assumed that maintaining high-quality foraging habitat within each LAU through time is very important. In addition, we inferred that limits must be placed on the extent of habitat alteration that can occur at one time within an LAU. Limits on alterations within LAUs are intended to aid in maintaining a distribution of suitable lynx habitat across the landscape. Although we acknowledge the positive and negative impacts of large scale, landscape events on lynx habitat, we recognize also that human alteration of habitat differs from natural events such as fire. Until landscape analyses are completed, we recommend limits on human alteration of lynx habitat measured at an LAU scale. The development of landscape analyses is recommended and can be used to assess the potential for designing larger treatments that could benefit lynx habitat. In these cases, the limitations on changes within individual LAUs may be waived or modified to accommodate preferred conditions on a landscape scale, encompassing many LAUs.

At highly developed recreational facilities, such as ski areas or resorts, we assumed that diurnal security habitat might be needed within a home range, to provide the animal(s) with the opportunity to rest undisturbed. These areas should be in proximity to foraging or denning habitats, and within the range of daily movements. We assumed that diurnal security habitat is not a static or permanently delineated area, but one that may change or shift over time within a particular home range

Risk Factors Specific to Home Range

Risk Factors Affecting Lynx Productivity

Timber management may reduce the amount and/or quality of foraging habitat available for an individual lynx. Timber management can affect the spatial arrangement of foraging habitat and denning habitat. The proximity of foraging habitat to denning habitat can influence kitten survival. Timber harvest may reduce the amount of coarse woody debris in an area, needed throughout the home range to protect kittens and to maintain red squirrel habitat.

Fire exclusion may alter the natural mosaic of forest successional stages, and thereby result in less snowshoe hare habitat over time. Road construction to facilitate suppression of wildfires may increase human access into lynx habitat, and could lead to increased competition from other predators such as coyotes. Creation of fuel breaks on ridges eliminates cover and may discourage use by lynx.

Grazing within lynx habitat may impact important microsites such as high elevation riparian meadows and willow communities, thus reducing snowshoe hare habitat.

Use of roads and trails during winter that results in compacted snow may allow coyotes to travel into deep snow lynx habitats and compete for snowshoe hare prey. High-intensity recreational use, such as that occurring at ski areas, may provide a level of disturbance that effectively precludes lynx use (at least temporarily) of otherwise suitable habitat.

Other human developments that could degrade habitat within a lynx home range include oil and gas field development, surface mining, and construction of reservoirs.

Risk Factors Affecting Mortality

At the home range scale, the risk of mortality to which an animal is exposed may be influenced by human presence and activities. For example, road networks and snowmobile use may improve the ease of trapping within a particular area, and increase the potential for accidental capture of lynx. Specific predator control activities are often conducted at scales pertinent to lynx home range.

Risk Factors Affecting Movements

Paved highways with high traffic volume, particularly if it continues during nighttime, can impede lynx movement within a home range.

Land ownership may fragment lynx habitat, if land is converted to conditions or uses that are not suitable habitat.

Conservation Measures

Approach to Development of Conservation Measures

The following conservation measures are intended to conserve the lynx, and to reduce or eliminate adverse effects from the spectrum of management activities on federal lands. These measures are provided to assist federal agencies in seeking opportunities to benefit lynx and to help avoid negative impacts through the thoughtful planning of activities. Plans that incorporate them, and projects that implement them, are generally not expected to have adverse effects on lynx, and implementation of these measures across the range of the lynx is expected to lead to conservation of the species.

However, because it is impossible to provide standards and guidelines that will address all possible actions, in all locations across the broad range of the lynx, it is imperative that project specific analysis and design be completed, for all actions that have the potential to effect lynx. Circumstances unique to individual projects or actions and their locations may still result in adverse effects on lynx. In these cases, additional or modified mitigating measures may be necessary to avoid or minimize adverse effects.

As described previously, little research has been conducted on lynx in the contiguous United States. We have cited the literature as a basis of management recommendations where possible. However, on many issues, no information exists. In these cases, we have offered recommendations to fulfill the purpose of developing a useful, proactive plan until additional information from scientific assessments, lynx surveys, and effectiveness monitoring become available.

The conservation measures are written to support management of lynx and their habitat. However, in the absence of specific knowledge about lynx, many of the recommendations were drawn from knowledge about their primary prey (snowshoe hares) and important alternate prey (red squirrels), other forest carnivores, and basic principles for maintaining or restoring native ecological processes and patterns. A benefit of this approach is that it should enhance compatibility with the needs of other species that inhabit the same ecosystems.

Until conclusive information is developed concerning lynx management, we recommend the agencies retain future options. That is, choose to err on the side of maintaining and restoring habitat for lynx and their prey. In particular, managers should avoid making an irretrievable commitment of resources that could ultimately prove crucial in maintaining or restoring viable, self-sustaining lynx populations within an ecosystem.

The order in which the conservation measures appear does not imply their relative priority.

The terms "objectives", "standards", and "guidelines" have specific meanings under public land management laws. They are not necessarily intended to have that meaning here. See the glossary for how these terms are used in this document.

Scales of Analysis

The conservation measures will likely be implemented through two scales of decision-making: programmatic and project planning. Programmatic plans provide broad direction for management activities by establishing goals, objectives, desired future condition statements, standards, guidelines, and land allocations. Direction in programmatic plans may either be substantive (e.g., requiring that certain amounts of habitat always be maintained), or may be procedural (e.g., requiring that certain analyses be conducted at the project level). Substantive direction in programmatic plans of necessity is written to address typical conditions that would be encountered. Project planning implements the broad programmatic direction, by accomplishing procedural requirements and designing activities that tailor substantive management direction to the unique conditions and circumstances of a particular site.

Project Planning Analysis Units: Lynx analysis units (LAUs) are intended to provide the fundamental or smallest scale with which to begin evaluation and monitoring of the effects of management actions on lynx habitat.

LAUs do not depict actual lynx home ranges, but their scale should approximate the size of area used by an individual lynx. LAUs need not be a new analysis unit. Rather, to promote integration with other resource analyses, we recommend that previously delineated and accepted ecological units, such as Hydrologic Unit Codes (HUCs) or Landtype Associations (LTAs) be used.

Several of the conservation measures require analysis units within which rather specific parameters can be measured (e.g., limits on human alteration of habitat, no net increase in groomed over-the-snow routes). LAUs provide this analysis unit. Application of certain conservation measures at the LAU scale allows blocks of quality lynx habitat to be maintained within each LAU, thereby maintaining a good distribution of lynx habitat at the scale of a lynx home range. Limits on impacts at the LAU scale are necessary until we develop a more complete understanding of landscape level events and their effects on lynx. Once a broad scale assessment is complete, the utility of the LAU and appropriateness of limitations at the LAU scale should be readdressed.

LAUs will likely encompass both lynx habitat (may or may not be currently in suitable condition for denning or foraging habitat) and other areas (such as lakes, low elevation ponderosa pine forest, and alpine tundra). Conservation measures (objectives, standards, and guidelines) generally apply only to lynx habitat within the LAUs.

The LAU may not provide a large enough analysis area within which to address direct, indirect, and cumulative effects of particular actions. In many cases, project impacts must be assessed within the context of two or more LAUs (e.g., large-scale ski area development, prescribed fire). Additionally, naturally occurring events such as lightning-ignited fire may impose changes across many LAUs.

Programmatic Planning Analysis Units: Programmatic planning should not be limited to or focused on the scale of individual LAUs. Programmatic planning may entail the consideration of landscape patterns across large areas, such as all the LAUs within a given subbasin or mountain range.

Conservation Measures Applicable to All Programs and Activities

In the previous sections, lynx population status, habitat description, and relevant risk factors were identified for four scales: range-

Gary Koehler

Kitten/logs

wide, geographic area, planning area, and home range. To provide meaningful results, analysis must be matched to the appropriate biological scale. For example, consideration of genetic variation and interchange would require sampling within the entire range of the species. Similarly, consideration of population connectivity is probably best addressed at the scale of one or more geographic areas. To estimate historical landscape patterns, analysis must be large enough to encompass the largest disturbance events, which might involve an entire planning area. Juxtaposition of denning and foraging habitat is appropriately evaluated at the home range scale.

Programmatic planning—objectives.

1. Design vegetation management strategies that are consistent with historical succession and disturbance regimes. The broad-scale strategy should be based on a comparison of historical and current ecological processes and landscape patterns, such as age-class distributions and patch size characteristics. It may be necessary to moderate the timing, intensity, and extent of treatments to maintain all required habitat components in lynx habitat, to reduce human influences on mortality risk and interspecific competition, and to be responsive to current social and ecological constraints relevant to lynx habitat.

Programmatic planning—standards.

1. Conservation measures will generally apply only to lynx habitat on federal lands within LAUs.

2. Lynx habitat will be mapped using criteria specific to each geographic area to identify appropriate vegetation and environmental conditions. Primary vegetation includes those types necessary to support lynx reproduction and survival. It is recognized that other vegetation types that are intermixed with the primary vegetation will be used by lynx, but are considered to contribute to lynx habitat only where associated with the primary vegetation. Refer to glossary and description for each geographic area.

3. To facilitate project planning, delineate LAUs. To allow for assessment of the potential effects of the project on an individual lynx, LAUs should be at least the size of area used by a resident lynx and contain sufficient year-round habitat.

4. To be effective for the intended purposes of planning and monitoring, LAU boundaries will not be adjusted for individual projects, but must remain constant.

5. Prepare a broad-scale assessment of landscape patterns that compares historical and current ecological processes and vegetation patterns, such as age-class distributions and patch size characteristics. In the absence of guidance developed from such an assessment, limit disturbance within each LAU as follows: if more than 30 percent of lynx habitat within a LAU is currently in unsuitable condition, no further reduction of suitable conditions shall occur as a result of vegetation management activities by federal agencies.

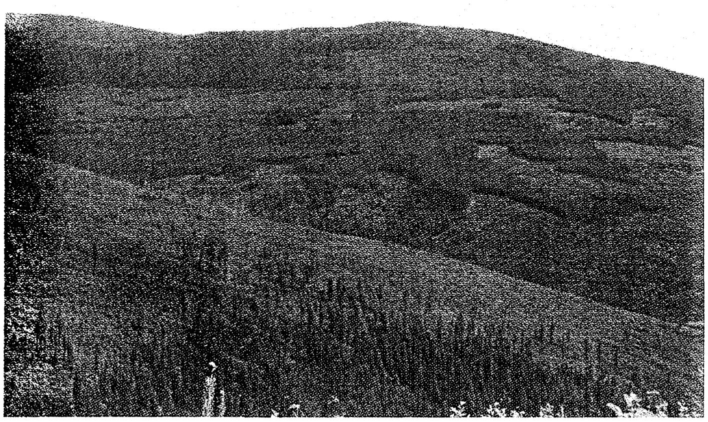
Programmatic planning—guidelines.

1. The size of LAUs should generally be 6,500- 10,000 ha (16,000 - 25,000 acres or 25-50 square miles) in contiguous habitat, and

likely should be larger in less contiguous, poorer quality, or naturally fragmented habitat. Larger units should be identified in the southern portions of the Northern Rocky Mountains Geographic Area (in Idaho from the Salmon River south, Oregon, Wyoming, and Utah) and in the Southern Rocky Mountains Geographic Area.

In the west, we recommend using watersheds (e.g., 6th code hydrologic unit codes (HUCs) in more northerly portions of geographic areas, and 5th code HUCs in more southerly portions). In the east, terrestrial ecological units that have been delineated at the landtype association or subsection level (e.g., LTAs or whatever scale most closely approximates the size of a lynx home range) may be an appropriate context for analysis. Coordinate delineation of LAUs with adjacent administrative units and state wildlife management agencies, where appropriate.

Clayton Apps



Landscape mosaic

2. LAUs with only insignificant amounts of lynx habitat may be discarded, or lynx habitat within the unit incorporated into neighboring LAUs. Based on studies at the southern part of lynx range in the western U.S., it appears that at least 10 mi2 of primary vegetation should be present within each LAU to support survival and reproduction. The distribution of habitat across the LAU should consider daily movement distances of resident females (typically up to 3-6 miles).

3. After LAUs are identified, their spatial arrangement should be evaluated. Determine the number and arrangement of contiguous LAUs needed to maintain lynx habitat well distributed across the planning area.

Project planning—standards.

1. Within each LAU, map lynx habitat. Identify potential denning habitat and foraging habitat (primarily snowshoe hare habitat, but also habitat for important alternate prey such as red squirrels), and topographic features that may be important for lynx movement (major ridge systems, prominent saddles, and riparian corridors). Also identify non-forest vegetation (meadows, shrub-grassland communities, etc.) adjacent to and intermixed with forested lynx habitat that may provide habitat for alternate lynx prey species.

2. Within a LAU, maintain denning habitat in patches generally larger than 5 acres, comprising at least 10 percent of lynx habitat. Where less than 10 percent denning habitat is currently present within a LAU, defer any management actions that would delay development of denning habitat structure.

3. Maintain habitat connectivity within and between LAUs.

Conservation Measures to Address Risk Factors Affecting Lynx Productivity

A. Timber Management in Lynx Habitat

Timber management modifies the vegetation structure and mosaic of forested landscapes. Timber management can be used in conjunction with, or in place of, fire as a disturbance process to create and maintain snowshoe hare habitat. In the southern portion of its range, lynx populations appear to be limited by the availability of snowshoe hare prey, as suggested by large home range sizes, high kitten mortality due to starvation, and greater reliance on alternate prey, especially red squirrels, as compared with populations in northern Canada. Timber management practices should be designed to maintain or enhance habitat for snowshoe hare and alternate prey such as red squirrel. Dense horizontal cover of conifers, just above the snow level in winter, is critical for snowshoe hare habitat. This structure may occur either in regenerating seedling/sapling stands, or as an understory layer in older stands.

Most aspen stands in the Rocky Mountains are in late successional condition as a result of past fire prevention and grazing. In aspen stands intermixed with spruce-fir forests, particularly in southern Idaho, southern Montana, Wyoming, Utah, and Colorado, treatments that result in dense regeneration of aspen are likely to enhance habitat for potential prey of lynx.

Programmatic planning—objectives.

1. Evaluate historical conditions and landscape patterns to determine historical vegetation mosaics across landscapes through time. For example, large infrequent disturbance events may have been more characteristic of lynx habitat than small frequent disturbances.

2. Maintain suitable acres and juxtaposition of lynx habitat through time. Design vegetation treatments to approximate historical landscape patterns and disturbance processes.

3. If the landscape has been fragmented by past management activities that reduced the quality of lynx habitat, adjust management practices to produce forest composition, structure, and patterns more similar to those that would have occurred under historical disturbance regimes.

Project planning—objectives.

1. Design regeneration harvest, planting, and thinning to develop characteristics suitable for snowshoe hare habitat.

Dick Wenger

Open stand

Dick Wenger

Closed stand

2. Design project to retain/enhance existing habitat conditions for important alternate prey (particularly red squirrel).

Project planning—standards.

1. Management actions (e.g., timber sales, salvage sales) shall not change more than 15 percent of lynx habitat within a LAU to an unsuitable condition within a 10-year period.

2. Following a disturbance, such as blowdown, fire, insects/pathogens mortality that could contribute to lynx denning habitat, do not salvage harvest when the affected area is smaller than 5 acres. Exceptions to this include: 1) Areas such as developed camp-

grounds; 2) LAUs where denning habitat has been mapped and field validated (not simply modeled or estimated), and denning habitat comprises more than 10% of lynx habitat within a LAU; in these cases, salvage harvest may occur, provided that at least the minimum amount is maintained in a well-distributed pattern (see glossary).

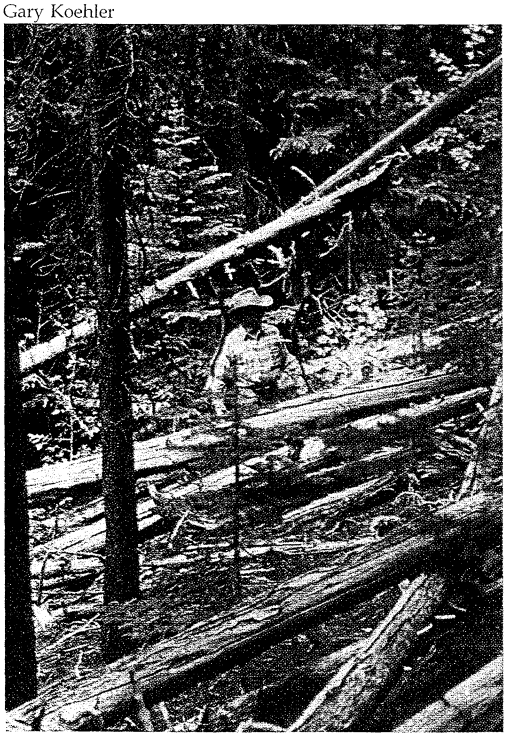
3. In lynx habitat, pre-commercial thinning will be allowed only when stands no longer provide snowshoe hare habitat (e.g., self-pruning processes have eliminated snowshoe hare cover and forage availability during winter conditions with average snowpack).

4. In aspen stands within lynx habitat in the Cascade Mountains, Northern Rocky Mountains and Southern Rocky Mountains Geographic Areas, apply harvest prescriptions that favor regeneration of aspen.

Project planning – guidelines.

1. Plan regeneration harvests in lynx habitat where little or no habitat for snowshoe hares is currently available, to recruit a high density of conifers, hardwoods, and shrubs preferred by hares. Consider the following:

Gary Koehler



Denning habitat

a) Design regeneration prescriptions to mimic historical fire (or other natural disturbance) events, including retention of fire-killed dead trees and coarse woody debris;

b) Design harvest units to mimic the pattern and scale of natural disturbances and retain natural connectivity across the landscape. Evaluate the potential of riparian zones, ridges, and saddles to provide connectivity; and

c) Provide for continuing availability of foraging habitat in proximity to denning habitat.

2. In areas where recruitment of additional denning habitat is desired, or to extend the production of snowshoe hare foraging habitat where forage quality and quantity is declining due to plant succession, consider improvement harvests (commercial thinning, selection, etc). Improvement harvests should be designed to:

a) Retain and recruit the understory of small diameter conifers and shrubs preferred by hares;

b) Retain and recruit coarse woody debris, consistent with the likely availability of such material under natural disturbance regimes; and

c) Maintain or improve the juxtaposition of denning and foraging habitat.

B. Wildland Fire Management

Wildland fire and insects have historically played the dominant role in maintaining a mosaic of forest successional stages in lynx habitat. Stand-replacing fires were infrequent and affected large areas. In areas with a mixed fire regime, moderate to low intensity fires also occurred in the intervals between stand-replacing events. Refer to the geographic area descriptions for more detailed information regarding historical fire regimes.

Periodic vegetation disturbances maintain the snowshoe hare prey base for lynx. In the period immediately following large stand-replacing fires, snowshoe hare and lynx densities are low. Populations increase as the vegetation grows back and provides dense horizontal cover, until the vegetation grows out of the reach of hares. Low to moderate intensity fires may also stimulate understory development in older stands.

Fire exclusion may have altered the pattern and composition of vegetation in subalpine forests. In the western United States, particularly in the southern portion of the Northern Rocky Mountains Geographic Area and in the Southern Rocky Mountains Geographic Area, fire exclusion is one of the primary factors contributing to the decline or loss of aspen. Aspen communities occupy a small percentage of the total forested area, but they provide important habitat diversity. Aspen/tall forb community types, especially those that include snowberry, serviceberry and chokecherry shrubs in the understory, are very productive and may contribute to the quality of lynx foraging habitat.

Wildland fire management activities include suppression and pre-suppression activities, as well as prescribed fire (natural and management ignitions).

Programmatic planning—objectives.

1. Restore fire as an ecological process. Evaluate whether fire suppression, forest type conversions, and other forest management practices have altered fire regimes and the functioning of ecosystems.

2. Revise or develop fire management plans to integrate lynx habitat management objectives. Prepare plans for areas large enough to encompass large historical fire events.

3. Use fire to move toward landscape patterns consistent with historical succession and disturbance regimes. Consider use of mechanical pre-treatment and management ignitions if needed to restore fire as an ecological process.

4. Adjust management practices where needed to produce forest composition, structure, and patterns more similar to those that would have occurred under historical succession and disturbance regimes.

5. Design vegetation and fire management activities to retain or restore denning habitat on landscape settings with highest probability of escaping stand-replacing fire events. Evaluate current distribution, amount, and arrangement of lynx habitat in relation to fire disturbance patterns.

6. In the Great Lakes Geographic Area, restore tree species composition and structure so that fire can be returned to the ecosystem where feasible.

Project planning— objectives.

1. Use fire as a tool to maintain or restore lynx habitat.

2. When managing wildland fire, minimize creation of permanent travel ways that could facilitate increased access by competitors.

Project planning—standards.

1. In the event of a large wildfire, conduct a post-disturbance assessment prior to salvage harvest, particularly in stands that were formerly in late successional stages, to evaluate potential for lynx denning and foraging habitat.

2. Design burn prescriptions to regenerate or create snowshoe hare habitat (e.g., regeneration of aspen and lodgepole pine).

Project planning—guidelines.

1. Design burn prescriptions to promote response by shrub and tree species that are favored by snowshoe hare.

2. Design burn prescriptions to retain or encourage tree species composition and structure that will provide habitat for red squirrels or other alternate prey species.

3. Consider the need for pre-treatment of fuels before conducting management ignitions.

4. Avoid constructing permanent firebreaks on ridges or saddles in lynx habitat.

5. Minimize construction of temporary roads and machine fire lines to the extent possible during fire suppression activities.

6. Design burn prescriptions and, where

feasible, conduct fire suppression actions in a manner that maintains adequate lynx denning habitat (10% of lynx habitat per LAU).

C. Recreation Management

Lynx have evolved a competitive advantage in environments with deep soft snow that tends to exclude other predators during the middle of winter, a time when prey is most limiting (Murray and Boutin 1991, Livaitis 1992, Buskirk et al. 2000). Widespread human activity (snowshoeing, cross-country skiing, snowmobiling, snow cats) may lead to patterns of snow compaction that make it possible for competing predators such as coyotes and bobcats to occupy lynx habitat through the winter, reducing its value to and even possibly excluding lynx (Bider 1962, Ozoga and Harger 1966, Murray et al. 1995, O'Donoghue et al. 1998). In order to maintain a competitive advantage for lynx, it may be necessary to minimize or even preclude snow compacting activities in and around quality snowshoe hare habitat. To not do so may lead to the elimination of lynx, or preclude the ability to re-establish them, in these landscapes.

A consideration for lynx in winter landscapes is exploitation or interference competition from other predator/competitors (Buskirk et al. 2000) and human disturbance (e.g., large developed recreational sites or areas of concentrated winter recreational use). Lynx may be able to adapt to the presence of regular and concentrated recreational use, so long as critical habitat needs are being met. Therefore it is essential that an interconnected network of foraging habitat be maintained that is not subjected to widespread human intervention or competition from other predator species.

In areas of concentrated recreational use (e.g., large ski areas), it may be necessary to maintain or provide "diurnal security habitat". In landscapes where there is widespread or intense recreational use, the natural diurnal patterns of human and lynx activity may provide the opportunity to maintain both uses in the landscape. Most human activity occurs during daylight hours, while lynx appear to be most active dusk to dawn, although weather may affect the time period when lynx are most active (Apps 2000). A key to providing temporal segregation of use may be in ensuring there are places in that landscape were lynx can bed during the day relatively undisturbed. Sites that are similar to denning habitat (i.e., areas that are tangled with large woody debris) will tend to exclude most human activity because of the inherent difficulty they pose for human movement. Diurnal security habitat should be sufficiently large to provide effective and visual insulation from human activity, and must be well distributed and in proximity to foraging habitat.

Where such diurnal security sites exist, they should be protected from actions or activities that would destroy or compromise their functional value. In landscapes where these areas are lacking or inadequate, it may be desirable to create them, focusing on location, adequate size, and an abundance of jackstrawed large woody debris.

Landscape connectivity may be provided by narrow forested mountain ridges, plateaus, or forest stringers that link more extensive areas of lynx habitat. Woodland riparian communities that provide travel cover across otherwise open areas may also provide connectivity.

Minimizing disturbance around denning habitat is important from May to August.

<u>Programmatic planning—objectives.</u>

1. Plan for and manage recreational activities to protect the integrity of lynx habitat, considering as a minimum the following:

a) Minimize snow compaction in lynx habitat.

b) Concentrate recreational activities within existing developed areas, rather than developing new recreational areas in lynx habitat.

c) On federal lands, ensure that development or expansion of developed recreation sites or ski areas and adjacent lands address landscape connectivity and lynx habitat needs.

Programmatic planning—standards.

1. On federal lands in lynx habitat, allow no net increase in groomed or designated over-the-snow routes and snowmobile play areas by LAU. This is intended to apply to dispersed recreation, rather than existing ski areas.

2. Map and monitor the location and intensity of snow compacting activities (for example, snowmobiling, snowshoeing, cross-country skiing, dog sledding, etc.) that coincide with lynx habitat, to facilitate future evaluation of effects on lynx as information becomes available.

Programmatic planning—guidelines.

1. Provide a landscape with interconnected blocks of foraging habitat where snowmobile, cross-country skiing, snowshoeing, or other snow compacting activities are minimized or discouraged.

2. As information becomes available on the impact of snow-compacting activities and disturbance on lynx, limit or discourage this use in areas where it is shown to compromise lynx habitat. Such actions should be undertaken on a priority basis considering habitat function and importance.

Project planning—standards.

Developed Recreation:

1. In lynx habitat, ensure that federal actions do not degrade or compromise landscape connectivity when planning and operating new or expanded recreation developments.

2. Design trails, roads, and lift termini to direct winter use away from diurnal security habitat.

Dispersed Recreation:

1. To protect the integrity of lynx habitat, evaluate (as new information becomes available) and amend as needed, winter recreational special use permits (outside of permitted ski areas) that promote snow compacting activities in lynx habitat.

Project planning—guidelines.

Developed Recreation:

1. Identify and protect potential security habitats in and around proposed developments or expansions.

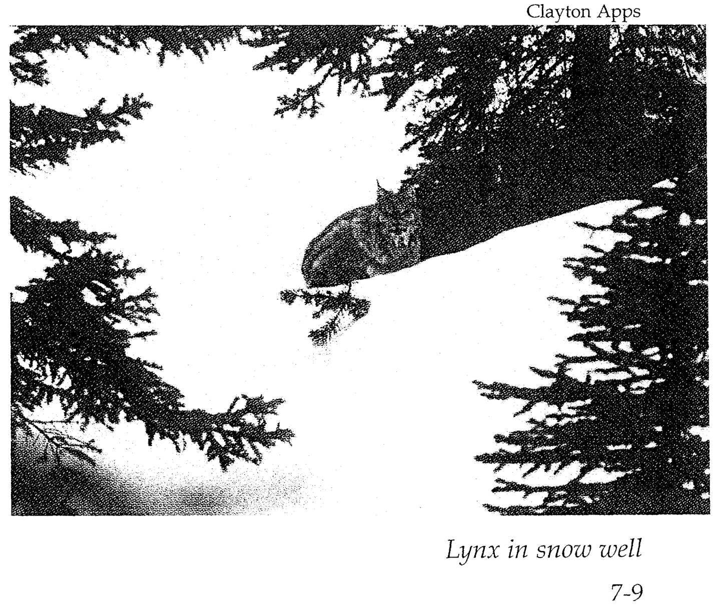
2. When designing ski area expansions, provide adequately sized coniferous inter-trail islands, including the retention of coarse woody material, to maintain snowshoe hare habitat.

3. Evaluate, and adjust as necessary, ski operations in expanded or newly developed areas to provide nocturnal foraging opportunities for lynx in a manner consistent with operational needs, especially in landscapes where lynx habitat occurs as narrow bands of coniferous forest across the mountain slopes.

D. Forest/Backcountry Roads and Trails

Forest and backcountry roads and trails are those that occur on public lands; highways are addressed separately. Refer also to

Clayton Apps



Lynx in snow well

the conservation measures in the Forest Management, Recreation, and Trapping sections.

Plowed roads and groomed over-the-snow routes may allow competing carnivores such as coyotes and mountain lions to access lynx habitat in the winter, increasing competition for prey (Buskirk et al. 2000). However, plowed or created snow roads may be necessary to accomplish winter logging, which may be desirable to meet a variety of resource management objectives.

Preliminary information suggests that lynx may not avoid roads, except at high traffic volumes. Therefore, at this time, there is no compelling evidence to recommend management of road density to conserve lynx. However, new road construction continues to occur in many watersheds within lynx habitat, many of which are already highly roaded, and the effects on lynx are largely unknown. Further research directed at elucidating the effects of road density on lynx is needed.

Programmatic planning—objectives.

1. Maintain the natural competitive advantage of lynx in deep snow conditions.

Programmatic planning—standards.

1. On federal lands in lynx habitat, allow no net increase in groomed or designated over-the-snow routes and snowmobile play areas by LAU. Winter logging activity is not subject to this restriction.

Programmatic planning—guidelines.

1. Determine where high total road densities (>2 miles per square mile) coincide with lynx habitat, and prioritize roads for seasonal restrictions or reclamation in those areas.

2. Minimize roadside brushing in order to provide snowshoe hare habitat.

3. Locate trails and roads away from forested stringers.

4. Limit public use on temporary roads constructed for timber sales. Design new roads, especially the entrance, for effective closure upon completion of sale activities.

5. Minimize building of roads directly on ridgetops or areas identified as important for lynx habitat connectivity.

E. Livestock Grazing

In riparian areas within lynx habitat, ungulate forage use levels may reduce forage resources available to snowshoe hares. Browsing or grazing can have a direct effect on snowshoe hare habitat if it alters the structure or composition of native plant communities.

Throughout the Rocky Mountains, grazing has been a factor in the decline or loss of aspen as a seral species in subalpine forests. Young, densely regenerating aspen stands with a well-developed understory provide good quality habitat for snowshoe hares and other potential lynx prey species, such as grouse. Grazing should be managed to allow for regeneration of aspen clones.

Particularly in the naturally fragmented habitats of the western United States, inclusions of high elevation shrub-steppe habitats often may exist within the home range of a lynx. Resident lynx are also known to occasionally make exploratory movements out of their home ranges (Squires and Laurion 2000, Aubry et al. 2000), encountering these habitats and potential alternate prey such as ground squirrels and jackrabbits. Therefore, shrub-steppe habitats within the elevational ranges of forested lynx habitat should be considered lynx habitat and be managed to maintain or achieve mid seral or higher conditions, thereby providing maximum natural cover and prey availability. Those areas that are currently in late seral condition should not be degraded.

Programmatic planning—objectives.

1. In lynx habitat and adjacent shrub-steppe habitats, manage grazing to maintain the composition and structure of native plant communities.

Project planning—objectives.

1. Manage livestock grazing within riparian areas and willow carrs in lynx habitat to provide conditions for lynx and lynx prey.

2. Maintain or move towards native composition and structure of herbaceous and shrub plant communities.

3. Ensure that ungulate grazing does not impede the development of snowshoe hare habitat in natural or created openings within lynx habitat.

Project planning—standards.

1. Do not allow livestock use in openings created by fire or timber harvest that would delay successful regeneration of the shrub and tree components. Delay livestock use in post-fire and post-harvest created openings until successful regeneration of the shrub and tree components occurs.

2. Manage grazing in aspen stands to ensure sprouting and sprout survival sufficient to perpetuate the long-term viability of the clones.

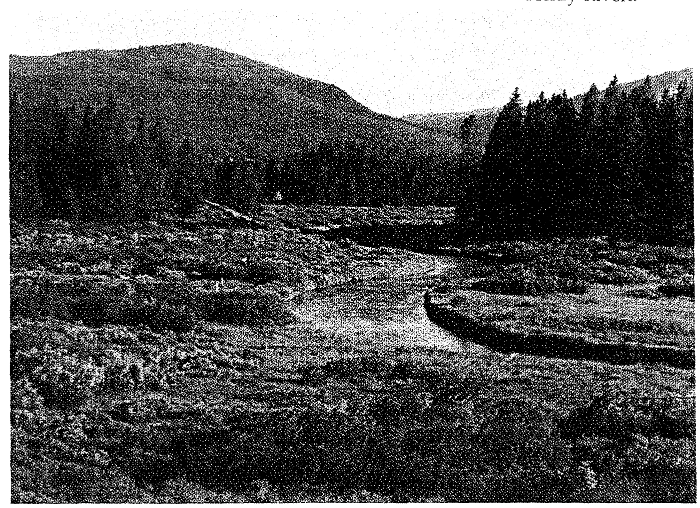
3. Within the elevational ranges that encompass forested lynx habitat, shrub-steppe habitats should be considered as integral to the lynx habitat matrix and should be managed to maintain or achieve mid seral or higher condition.

4. Within lynx habitat, manage livestock grazing in riparian areas and willow carrs to maintain or achieve mid seral or higher condition to provide cover and forage for prey species.

F. Other Human Developments: Oil & Gas Leasing, Mines, Reservoirs, Agriculture

Most of these activities affect lynx habitat by changing or eliminating native vegetation, and may also contribute to fragmentation. The main effects of leases and mines on lynx are probably related to the potential for plowed roads to provide access for lynx competitors, particularly coyotes. Construction of reservoirs will be handled under normal FERC and consultation procedures, and no conservation measures were developed specific to those projects.

Henry Rivera



Riparian area

Programmatic planning—objectives.

1. Design developments to minimize impacts on lynx habitat.

Programmatic planning—guidelines.

1. Map oil and gas production and transmission facilities, mining activities and facilities, dams, and agricultural lands on public lands and adjacent private lands, in order to assess cumulative effects.

Project planning—standards.

1. On projects where over-snow access is required, restrict use to designated routes.

Project planning—guidelines.

1. If activities are proposed in lynx habitat, develop stipulations for limitations on the timing of activities and surface use and occupancy at the leasing stage.

2. Minimize snow compaction when authorizing and monitoring developments. Encourage remote monitoring of sites that are located in lynx habitat, so that they do not have to be visited daily.

3. Develop a reclamation plan (e.g., road reclamation and vegetation rehabilitation) for abandoned well sites and closed mines to restore suitable habitat for lynx.

4. Close newly constructed roads (built to access mines or leases) in lynx habitat to public access during project activities. Upon project completion, reclaim or obliterate these roads.

Conservation Measures to Address Mortality Risk Factors

A. Trapping (legal and non-target)

Lynx are known to be very vulnerable to trapping. Ward and Krebs (1985) stated that trapping was the single most important mortality factor in their Yukon study area. Incidental trapping of lynx can occur in areas where regulated trapping of other species overlaps with lynx habitat (Mech 1973, Carbyn and Patriquin 1983, Squires and Laurion 2000). Lynx may be more vulnerable to trapping near open roads (Koehler and Aubry 1994, Bailey et al. 1986).

The U.S. Fish and Wildlife Service (FWS) is proposing to work with the States to develop a 4-d. rule for all regulated or unregulated trapping (e.g., coyote, wolverine, bobcat, fox) in lynx habitats by establishing adequate trapping protocols to minimize incidental take. Each state would work with FWS to customize the protocol for their specific regions.

Programmatic planning – objectives.

1. Reduce incidental harm or capture of lynx during regulated and unregulated trapping activity, and ensure retention of an adequate prey base.

Programmatic planning – guidelines.

1. Federal agencies should work cooperatively with States and Tribes to reduce incidental take of lynx related to trapping.

B. Predator Control

Predator control activities conducted on federal lands by Wildlife Services include trapping, shooting, and poisoning animals on domestic livestock allotments, occasionally within lynx habitat. Similar efforts may be conducted on adjacent private lands. Although such actions are intended to target the offending animal, non-target animals including lynx may be impacted.

Programmatic planning – objectives.

1. Reduce incidental harm or capture of lynx during predator control activities, and ensure retention of adequate prey base.

Programmatic planning – standards.

1. Predator control activities, including trapping or poisoning on domestic livestock allotments on federal lands within lynx habitat, will be conducted by Wildlife Services personnel in accordance with FWS recommendations established through a formal Section 7 consultation process.

C. Shooting

Lynx may be mistakenly shot by legal predator hunters seeking bobcats, or illegally by poachers. Prey species, such as snowshoe hares and ground squirrels, may also be affected by legal shooting.

Programmatic planning – objectives.

1. Reduce lynx mortalities related to mistaken identification or illegal shooting.

Programmatic planning – guidelines.

1. Initiate interagency information and education efforts throughout the range of lynx in the contiguous states. Utilize trailhead posters, magazine articles, news releases, state hunting and trapping regulation booklets, etc., to inform the public of the possible presence of lynx, field identification, and their status.

2. Federal agencies should work cooperatively with States and Tribes to ensure that important lynx prey are conserved.

D. Competition and Predation as Influenced by Human Activities

Habitat changes that benefit competitor/ predator species, including some vegetation management practices and providing packed snow travel ways, may lead to increased starvation or direct mortality of lynx. Refer also to applicable conservation measures in the Forest Management, Recreation, and Forest/ Backcountry Roads and Trails sections.

Programmatic planning – objectives.
1. Maintain the natural competitive advantage of lynx in deep snow conditions.

Programmatic planning – standards.
1. On federal lands in lynx habitat, allow no net increase in groomed or designated over-the-snow routes and snowmobile play areas by LAU. This is intended to apply to dispersed recreation, rather than existing ski areas.

E. Highways

Direct mortality from vehicular collisions may be detrimental to lynx populations in the lower 48 states. Mortality levels can drastically increase with relatively small increases in traffic volumes and speed.

Programmatic planning – objectives.
1. Reduce the potential for lynx mortality related to highways.

Programmatic planning – standards.
1. Within lynx habitat, identify key linkage areas and potential highway crossing areas.

Programmatic planning – guidelines.
1. Where needed, develop measures such as wildlife fencing and associated underpasses or overpasses to reduce mortality risk.

Conservation Measures to Address Movement and Dispersal

It is essential to provide landscape connectivity so that all or most habitat has the potential of being occupied, and populations remain connected.

At the southern periphery and eastern portions of lynx range, habitat occurs in narrow fragmented bands (man-made or naturally-occurring), or has been fragmented by human developments. Connected forested habitats allow lynx, and other large and medium size carnivores, to easily move long distances in search of food, cover and mates. Highways and private lands that are subdivided for commercial or residential developments or have high human use patterns, can interrupt existing habitat connectivity and further fragment lynx habitat, reducing the potential for population interchange. In some areas, particularly the eastern United States, habitat connectivity may be difficult to achieve because of mixed ownerships. Land exchanges and cooperative management with private landowners may be the only options available to provide landscape connectivity.

Shrub-steppe habitats provide connectivity between mountain ranges and other blocks of subalpine forest. Where blocks of lynx habitat are separated by intervening basins, valleys, or high mesas of shrub-steppe, land managers should evaluate those shrub-steppe expanses for potential to provide landscape connectivity. Vegetative or geomorphic features within shrub-steppe habitats that may be particularly important are riparian systems and relatively high ridge systems. Where such features exist, land management practices should be consistent with maintaining landscape connectivity. Livestock grazing within shrub-steppe habitats in such areas should be managed to maintain or achieve mid seral or higher condition, to maximize cover and prey availability. Such areas that are currently in late seral condition should not be degraded.

Programmatic planning—objectives.

1. Maintain and, where necessary and feasible, restore habitat connectivity across forested landscapes.

Programmatic planning—standards.

1. Identify key linkage areas that may be important in providing landscape connectivity within and between geographic areas, across all ownerships.

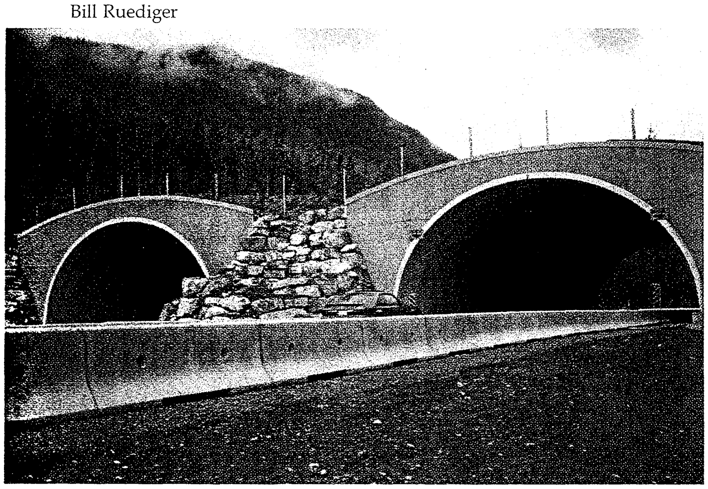
2. Develop and implement a plan to protect key linkage areas on federal lands from activities that would create barriers to movement. Barriers could result from an accumulation of incremental projects, as opposed to any one project.

3. Evaluate the potential importance of shrub-steppe habitats in providing landscape connectivity between blocks of lynx habitat. Livestock grazing within shrub-steppe habitats in such areas should be managed to maintain or achieve mid seral or higher condition, to maximize cover and prey availability. Such areas that are currently in late seral condition should not be degraded.

Programmatic planning—guidelines.

1. Where feasible, maintain or enhance native plant communities and patterns, and habitat for potential lynx prey, within identified key linkage areas. Pursue opportunities for cooperative management with other landowners.

Bill Ruediger



Wildlife overpass

A. Highways

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

Within key linkage areas, highway crossing structures should be employed to reduce effects on wildlife. Information from Canada (Trans-Canada Highway) suggests crossings should generally be at ½-mile intervals and not farther than 1 mile apart, depending on topographic and vegetation features.

Programmatic planning—objectives.

1. Ensure that connectivity is maintained across highway rights-of-way.

Programmatic planning—standards.

1. Federal land management agencies will work cooperatively with the Federal Highway Administration and State Departments of Transportation to address the following within lynx geographic areas:

a) Identify land corridors necessary to maintain connectivity of lynx habitat.

b) Map the location of "key linkage areas" where highway crossings may be needed to provide habitat connectivity and reduce mortality of lynx (and other wildlife).

Programmatic planning—guidelines.

1. Evaluate whether land ownership and management practices are compatible with

maintaining lynx highway crossings in key linkage areas. On public lands, management practices will be compatible with providing habitat connectivity. On private lands, agencies will strive to work with landowners to develop conservation easements, exchanges, or other solutions.

Project planning—standards.

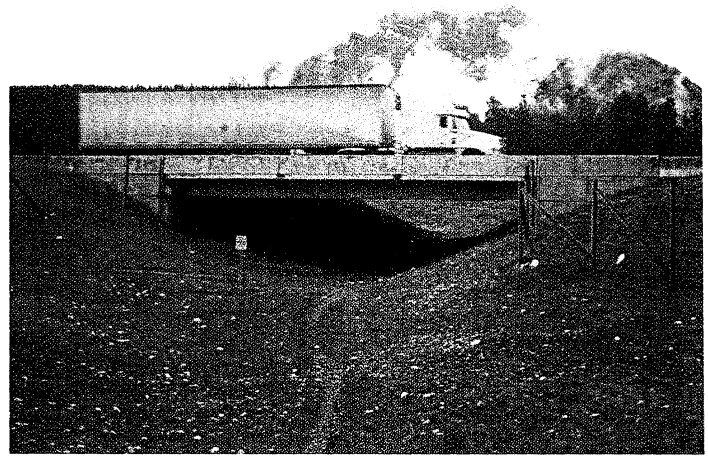
1. Identify, map, and prioritize site-specific locations, using topographic and vegetation features, to determine where highway crossings are needed to reduce highway impacts on lynx.

2. Within the range of lynx, complete a biological assessment for all proposed highway projects on federal lands. A land management agency biologist will review and coordinate with highway departments on development of the biological assessment.

Project planning—guidelines.

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

Bill Ruediger



Wildlife underpass

B. Land Ownership

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

Programmatic planning—objectives:

1. Retain lands in key linkage areas in public ownership.

Programmatic planning—standards:

1. Identify key linkage areas by management jurisdiction(s) in management plans and prescriptions.

Programmatic planning—guidelines:

1. In land adjustment programs, identify key linkage areas. Work towards unified management direction via habitat conservation plans, conservation easements or agreements, and land acquisition.

Project planning—standards:

1. Develop and implement specific man-

agement prescriptions to protect/ enhance key linkage areas.

2. Evaluate proposed land exchanges, land sales, and special use permits for effects on key linkage areas.

C. Ski Areas/Large Resorts and Associated Activities

Ski areas and large resorts are often developed in and across bands of high elevation boreal forests containing lynx habitat. Landscape location, the high intensity of recreational and operational use, and associated development pose a risk to lynx movement and dispersal. Developments that may impede lynx movement occur in Utah and western Wyoming (Northern Rocky Mountains Geographic Area), Colorado (Southern Rocky Mountains Geographic Area), and possibly portions of the Northeast Geographic Area.

Programmatic planning—objectives:

1. When conducting landscape level planning on Federal lands, allocate land uses such that landscape connectivity is maintained.

Programmatic planning—standards:

1. Within identified key linkage areas, provide for landscape connectivity.

Project planning—standards:

1. When planning new or expanding recreational developments, ensure that key linkage areas are protected.

Project planning—guidelines:

1. Plan recreational development, and manage recreational and operational uses to provide for lynx movement and to maintain effectiveness of lynx habitat.

Other Large-Scale Factors

Little information is available concerning the remaining three risk factors: fragmentation and degradation of refugia, management of shrub-steppe habitats, and non-native invasive plant species. It is likely that extensive areas of contiguous habitat are necessary to ensure persistence of lynx populations, but the necessary size and characteristics of such refugia are uncertain. Patterns of movement and dispersal into shrub-steppe habitat by lynx within the southern portion of its range are essentially unknown (McKelvey et al. 2000a). Non-native invasive plant species have the potential to affect large areas, but have not been studied with regard to impacts on lynx habitat.

Our primary recommendation at this time is to encourage further research on these topics. We believe these elements may be important in the long-term conservation of lynx. Although existing information is not sufficient to develop specific management direction, we have provided conceptual definitions and initial management considerations.

A. Fragmentation and Degradation of Refugia

We believe refugia have been and will continue to be important in the persistence of lynx populations, by providing protection from human exploitation. Refugia, or areas that could be developed into lynx refugia if needed, should be identified by geographic area.

Conceptually, refugia should encompass large areas of high-quality habitat, in which lynx are present or occurred historically, and where natural ecological processes predominate. Refugia should be relatively secure from human exploitation, habitat degradation, or substantial winter access; however, it is recognized that some active management may be needed to maintain or restore desired vegetation characteristics. Refugia should be sufficiently well connected to permit genetic interchange within and between geographic areas.

The appropriate size of area necessary to provide refugia for lynx is not known. In north-central Washington, an area of about 1,800 km^2 (700 mi^2) has sustained a local population of about 25 lynx (Koehler 1990). It should be noted that this area is connected to habitat and populations in Canada.

The design of refugia should consider the full suite of large and mid-sized carnivores, so that the areas are complementary and effective in meeting the habitat requirements of all of the species under consideration.

B. Lynx Movement and Dispersal Across Shrub-steppe Habitats

Connectivity between geographically separated populations is probably important for lynx persistence in many areas in the western United States. The apparent genetic homogeneity of the species throughout its range (Koehler and Aubry 1994) suggests that genetic interchange has occurred, even in local populations that appear to be geographically isolated from other lynx habitat. Although it is well known that lynx are capable of moving long distances (Poole 1997), the frequency, timing, synchrony with Canadian population cycles, and other characteristics of lynx movements in the southern portions of its range are poorly understood (McKelvey et al. 2000b).

Particularly in the Southern Rocky Mountains Geographic Area, spruce-fir forests often extend into shrub-steppe habitats. Throughout the western U.S., lynx occurrence has been documented in more than 20 mountain ranges that are surrounded by shrub-steppe habitats. Many of these have had a number of lynx documented over time, suggesting the existence of small resident populations. In Idaho, lynx have been documented in shrub-steppe habitats during jackrabbit population highs. In Wyoming, a male and a female lynx have been observed hunting Wyoming ground squirrels in sagebrush. This suggests that movement into shrub-steppe habitats may be a response to abundant prey, in contrast to dispersal during periods of prey scarcity as has been documented in the north.

Until more information is available, land management agencies should map mid- to late-seral shrub habitats, and assess vegetation conditions and landscape level habitat fragmentation. The primary areas of consideration would be in western Wyoming, southeastern Idaho, southwestern Montana, northeastern Utah, Colorado, and eastern Oregon. It is also recommended that agencies implement land management practices that would provide for habitat connectivity.

C. Non-native Invasive Plant Species

The impact of non-native invasive plants on biodiversity is a major concern in North America. Although the magnitude of the effects of non-native invasive plant infestations specifically on lynx habitat in the United States has not been documented, the potential exists for large-scale impacts and alteration of habitat. Weeds such as diffuse and spotted knapweed *(Centaurea diffusa and C. maculosa)*, leafy spurge *(Euphorbia spp.)*, rush skeletonweed *(Chondrilla juncea)*, dalmation toadflax *(Linaria dalmatica)*, and Canada thistle *(Cirsium arvense)* have the potential to alter these habitats at both the local and ecosystem scale. Many of these plants are more easily eradicated at infestation levels of a few plants or a few acres. Once established, they spread aggressively and become extremely difficult to control.

Management activities should seek to minimize the loss or modification of lynx habitat as a result of the spread of non-native invasive plant species. Actions could include efforts to prevent the establishment of new populations, controlling the spread of existing infestations, providing information to the public, and cooperating with other agencies and landowners in developing and implementing prevention and control programs.

Inventory, Monitoring, and Research Needs

Inventory and Monitoring of Lynx Distribution

An assessment of present distribution of lynx populations and lynx habitat is a critical first step. A national field sampling survey is being conducted to delineate lynx distribution by collecting hair samples (McKelvey et al. 2000d).

Surveys are needed to further refine understanding of lynx distribution and occurrence at various scales. In particular, detection of lynx presence should be emphasized in the Great Lakes and Northeast Geographic Areas, southeastern Washington and northeastern Oregon, the Oregon Cascades, central and southern Idaho, and Utah. Monitoring of the reintroduction effort in Colorado could yield important information on lynx use of habitat, diet, and movements.

It is also critical that continuing efforts are made to document and evaluate lynx observations, including snow track surveys, incidental and legal trapping of lynx, and incidental observations. For all such observations, data should include date, times, location, habitat features and conditions, an estimate of potential prey species and availability, and an indication of the certainty of identification and locational accuracy of the observation.

Inventory and Monitoring of Lynx Habitat Conditions

Monitoring of the distribution and abundance of snowshoe hares across the range of the lynx would provide important insights and validation of assumptions used in this conservation strategy. Future work should address summer vs. winter forage abundance and availability, and use of alternate prey species by lynx.

There is a need to conduct an inventory and to monitor trends in recreational activities that cause snow compaction. This should include an assessment of where and when these activities are occurring, and the relative intensity of use.

Clayton Apps

Lynx release from trap

Effectiveness and Validation of Conservation Measures

The effectiveness of the conservation measures need to be evaluated, to verify that it is feasible to implement them as written, to verify that they do in fact lead to conservation of the species, and to validate that the assumptions they were based on are correct. As an example, research should be designed to investigate interspecific competition and the relative role of snow compaction in altering competitive relationships between lynx and coyotes. Accomplishment of these objectives will likely require several well-designed research projects.

Research Needs

In the development of the Lynx Conservation Assessment and Strategy, the Lynx Biology Team came across several situations where more information would have been helpful in establishing the conservation measures for lynx. The Lynx Biology Team did their best to recommend appropriate conservation measures, but much information about lynx is incomplete, and may have been extrapolated between different geographic areas. The following is a list of research items that the Lynx Biology Team recommends for consideration by agency line officers. The list is not in order of priority.

1. *Precommercial thinning* – One of the most controversial conservation measures recommends that precommercial thinning of conifers be curtailed or eliminated in lynx habitat. Many commenters suggested that lynx habitat might be improved by precommercial thinning. More information needs to be developed to determine where, when, or if precommercial thinning can benefit snowshoe hare or lynx habitat. Examples exist where precommercially thinned vegetation has "filled in" with understory trees and developed into snowshoe hare habitat. It has been suggested this could be a technique to extend the time vegetation provides habitat for hares. However, the duration between time of thinning and regrowth to a height providing winter snowshoe hare habitat has not been documented. Additionally, there are no available data to determine the amount of time habitat is lost for snowshoe hares post-thinning, or the extended period of time the precommercially thinned vegetation provides hare habitat as compared with sites that have not been thinned.

2. *Snow compaction* – Lynx evolved with physical adaptations thought to provide them with competitive advantages (big feet, light body frame) in deep snow. This has allowed lynx to exploit deep snow conditions during critical winter periods not available to other carnivores like coyotes, bobcats and mountain lions. Snowmobile, cross country ski, and snowshoe trails created by humans result in packed trails in deep snow situations that are used by coyotes, bobcats, mountain lions and other carnivores to access areas where lynx are present and that would probably not otherwise be accessible. Interspecific competition between lynx and other carnivores during deep snow and other periods is poorly understood. More information would be beneficial on the inter-relationships between lynx and other carnivores (including competition for prey) during deep snow conditions and the impacts of compacted snow routes into lynx habitat.

3. *Highways and key linkage areas* – There is a concern that highways create partial or complete barriers for dispersal and movement of lynx and other carnivores. Whether or not lynx are displaced by highway activity and noise is also uncertain. Most lynx research has been conducted in areas where major highways are absent. Evidence was largely extrapolated from other species like Florida panther, or from documentation of

causes of mortality of translocated lynx. Highways continue to expand in traffic volume, speed, number of lanes, and other complicating factors like fencing and barriers between lanes. An assessment of the effects of habitat fragmentation and mortality on lynx population viability is needed. Topography, terrain, vegetation patterns, and other factors that would facilitate crossings by lynx are largely unknown. Research into the effects of highways on lynx dispersal and movements, and the potential effectiveness of crossing structures, would be useful.

4. *Forest road density* – The effects of open road densities on lynx are poorly understood but seem to be primarily related to snow compaction that allows competitors into lynx habitat during the critical winter period. It is known that several other wildlife species (e.g., grizzly bears and elk) are sensitive to forest road densities. Further study is needed to elucidate whether or not lynx benefit by closing roads, the effects of open forest roads, and the associated human use patterns on lynx.

5. *Human disturbances* – Many researchers and observers feel lynx are not disturbed by human presence, in contrast to some other wildlife species such as grizzly bears. On the other hand, there is a concern that high levels of human disturbance, particularly near den sites, may be detrimental to lynx. The effects of human activities on lynx activity patterns and energetics (how much energy is expended during food gathering and daily movements) are unknown.

6. *Aspen and snowshoe hare* – In much of the southern portion of the range of lynx (eastern and western U.S.), aspen is a significant vegetation component. It exists in various kinds of conditions and stands, from relatively large, unbroken stands to aspen-conifer mixtures. Aspen stands are commonly adjacent to or interspersed with spruce-fir forests in the western U.S. It is known that snowshoe hare utilize aspen stands, but their importance to hare and lynx are not well understood. Grazing, both from domestic livestock and wild ungulates, has affected aspen, particularly regeneration of young, dense stands favored by snowshoe hares. Further study of lynx and snowshoe areas is needed in areas that contain a significant component of aspen.

7. *Shrub-Steppe Habitat* – Since almost all lynx research has come from the northern lynx habitats, there is little information about how lynx may utilize shrub-steppe habitats. These habitats are commonly interspersed with or adjacent to lynx habitat from Montana and Idaho southward, including northeastern Oregon. The extent to which lynx use potential alternate prey species such as ground squirrels, white-tailed jackrabbits, or black-tailed jackrabbits are important questions that need answers. Lynx apparently must disperse across shrub-steppe habitats to maintain metapopulation connectivity. The trigger for that movement is another important question whose answer may have important consequences for lynx conservation.

8. *Grazing* – Little or no information exists as to the effect of large herbivores on snowshoe hare productivity, either through direct competition or changes in plant communities. Existing research has shown that grazing by large herbivores can affect the habitat of black-tailed jackrabbits. Research is needed to determine whether the same effects may occur with snowshoe hare.

9. *Refugia* – Refugia should be identified as part of an overall carnivore strategy. Further study is needed to determine the appropriate size and characteristics of areas that could function as refugia.

Analysis of Cumulative Effects

Lynx analysis units provide the smallest unit within which to begin tracking or evaluating cumulative effects. Lynx Analysis Units are defined and described in the previous section entitled "Home Range Description and Risk Factors." Depending on the scale of the project, measurement of cumulative effects may consider activities occurring in one or more LAUs.

Definitions of cumulative effects vary slightly, depending upon regulatory context. The Council on Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) define cumulative effects as: "...the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or nonfederal) or person undertakes such other actions." (40 CFR, sec. 1508.7) (CEQ 1997). Regulations for implementing the Endangered Species Act of 1973 (ESA), define cumulative effects as "...those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject of consultation" (50 CFR part 402). Future Federal actions are excluded from the definition of cumulative effects under ESA because all Federal actions will require review under section 7. However, cumulative effects are added to the environmental baseline, which includes all Federal and private past actions.

A biological assessment should thoroughly evaluate the environmental baseline and potential effects of the action on lynx. Under NEPA and CEQ regulations, cumulative effects must be evaluated along with the direct effects and indirect effects of each alternative proposed by a Federal agency (CEQ 1997).

The basis of cumulative effects analysis is that the combined number, type and juxtaposition of human activities and natural disturbances may have a significant effect, even though each individual action appears to have minimal effects. Assumptions include:

1. Lynx can persist in most situations with some level of human activity.
2. Human activities and alteration of habitat decrease habitat quality and lynx use of habitat, but the thresholds are not known.
3. Areas without high human activity levels are likely more favorable to lynx.

4. Habitat connectivity is important to lynx conservation.

The following are some considerations to include in analyzing cumulative effects of proposed action on lynx:

1. Lynx habitat components within LAUs should be mapped along with human activities. Some human activities may be seasonal (e.g., cross country ski trail) or temporal (e.g., timber harvest). Others may be yearlong and permanent (e.g., 4 season resort or highway).

2. Consider the combined effects of human activities and projects within an LAU, including:

a) The proportion of the LAU affected by human alteration of habitat, permanent development, and other disturbances at a given time.

b) The proportion of adjacent LAUs affected by human alteration of habitat, permanent development, and other disturbances at a given time

c) Habitat connectivity within and between LAUs.

The conservation measures include a standard for no net increase in groomed or designated over-the-snow routes. The following criteria are to be used in determining the winter baseline conditions by which actions can be evaluated in relation to this standard. Use approved access and travel management plans to identify a list of trails, roads or other authorized areas approved for winter recreation use, or a map displaying the same set of conditions. To establish the baseline, include only those roads and trails that are actually being used during the winter season. Broad areas of use should be identified as snow play or congregation areas. Try to omit large areas that are mapped as open to winter recreation, but are not actually used. If your unit does not have an approved access and travel management plan, utilize the knowledge of your recreational specialist or other knowledgeable individuals to delineate trails, roads and other broad areas of use.

In dealing with recreational special use permits (outside of developed ski areas and recreation sites) related to snow compaction, validate this use is established, (i.e., previously approved) and that the request is for the same level of use and areas as previous permit reauthorizations. Requests for reauthorization that request additional areas or uses would be subject to the no net increase conservation measure.

Glossary

Altithermal—A period in time, 4,000 to 5,600 years ago, when climatic warming and drying may have reached its thermal maximum.

Boreal Forest—Forests growing in northern and mountainous parts of the northern hemisphere.

Broad-scale Assessment—A synthesis of current scientific knowledge, including a description of uncertainties and assumptions, to provide an understanding of past and present conditions and future trends, and a characterization of ecological, social and economic components within an area.

Canopy Cover—The percentage of ground surface that is shaded by the live foliage of plants as seen from above. This measurement or estimate is used to describe how open or dense a stand of trees is.

Carr—Deciduous woodland or shrub land occurring on permanently wet, organic soil.

Clearcutting—A regeneration harvest method that removes all merchantable trees in a single cutting except for wildlife trees or snags. A "clearcut" is an area from which all merchantable trees have been cut.

Coarse Woody Debris—Any piece(s) of dead woody material, e.g., dead boles, limbs, and large root masses on the ground or in streams.

Competition—An interaction that occurs when two or more individuals make demands of the same resources that are in short supply. Exploitation competition occurs when one species uses common resources in a manner that reduces the fitness of the other species, for example by causing starvation or reduced reproductive success. Interference competition occurs when one species, almost invariably the species with larger body size, acts aggressively toward another, denying it access to a resource.

Composition (of forest vegetation)—The proportion of each tree species in a stand, expressed as a percentage of the total number, basal area, or volume of all tree species in the stand.

Connectivity—see Habitat Connectivity.

Cover Type—The present vegetation composition of an area, described by the dominant plant species.

Cumulative Effects—Effects on lynx or lynx habitat that result from the incremental impact of the proposed action when added to other past, present, and/or reasonably foreseeable future actions. Cumulative effects can be significant even when direct and indirect effects are minor.

Denning Habitat—Habitat used during parturition and rearing of young until they are mobile. The common component appears to be large amounts of coarse woody debris, either down logs or root wads. Coarse woody debris provides escape and thermal cover for kittens. Denning habitat may be found either in older mature forest of conifer or mixed conifer/deciduous types, or in regenerating stands (>20 years since disturbance). Denning habitat must be located within daily travel distance of foraging habitat (typical maximum daily distance for females is 3-6 miles).

Developed Recreation—Recreational uses that are dependent upon facilities and therefore occur in concentrated use areas. Examples include campgrounds and ski areas. Facilities in these areas might include roads, parking lots, picnic tables, drinking water, toilets, ski lifts, and buildings. Dispersed Recreation - Those outdoor recreation activities in forest, range, or desert environments that normally take place outside of developed sites or areas that support concentrated recreational use. Dispersed recreation activities may require facilities for safeguarding visitors, protecting resources, and enhancing the quality of the visitor experience.

Disturbance—Events that alter the structure, composition, or function of terrestrial or aquatic habitats. Natural disturbances include drought, floods, wind, fires, wildlife grazing, and insects and pathogens. Human-caused disturbances include actions such as timber harvest, livestock grazing, road construction, and the introduction of exotic species.

Diurnal Security Habitat—In lynx habitat, areas that provide secure winter daytime bedding sites for lynx in highly disturbed landscapes, e.g., large developed winter recreational sites or areas of concentrated winter recreational use. It is presumed that lynx may be able to adapt to the presence of regular and concentrated human use during winter, so long as other critical habitat needs are being met, and security habitat blocks are present and adequately distributed in such disturbed landscapes. Security habitat will provide lynx the ability to retreat from human disturbance during winter daytime hours, emerging at dusk to hunt when most human activity ceases. Security habitats will generally be sites that naturally discourage winter human activity because of extensive forest floor structure, or stand conditions that otherwise make human access difficult, and should be protected to the degree necessary. Security habitats are likely to be most effective if they are sufficiently large to provide effective visual and acoustic insulation from winter human activity and to easily allow movement away from infrequent human intrusion. These winter habitats must be distributed such that they are in proximity to foraging habitat.

Down Log—Tree stem that is dead and has fallen to the ground, not in a standing position.

Ecological Integrity—The degree to which the elements of biodiversity and the functions that link them together are complete and capable of performing desired functions. Absolute measures of ecological integrity do not exist.

Ecological Processes—The flow and cycling of energy, materials, and organisms through an ecosystem.

Ecological Status—The relative degree to which the kinds, proportions, and amounts of plants in a community resemble that of the potential natural community (PNC). This relative degree of similarity between the present vegetation and the PNC can be calculated by determining the coefficient of similarity (2w / a+b), where a is the sum of species values for measured factors of present vegetation, b is the sum of values in the PNC, and w is the sum of the values common to both.

Endangered Species Act—A law passed in 1973 for the purposes of conserving the ecosystems upon which endangered species and threatened species depend, and providing a program for the conservation of such species.

Fire Suppression—Any act taken to slow, stop, or extinguish a fire.
Fire Regime—The characteristics of fire in a

given ecosystem, such as the frequency, predictability, intensity, and seasonality of fire.

Foraging Habitat—Habitat that supports primary prey (snowshoe hare) and/or important alternate prey (especially red squirrels) that are available to lynx. The highest quality snowshoe hare habitats are those that support a high density of young trees or shrubs (> 4,500 stems or branches per acre), tall enough to protrude above the snow. These conditions may occur in early successional stands following some type of disturbance, or in older forests with a substantial understory of shrubs and young conifer trees. Coarse woody debris, especially in early successional stages (created by harvest regeneration units and large fires), provides important cover for snowshoe hares and other prey. Red squirrel densities tend to be highest in mature cone-bearing forests with substantial quantities of coarse woody debris.

Four-Season Resorts—Recreational facility on national forest land, permitted to operate during more than one season of the year. Resorts with either a winter or summer emphasis may be authorized to allow facilities to remain open to allow additional recreation use during alternative seasons. Permit holders who operate ski-based facilities during the winter season and permit holders with summer-based resorts with overnight lodging normally are assigned responsibility for public safety and resource protection, and are required to manage their permit area for 365 days per year.

Fragmentation (of habitat)—Human alteration of natural landscape patterns, resulting in reduction of total area, increased isolation of patches, and reduced connectivity between patches of natural vegetation.

Geographic Area—Large land areas identified for purposes of analysis and development of conservation measures for lynx. The five areas -- Cascade Mountains, Northern Rocky Mountains, Southern Rocky Mountains, Great Lakes, and Northeast -- have uniquely different forest ecosystems, management histories, and current lynx population status.

Goals (management)—Descriptions of what an agency strives to accomplish.

Guidelines (management)—Techniques, priorities, processes, or prescriptions that should be used to meet objectives; rationale for deviations must be documented.

Habitat—The complete suite of biotic and abiotic components of the environment where an animal lives.

Habitat Connectivity (Landscape)—Cover (vegetation) in sufficient quantity and arrangement to allow for the movement of lynx. Narrow forested mountain ridges or shrub-steppe plateaus may provide a linkage between more extensive areas of lynx habitat. Wooded riparian communities may provide travel cover across otherwise open valley floors between mountain ranges, or lower elevation ponderosa pine or pinyon-juniper woodlands may link high elevation spruce-fir forests.

Habitat Type—A classification of land area that indicates its capability to support a particular plant association, that would develop under present environmental conditions if all successional sequences were completed without interference.

Highway—A road that is at least 2 lanes wide, paved with asphalt or concrete. Average daily traffic may exceed 5,000 vehicles and speeds are 45 mph or greater.

Home Range—That area used by an individual, either during the entire calendar year or seasonally, in its normal activities of foraging, mating, and rearing of young. The entire area of the home range is usually not defended, and individual home ranges may overlap. Home ranges may be occupied by an individual, a pair, a family group, or a social group consisting of several families.

Hydrologic Unit/Watershed—The drainage basin contributing water, organic matter, dissolved nutrients and sediments to a stream or lake.

Infrastructure—Facilities, utilities, and transportation systems required to meet public and administrative needs.

Intermediate Harvest Treatment—Any treatment or tending designed to enhance growth, quality, vigor, and composition of the stand after establishment or regeneration, and prior to final harvest.

Key Linkage Areas—Critical areas for lynx habitat. Usually, the factors placing connectivity at risk are highways or private land developments. Special management emphasis is recommended to maintain or increase the permeability of key linkage areas.

Krummholz—The shrubby, multi-stemmed form assumed by trees near the tree line.

Lynx Analysis Unit (LAU)—The LAU is a project analysis unit upon which direct, indirect, and cumulative effects analyses are performed. LAU boundaries should remain constant to facilitate planning and allow effective monitoring of habitat changes over time. An area of at least the size used by an individual lynx, about 25-50 mi2.

Lynx Habitat—Lynx occur in mesic coniferous forests that have cold, snowy winters and provide a prey base of snowshoe hare. Vegetation types and elevations that provide lynx habitat include the following.

- **Northeastern U.S.:** Most lynx occurrences (88%) fell within Mixed Forest-Coniferous Forest-Tundra province; 77% of occurrences were associated with elevations of 250-500 m (820-2,460 ft) (McKelvey et al. 2000b). Lynx habitat includes coniferous and mixed coniferous/deciduous vegetation types dominated by spruce, balsam fir, pine, northern white cedar, hemlock, aspen, and paper birch.
- **Great Lakes states:** Most lynx occurrences (88%) fell within the Mixed Deciduous/Conifer Forest province (McKelvey et al 2000b). Lynx habitat includes boreal, coniferous, and mixed coniferous/deciduous vegetation types dominated by pine, balsam fir, black and white spruce, northern white cedar, tamarack, aspen, paper birch, conifer bogs and shrub swamps.
- **Western U.S.:** Most lynx occurrences (83%) were associated with Rocky Mountain Conifer Forest, and most (77%) were within the 1500-2000 m (4,920-6,560 ft) elevation zone (McKelvey et al 2000b). There is a gradient in the elevational distribution of lynx habitat from the northern to the southern Rocky Mountains, with lynx habitat occurring at 2,440-3,500 m (8,000-11,500 ft) in the southern Rockies. Primary vegetation that contributes to lynx habitat is lodgepole pine, subalpine fir, and Engelmann spruce (Aubry et al. 2000). In extreme northern Idaho, northeastern Washington, and northwestern Montana, cedar-hemlock habitat types may be considered primary vegetation. In central Idaho, Douglas-fir on moist sites at higher elevations may be considered primary vegetation. Secondary vegetation that, when interspersed within subalpine forests, may also contribute to lynx habitat, includes cool, moist Douglas-fir, grand fir, western larch, and aspen forests. Dry forest types (e.g., ponderosa pine, climax lodgepole pine) do not provide lynx habitat.

Primary vegetation is considered necessary to support lynx reproduction and survival. Secondary vegetation includes other vegetation types that, when intermingled with or immediately adjacent to primary habitat, may also contribute to lynx habitat. Mapping of lynx habitat and delineation of LAUs involves consideration of the amount and arrangement of primary vegetation and secondary vegetation, elevation, land ownership pattern, lynx occurrence records, and snow depth information. After lynx habitat is mapped, there is no longer a distinction between primary and secondary vegetation. Conservation measures generally apply only to lynx habitat on federal lands within LAUs.

Refer also to Denning Habitat and Foraging Habitat.

Lynx Habitat Currently in Unsuitable Condition—Areas within identified/mapped lynx habitat that are in early successional stages as a result of recent fires or vegetation management, in which the vegetation has not developed sufficiently to support snowshoe hare populations during all seasons. Management-created openings would likely include clearcut and seed tree harvest units, and might include shelterwood and commercially-thinned stands depending on unit size and remaining stand composition and structure.

Monitoring and Evaluation—The periodic evaluation, on a sample basis, of management practices to determine how well objectives and standards are being met, as well as the effects of those management practices on the land and environment.

Non-native Invasive Plant Species—Plants that have been introduced into an environment in which they did not evolve, usually having no natural enemies to limit their reproduction and spread (may be formally recognized by states as noxious weeds).

Objective—A measurable statement describing desired resource conditions, or range of conditions, intended to promote achievement of programmatic goals.

Planning Area—A unit for which programmatic planning direction is developed.

Potential Natural Community—see Habitat Type.

Precommercial Thinning—A thinning that does not yield trees of commercial value, usually designed to reduce stocking in order to concentrate growth on the more desirable trees.

Primary Vegetation—see Lynx Habitat

Programmatic Planning—Analysis of the nature, function, and relationships of issues and resources, to establish broad goals, objectives, and outputs for a large area over a period of years. Examples of programmatic plans are Regional Guides and Forest Land and Resource Management Plan, as required under the National Forest Management Act; Resource Management Plans, as required under the Federal Lands and Policy Management Act; and General Management Plans for individual national parks.

Project Planning—Site-specific analysis of the nature, function, and relationships of issues and resources, for the purpose of preparing projects that implement programmatic plan direction.

Refugia—Large, contiguous areas encompassing the full array of seasonal habitats, in which lynx are present or occurred historically, and where natural ecological processes predominate. Refugia must be relatively secure from human exploitation, habitat degradation, and substantial winter access.

Refugia should be sufficiently well connected to permit genetic interchange within and between geographic areas.

Regeneration Harvest—A cutting method by which a new age class is created. The major methods are clear-cutting, seed tree, shelterwood, selection, and coppice.

Riparian Area—Area with distinctive soil and vegetation between a stream or other body of water and the adjacent upland; includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

Salvage Harvest—Removal of dead trees or trees being damaged or dying due to injurious agents other than competition, in order to recover value that would otherwise be lost.

Site Potential—The potential of a site to grow a stand of trees that is sustainable for a given period of time.

Site-Specific Planning—see Project Planning.

Ski Area—A site and attendant facilities expressly developed to accommodate alpine or Nordic skiing. Operation of Nordic and alpine ski areas for up to 40 years and encompassing such acreage as the Forest Officer determines sufficient and appropriate is authorized by the National Ski Area Permit Act of 1986.

Snowshoe Hare Habitat—see Foraging Habitat.

Special Use Permit—A permit, term permit, lease, or easement that allows occupancy or use-rights or privileges on national forest system lands.

Stand—A group of trees or other vegetation occupying a specific area and sufficiently uniform in composition, age, spatial arrangement, and conditions as to be distinguishable from the vegetation on adjoining lands.

Standards—Required management actions specifying how to achieve objectives. Standards can include requirements to refrain from taking action in certain situations.

Structure (of forest vegetation)—The horizontal and vertical distribution of plants in a stand, including height, diameter, crown layers, and stems of trees, shrubs, herbaceous understory, snags, and coarse woody debris.

Subnivean Habitat—Habitat that is under the snow surface.

Succession—A relatively predictable process of changes in structure and composition of plant and animal communities over time. Conditions of the prior plant community or successional stage create conditions that are favorable for the development of the next stage.

Taiga—Subarctic coniferous forests and dominated by spruces and firs.

Territory—That portion, usually not the periphery, of the home range that is defended against conspecifics, and in some cases other species.

Unsuitable Areas—Areas such as lakes, low elevation ponderosa pine forest, and alpine tundra that do not support snowshoe hare populations and are not considered to be capable of providing lynx habitat. See also Lynx Habitat and Lynx Habitat Currently in Unsuitable Condition.

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Appendix A. List of administrative units involved in consultation for lynx (updated August 2000).

Cascade Mountains Geographic Area

Administrative Unit	State(s)
Mt. Baker-Snoqualmie NF	WA
Okanogan NF	WA
Wenatchee NF	WA
Gifford Pinchot NF	WA
Mt. Hood NF	OR
Deschutes NF	OR
Willamette NF	OR
Umpqua NF	OR
BLM Spokane District Office, Spokane District RMP	WA
North Cascades National Park complex	WA
Mount Rainier National Park	WA

Northern Rocky Mountains Geographic Area

Administrative Unit	State(s)
Ochoco NF	OR
Malheur NF	OR
Wallowa-Whitman NF	ID, OR, WA
Umatilla NF	OR, WA
Colville NF	WA
Idaho Panhandle NFs	ID, WA
Clearwater NF	ID
Nez Perce NF	ID
Lolo NF	MT
Kootenai NF	MT, ID
Flathead NF	MT
Lewis and Clark NF	MT
Helena NF	MT
Bitterroot NF	MT, ID
Beaverhead-Deerlodge NF	MT
Gallatin NF	MT
Custer NF	MT, SD
Payette NF	ID
Boise NF	ID
Sawtooth NF	ID, UT
Salmon-Challis NF	ID
Targhee NF	ID, WY
Caribou NF	ID, WY
Wasatch-Cache NF	ID, UT, WY
Uinta NF	UT
Ashley NF	UT, WY
Bridger-Teton NF	WY
Shoshone NF	WY
Bighorn NF	WY
BLM Butte Field Office, Headwaters Resource Area RMP	MT
BLM Dillon Field Office, Dillon Resource Area MFP	MT
BLM Lewistown Field Office, West HiLine RMP	MT
BLM Missoula Field Office, Garnet RMP	MT
BLM Burley Field Office, Cassia RMP	ID
BLM Idaho Falls Field Office, Big Lost MFP	ID
BLM Idaho Falls Field Office, Little Lost/Birch Creek MFP	ID
BLM Idaho Falls Field Office, Mackay MFP	ID
BLM Idaho Falls Field Office, Medicine Lodge RMP	ID
BLM Pocatello Field Office, Malad RMP	ID
BLM Pocatello Field Office, Pocatello RMP	ID
BLM Shoshone Field Office, Bennett-Timmerman RMP	ID
BLM Shoshone Field Office, Sun Valley RMP	ID
BLM Challis Field Office, Challis MFP	ID
BLM Challis Field Office, Mackay MFP	ID
BLM Challis Field Office, Ellis/Pahsimeroi MFP	ID
BLM Salmon Field Office, Lemhi RMP	ID
BLM Cascade Field Office, Cascade RMP	ID
BLM Coeur d'Alene Field Office, Emerald Empire Resource Area MFP	ID
BLM Cottonwood Field Office, Chief Joseph MFP	ID
BLM Burns District Office, Three Rivers RMP	OR
BLM Baker Resource Area, Baker RMP	OR

BLM Malheur Resource Area, Malheur RMP	OR
BLM Prineville District Office, Two Rivers RMP	OR
BLM Prineville District Office, John Day & Brothers RMP	OR
BLM Prineville District Office, LaPine RMP	OR
BLM Kemmerer Field Office, Kemmerer RMP	WY
BLM Lander Field Office, Lander RMP	WY
BLM Pinedale Field Office, Pinedale RMP	WY
BLM Salt Lake Field Office, Box Elder RMP	UT
BLM Salt Lake Field Office, Randolph MFP	UT
BLM Salt Lake Field Office, Wasatch-Pony Express RMP	UT
BLM Vernal Field Office, Book Cliffs RMP	UT
BLM Vernal Field Office, Diamond Mountain RMP	UT
Glacier National Park	MT
Yellowstone National Park	WY, MT, ID
Grand Teton National Park	WY
Red Rocks National Wildlife Refuge	MT

Southern Rocky Mountains Geographic Area

Administrative Unit	State(s)
Arapaho-Roosevelt NF	CO
Medicine Bow-Routt NF	CO, WY
San Juan-Rio Grande NF	CO
White River NF	CO
Grand Mesa, Uncompahgre and Gunnison NFs	CO
Pike-San Isabel NF	CO
BLM Royal Gorge Field Office, Royal Gorge RMP	CO
BLM Saguache Field Office, San Luis Valley RMP	CO
BLM Little Snake Field Office, Little Snake RMP	CO
BLM Kremmling Field Office, Kremmling RMP	CO
BLM Grand Junction Field Office, Grand Junction RMP	CO
BLM White River Field Office, White River RMP	CO
BLM Gunnison Field Office, Gunnison RMP	CO
BLM Glenwood Springs Field Office, Glenwood Springs RMP	CO
BLM San Juan Field Office, San Juan/San Miguel RMP	CO
BLM Uncompahgre Field Office, Uncompahgre RMP	CO
Rocky Mountain National Park	CO

Great Lakes Geographic Area

Administrative Unit	State
Chippewa NF	MN
Superior NF	MN
Hiawatha NF	MI
Ottawa NF	MI
Voyageurs National Park	MN

Northeast Geographic Area

Administrative Unit	States
White Mountain NF	ME, NH

Appendix B. List of Species Referenced in the Document.

Animals

Shrews *(Sorex spp.)*
Mice *(Peromyscus spp.)*
Voles *(Microtus spp.)*
Mountain cottontail *(Sylvilagus nutallii)*
Snowshoe hare *(Lepus americanus)*
White-tailed jackrabbit *(Lepus townsendii)*
Black-tailed jackrabbit *(Lepus californicus)*
Beaver (*Castor canadensis)*
Porcupine (*Erithizon dorsatum)*
Red squirrel *(Tamiasciurus hudsonicus)*
Douglas squirrel *(Tamiasciurus douglasii)*
Flying squirrel *(Glaucomys sabrinus)*
Ground squirrel *(Spermophilus parryii, S. richardsonii, S. elegans)*
Fisher *(Martes pennanti)*
Marten *(Martes americana)*
Wolverine *(Gulo gulo)*
Weasel *(Mustela spp.)*
Canada lynx *(Lynx canadensis)*
Bobcat *(Lynx rufus)*
Mountain lion *(Puma concolor)*
Eurasian lynx *(Lynx lynx)*
Iberian lynx *(Felis pardina)*
Florida panther
Ocelot *(Felis pardalis)*
Red fox *(Vulpes vulpes)*
Coyote *(Canis latrans)*
Gray wolf *(Canis lupus)*
Grizzly bear *(Ursus arctos)*
Sage grouse *(Centrocercus urophasianus)*
Columbian sharp-tailed grouse *(Tympanichus phasianellus)*
Grouse *(Bonasa umbellus, Dendragopus spp.)*
Ptarmigan *(Lagopus spp.)*
Northern goshawk *(Accipiter gentilis)*
Great horned owl *(Bubo virginianus)*
Northern spotted owl *(Strix occidentalis)*
Red-tailed hawk *(Buteo jamaciensis)*
Broad-winged hawk *(Buteo platypterus)*
Cooper's hawk *(Accipiter cooperii)*

Plants

Eastern white pine *(Pinus strobus)*
Western white pine *(Pinus monticola)*
Bristlecone pine *(Pinus aristata)*
Jack pine *(Pinus divaricata)*
Red pine *(Pinus resinosa)*
Lodgepole pine *(Pinus contorta)*
Ponderosa pine *(Pinus ponderosa)*
Western larch *(Larix occidentalis)*
Tamarack *(Larix laricina)*
Spruce *(Picea spp.)*
Engelmann spruce *(Picea engelmannii)*
Black spruce *(Picea mariana)*
White spruce *(Picea glauca)*
Red spruce *(Picea rubens)*
Mountain hemlock *(Tsuga mertensiana)*
Western hemlock *(Tsuga heterophylla)*
Douglas-fir *(Pseudotsuga menziesii)*
Balsam fir *(Abies balsamea)*
Grand fir *(Abies grandis)*
Silver fir (*Abies amabilis)*
Subalpine fir *(Abies lasiocarpa)*
Northern white cedar *(Thuja occidentalis)*
Western redcedar *(Thuja plicata)*
Juniper (Juniperus spp.)
Quaking aspen *(Populus tremuloides)*
Willow *(Salix spp.)*
Paper birch *(Betula papyrifera)*
Yellow birch *(Betula alleghaniensis)*
Alder *(Alnus spp.)*
Hickory *(Carya spp.)*
American beech *(Fagus grandifolia)*
Oak *(Quercus spp.)*
Elm *(Ulmus spp.)*
Maple *(Acer spp.)*
Sugar maple *(Acer saccharum)*
Basswood *(Tilia spp.)*
Ash *(Fraxinus spp.)*
Serviceberry *(Amelanchier alnifolia)*
Huckleberry *(Vaccinium spp.)*
Grouse whortleberry *(Vaccinium scoparium)*
Menziesia *(Menziesia ferruginea)*
Thimbleberry *(Rubus parviflora)*
Snowberry *(Symphoricarpos alba)*
Chokecherry *(Prunus virginiana)*
Rose *(Rosa spp.)*
Ceanothus *(Ceanothus spp.)*
Sagebrush *(Artemisia spp.)*
Heartleaf arnica *(Arnica cordifolia)*
Western wheatgrass *(Agropyron smithii)*
Sixweeks fescue *(Vulpia ovina)*
Diffuse knapweed *(Centaurea diffusa)*
Spotted knapweed *(Centaurea maculosa)*
Leafy spurge *(Euphorbia spp.)*
Rush skeletonweed *(Chondrilla juncea)*
Dalmation toadflax *(Linaria dalmatica)*
Canada thistle *(Cirsium arvense)*